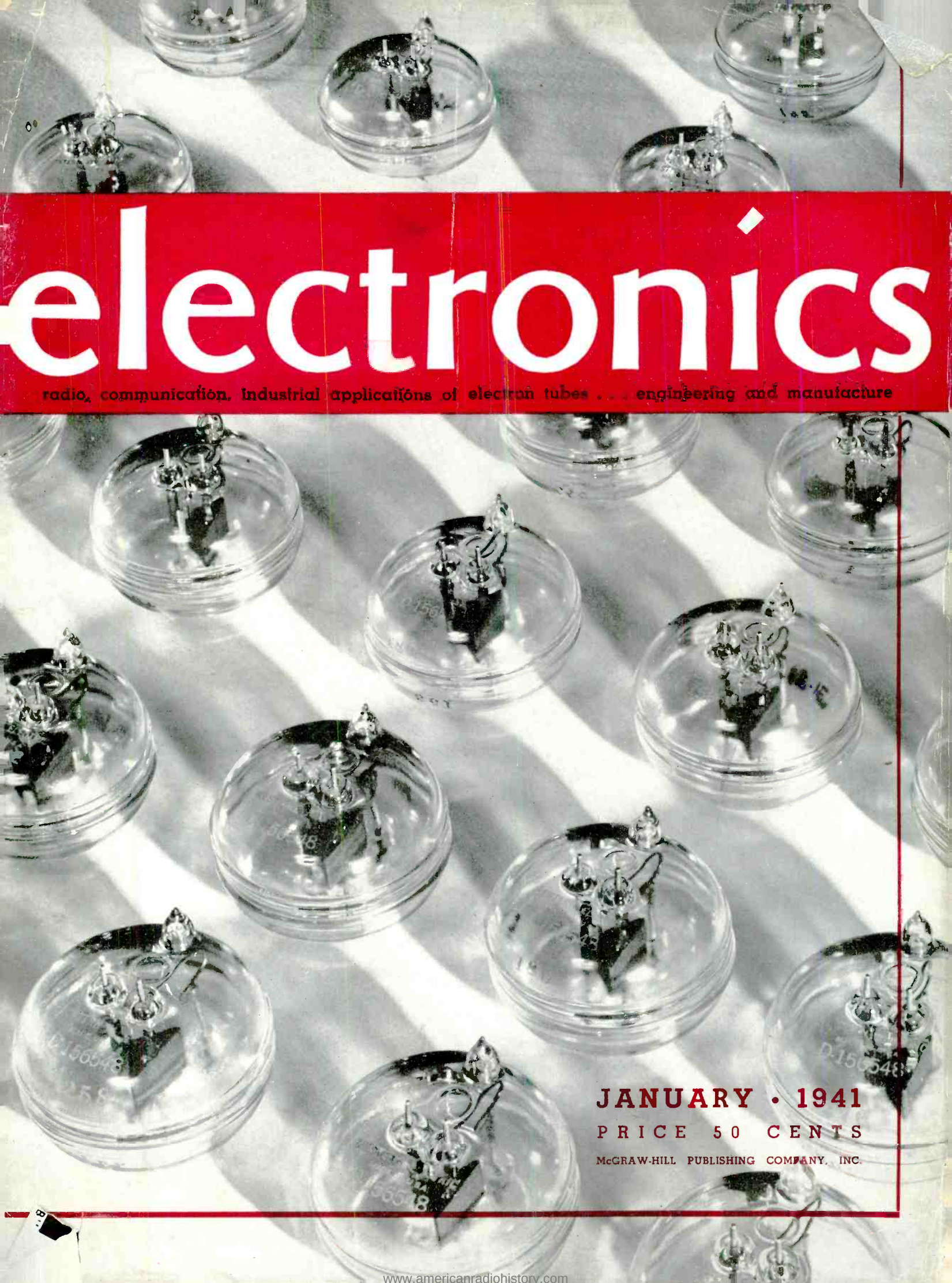


electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture

JANUARY • 1941

PRICE 50 CENTS

McGRAW-HILL PUBLISHING COMPANY, INC.

Constant Voltage

FOR YOUR LABORATORY, YOUR PRODUCT, OR YOUR PRODUCTION LINE

UTC STEADI-VOLT

- ACCURACY 1%
- INDEPENDENT OF LOAD
- NO MOVING PARTS
- HIGH POWER FACTOR
- HIGH EFFICIENCY
- NEGLIGIBLE TIME CONSTANT
- LOW DISTORTION
- LOW TEMPERATURE RISE

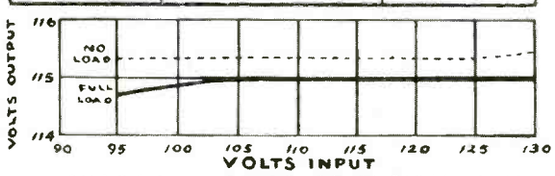
AUTOMATIC VOLTAGE REGULATORS

95-130 VOLT INPUTS . . . 110, 115, 120 VOLTS OUTPUT ± 1%

The UTC automatic voltage regulator is NEW. It involves no moving parts and effects instantaneous correction for either transient or chronic line voltage fluctuations.

STANDARD TYPES

Type No.	Capacity VA — 60 Cyc.	Net Price
AR-1	15	$12.00
AR-2	30	15.00
AR-3	60	21.00
AR-4	120	28.00
AR-5	250	46.00
AR-6	500	67.00
AR-7	1000	110.00
AR-8	2000	200.00



CHARACTERISTICS OF TYPICAL UNIT

Designs for 220 volt service available at 25% increase in price, for 50 cycle units increase price 25%; for 42 cycles, 35% increase; for 25 cycles, increase price 100%. Special secondary voltages available to customers' specifications at small increase in price.

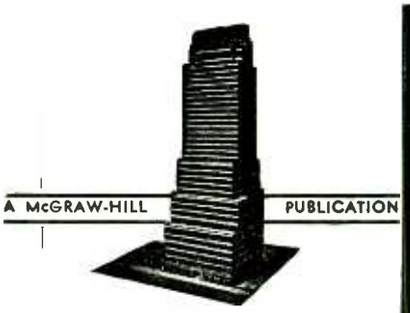
SPECIAL UNITS

The unique design of these regulators makes possible the construction of special units with relative ease. The output can be arranged to provide filament and plate voltage, or any other special voltages that may be required. Write for details.

UNITED TRANSFORMER CORP.

150 VARICK STREET ★ NEW YORK, N. Y.

EXPORT DIVISION: 100 VARICK STREET NEW YORK, N. Y. CABLES: "ARLA



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Founder and Honorary Chairman

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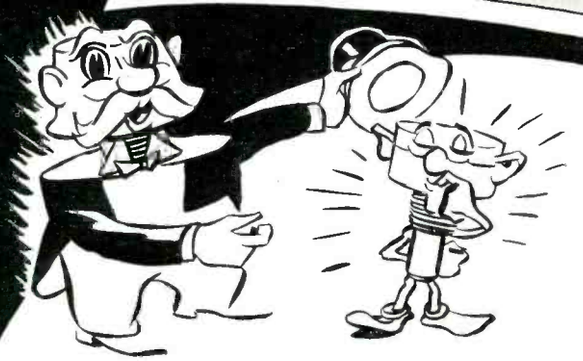
NOW! CENTRALAB'S ELF RADIOHM



OLD Man Centralab presents his little brother . . . aptly called the ELF Radiohm.

Designed and constructed like the popular MIDGET Radiohm it has the added feature of still smaller size.

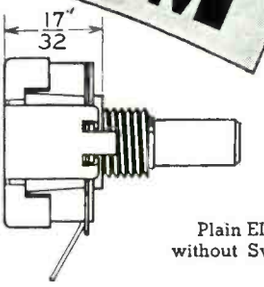
In spite of its small size it too features CENTRALAB'S long straight resistor strip in the inner circumference of the case . . . a particular advantage in producing good curve characteristics and low noise level on small controls.

Can be supplied with S.P.S.T. Switch with or without dummy lug. Switch rated at 2 Amperes at 125 volts. Underwriters approved.

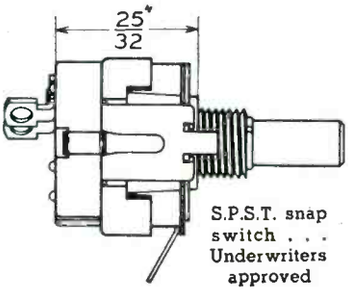
TAP POSITIONS at 31, 44, 56 and 69% of rotation based on 300 degrees total rotation.

Send for Specification form 691

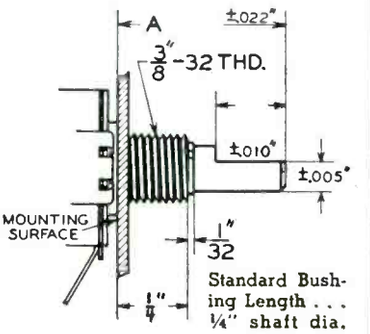
CENTRALAB: Div. of Globe-Union Inc.
MILWAUKEE, WISCONSIN



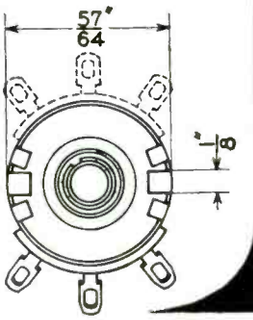
Plain ELF without Switch



S.P.S.T. snap switch . . . Underwriters approved



Standard Bushing Length . . . ¼" shaft dia.

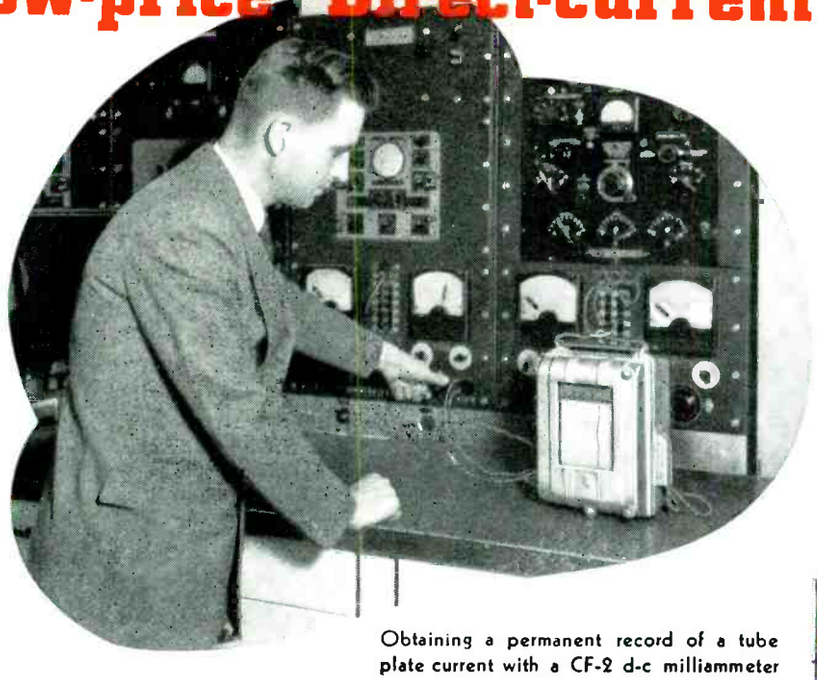


3 tap locations available

Centralab

NOW—FOR THE FIRST TIME

Low-price Direct-current Recorders



Obtaining a permanent record of a tube plate current with a CF-2 d-c milliammeter

for Low-range and High-sensitivity Measurements

Milliammeters
Microammeters
Millivoltmeters
and
Ammeters
Voltmeters

THIS new line of instruments (Type CF-2) makes it possible to obtain permanent records of circuit conditions where, previously, only indicating instruments, or expensive recording equipment, were available.

You will find these instruments ideal for electronics work because of their low power consumption.

THEY'RE INKLESS

There's no ink to spill, blur, or freeze. You are sure to obtain accurate records in temperatures from −10F to 120F, and rapidly fluctuating loads will not cause "painted" charts.

The CF-2 recorder is small, sturdy, accurate within 2 per cent, and readily portable—it weighs only 12 pounds. A reliable Telechron motor feeds the chart at either 1, 2, or 3 inches per hour.

For a-c measurements, the companion Type CF-1 instrument is available.

Get complete information from the nearest G-E Office. Ask for our Bulletin GEA-3187, General Electric, Schenectady, N. Y.

APPLICATIONS

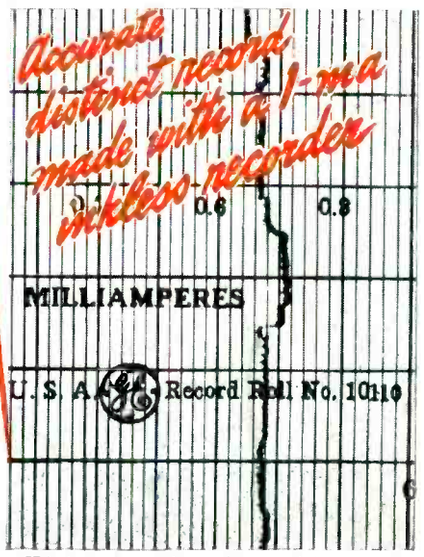
Here are just a few of the many possible uses for these recorders:

1 Development work—permanent records of circuit conditions will minimize the need for cut-and-try work, and will facilitate the duplication of test set-ups.

2 Smoke density—a recorder, used with auxiliary equipment, is an inexpensive way to obtain permanent records of smoke density, so that you will have proof for city inspectors.

3 Vacuum-tube circuits—to record plate current or voltage.

4 Moving vehicles—to study battery and generator performance.



CF instruments record by making one dot per second. This record was made with a relatively constant current. On fluctuating circuits the record may not be continuous, but the density of the dots gives an indication of the average current or voltage.

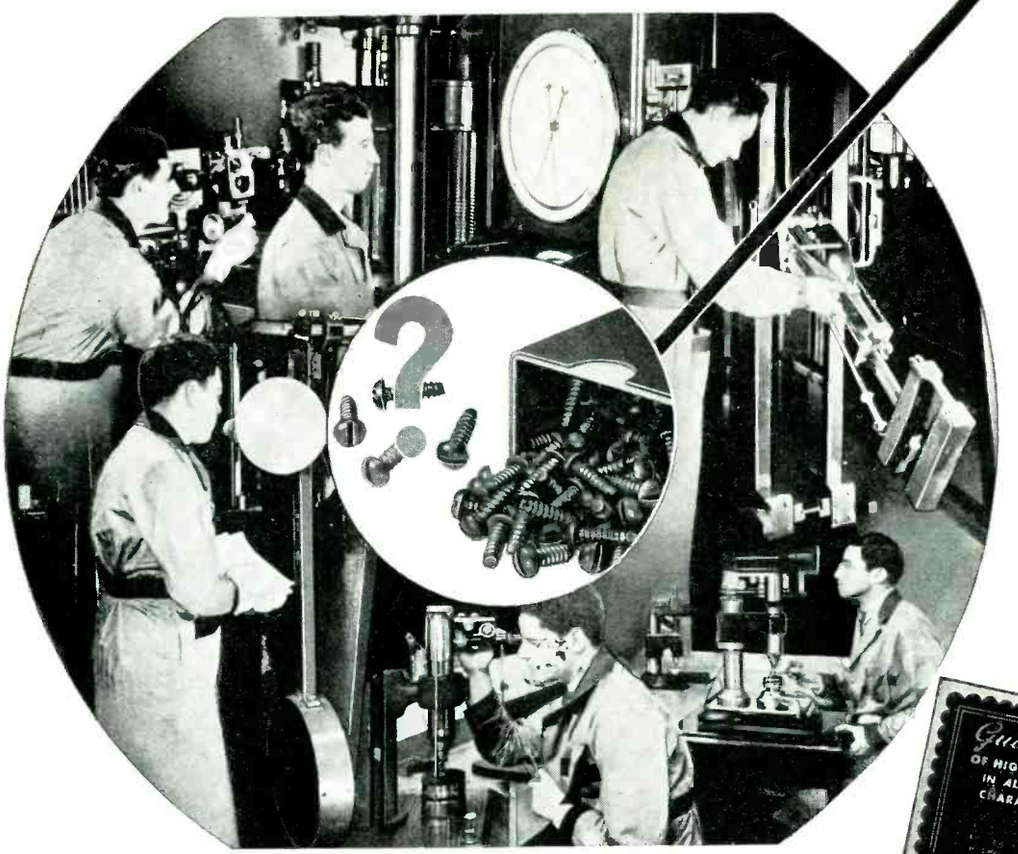
TYPICAL CHARACTERISTICS OF A POPULAR RATING

Range	0 to 1 ma
Resistance	16 ohms, approx.
Response time	3 sec. approx.
Dimensions	8 9/16 by 10 9/16 by 5 31/32 in.
Scale length	3 1/2 in.
Chart speed	3 in. per hour

GENERAL ELECTRIC

602-18

WE'LL KEEP THE "Doubtful Few" OFF YOUR ASSEMBLY BILLS



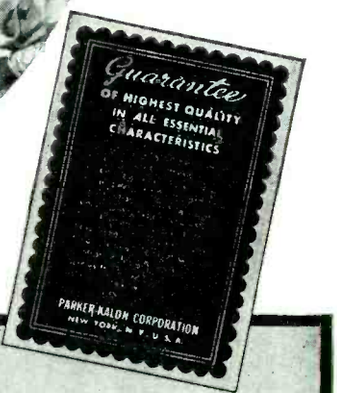
Parker-Kalon's Unequalled Quality-Control Laboratory eliminates the extra costs built up by "doubtful" screws

Fastening devices cost little . . . when they work right. When they don't, they cost plenty! The "Doubtful Few" . . . the imperfect units in a lot that won't drive properly, or fail in service . . . carry with them a high bill for extra time and labor, interrupted work and customer dissatisfaction.

To protect you against the cost-boosting "Doubtful Few", the Parker-Kalon Quality-Control Laboratory was established. Without counterpart in the industry, it makes it possible to hold Parker-Kalon Hardened Self-tapping Screws, Socket Screws and other fastening devices to higher standards than ever before could be attained!

Specify PARKER-KALON for fastening devices that ALWAYS WORK RIGHT AND HOLD TIGHT. Send for folder and free samples. Parker-Kalon Corp., 192-194 Varick Street, New York.

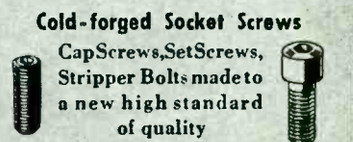
SOLD ONLY THROUGH RECOGNIZED DISTRIBUTORS



COSTS NO MORE *to get this Parker-Kalon Quality-Control Guarantee with every box of . . . .*

Hardened Self-tapping Screws
Types, sizes, head-styles for every assembly of metal or plastics

Cold-forged Socket Screws
Cap Screws, Set Screws, Stripper Bolts made to a new high standard of quality



Wing Nuts-Cap Nuts-Thumb Screws
Cold-forged . . Neater, Stronger

Quality-Controlled **PARKER-KALON Fastening Devices**

GL-880

A *MIDGET* IN SIZE—A *GIANT* IN OUTPUT

Three-fifths actual size

FOR HIGH-POWER **FM** AND TELEVISION

To Get the Most from Your Tube Dollar Be Sure to Specify GL-880's

GL-880 is the largest of the G-E developed tubes for high-frequency (FM and television) services. Its background is more than 28 years of G-E tube experience.

GL-880's ingenious "folded" anode reduces internal lead lengths by 10 inches without sacrificing cooling surface. High efficiency is obtained even at high frequencies.

Dual grid leads for separation of excitation and neutralization minimize neutralizing problems.

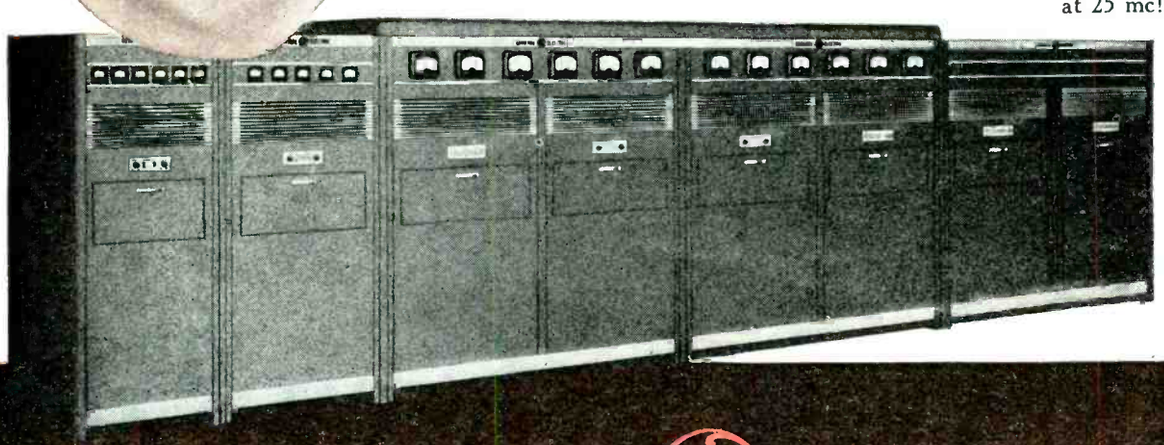
Easy to Drive

With only 1500 watts driving power at the grids, two GL-880's will deliver an easy 50 kw of FM at 50 mc.

Here's Real Versatility

Primarily for FM and Television, yes, but GL-880's have unusual efficiency at international and standard broadcast frequencies, and as modulators. A pair will give a 50-kw plate-modulated carrier at 25 mc!

Be sure to ask your nearby G-E representative for full information on the complete line of G-E transmitting tubes for all services. There are G-E offices in 80 principal cities. General Electric, Schenectady, New York.



G-E 50,000-watt FM broadcast transmitter

GENERAL ELECTRIC

181-18

Practically every Major Airline

Uses Eimac TUBES

Dependability, stamina and outstanding performance capabilities are perhaps more important to airline communications than to any other service. That's why Airline radio engineers are the ranking leaders—why equipment they select is the very finest.

It is no mere coincidence that Eimac Tubes were selected by most every major airline in the U. S. A. In actual performance, Eimac has established itself as the leader in this field—the tried and proven tube for aircraft ground stations. This fact should have an important bearing upon your choice of vacuum tubes. See nearest representative, or write.

Eitel-McCullough, Inc. • San Bruno, California

G. A. O'Reilly... TWA engineer...says, "We have many Eimac 450T's with nearly 10,000 hours of satisfactory service.

EIMAC REPRESENTATIVES

California, Nevada
HERB BECKER, 1530 W. 104th St., Los Angeles, Cal.

Wash., Ore., Idaho, Mont.
GENERAL SALES CO., Verner O. Jensen, 2605-07 Second Ave., Seattle, Wash.

Colo., Wyo., New Mexico, Arizona, Utah
RICHARD A. HYDE, 4253 Quitman St., Denver, Colo.

Ohio, Mich., Ky., Ind., Minn., Mo., Kan., Neb., Iowa
PEEL SALES ENGINEERING CO., E. R. Peel, 154 E. Erie St., Chicago, Ill.

N. Y., N. J., Penn., Md., Del., Dist. of Col., Maine, N. H. R. I., Conn., Mass.
ADOLPH SCHWARTZ, 14726 Elm Ave., Flushing, New York.

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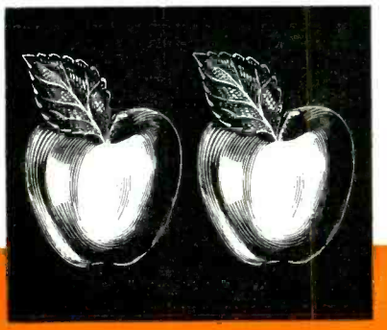
JAMES MILLAR, 316 Ninth St. N. E., Atlanta, Georgia.

Texas, La., Okla., Ark.
J. EARL SMITH, 2821 Live Oak St., Dallas, Texas.

Chicago, Illinois, Wisconsin
G. G. RYAN, 549 W. Washington Blvd., Chicago, Ill.



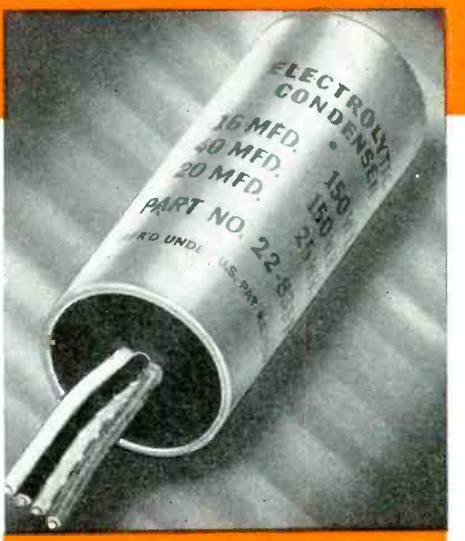
IF YOU HAVE TWO apples, they may look alike. But one can be dry and mealy, while the other gives you an extra measure of juice and goodness. It's the same with capacitors. For that *extra* measure of value, look to the hidden ingredients.

EXTRA MEASURE!

Get it every time...

READ WHY ENGINEERS SAY CORNELL-DUBILIER CAPACITORS FOR *EXTRA* SERVICE EVERY TIME

LOOKING like any other capacitors, C-Ds are different underneath. Hidden in the ingredients is an extra measure of quality. This quality accounts for the longer life, greater dependability, extra service engineers enjoy in C-Ds. You can expect extra service every time you specify Cornell-Dubilier capacitors. It's built in! . . . a product of C-D specialization — actually, extra years of capacitor experience. Next time, get the capacitor that offers you extra value at no extra cost.



Only Cornell-Dubilier Electrolytics offer all these EXTRA FEATURES!

- Special high voltage paper separator
- C-D etched plate
- Special C-D electrolyte
- Special high formation process

★

For complete technical information, write for engineering bulletin 170.

CORNELL-DUBILIER
ELECTRIC CORPORATION
1006 HAMILTON BLVD. • SO. PLAINFIELD, N. J.

REMEMBER! Only C-D union-made capacitors give you the EXTRAS at no extra cost.

Get the extras — WITH CORNELL-DUBILIER CAPACITORS!

Field Test Proves Accuracy of Clark Line Voltage Regulation

PROBLEM

¶ Maintaining voltage during final test of electric refrigeration motors.

CONDITIONS

¶ Motors have full load current of about 2½ amperes at 115 Volts.

¶ Power factor, when running, is about 60%.

¶ Starting current is about 10 to 11 times the full load running current.

¶ Power factor at starting is unknown, but must be very low.

¶ Clark Size 2 Regulator has capacity of about 25 amperes at 115 Volts, hence starting one motor is an overload on the Regulator.

¶ Under certain temperature conditions in the refrigerator, the motors can stall, giving locked rotor current for a couple of minutes before thermal devices trip and take motor off line.

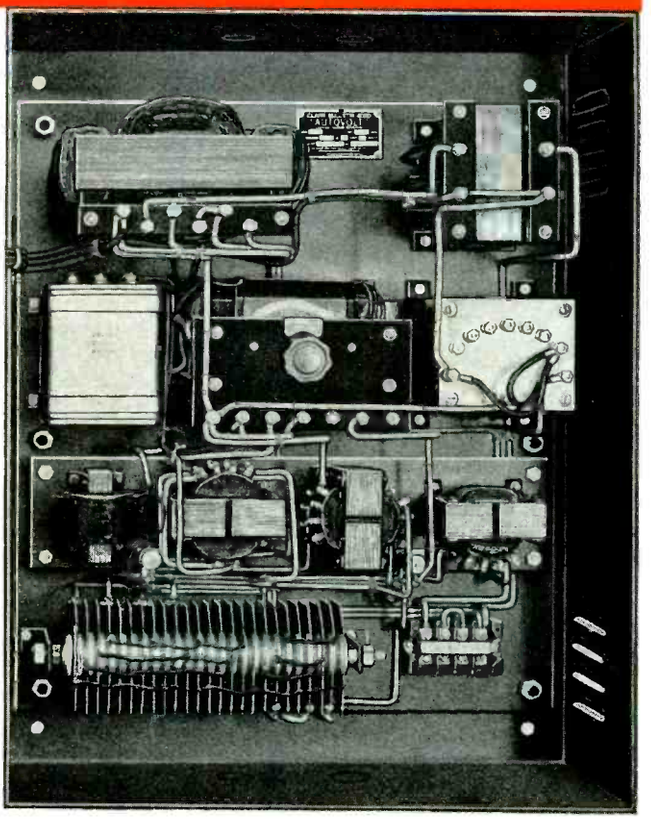
¶ Low load Power Factor is over .90, the Starting Power Factor below .30, and Running Power Factor .60.

RESULT

¶ The Clark Autovolt Regulator was adjusted to 113 Volts (correct output voltage).

¶ During starting period of one motor, output of Regulator showed very slight increase (less than one volt) then dropped to exactly 113 Volts.

¶ Regulation was maintained at low load .90 Power Factor, and at approximately 10% load .60 Power Factor, with no noticeable variation in the Voltmeter.



¶ During starting period the load was 120% at something less than .30 Power Factor, with total rise of less than 1 Volt.

YOUR INTEREST

¶ Equally fine Voltage Regulation can be obtained in your plant.

¶ Just state your voltage conditions, and "3C" engineers will gladly co-operate.

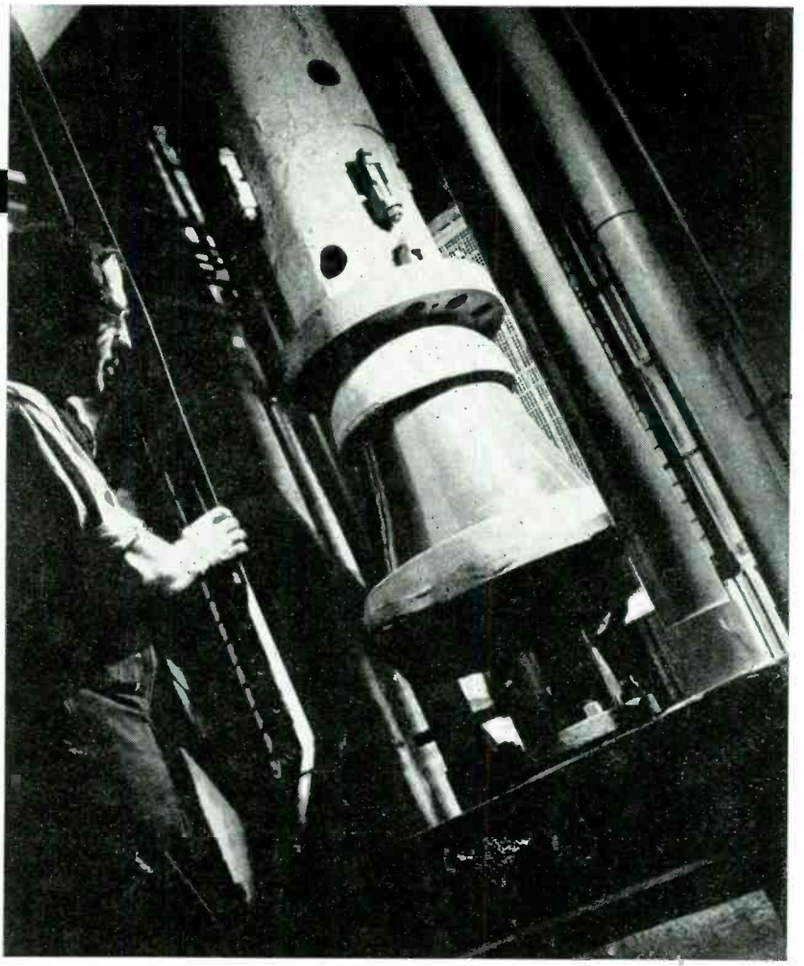
OFFICES IN PRINCIPAL CITIES

THE CLARK CONTROLLER CO.

1146 EAST 152ND ST. CLEVELAND, OHIO

THREE MILLION POUNDS

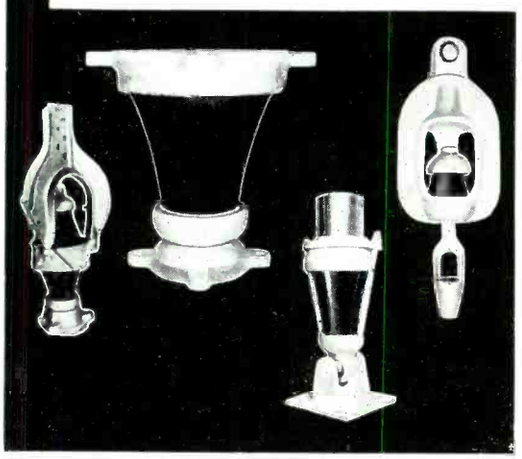
ON THIS PIECE OF PORCELAIN



. . . ALL LAPP TOWER INSULATORS INCORPORATE THE SAME ENGINEERING DESIGNS Visitors at the Lapp plant are often most amazed at this demonstration—the proof test of a porcelain base insulator with 1,500,000-lb. loading. On design test, this same unit withstood 3,000,000 lbs.

We *are* proud of a porcelain cone of two-and-a-half-inch wall thickness that will stand up under 3,000,000 lbs. of compression loading. But we don't claim any magic for it. It's merely the application of sound engineering principles in mechanical design and in porcelain production.

Back of every Lapp development is the same kind of thinking. Products for radio transmission include tower footing and guy insulators, porcelain water cooling systems and pressure gas-filled condensers. Every engineer contemplating installation of a new transmitter, or modernization of present equipment, should hear the Lapp story.



LAPP

INSULATOR CO., INC., LEROY, N. Y., U. S. A.

Introducing a New Era in Testing!

- Measures insulation leakage up to 1000 megohms.
- Measures photo-cell voltages through high resistance circuits.
- Measures sensitive relay voltages without disturbing operation.
- Ideal for measurements and tests on all types of electronic devices.
- Meter fully protected on all d-c volts and ohms measurements.

RCA JUNIOR VOLTOHMYST
Only **$34.95** *complete with leads and probes*

For the first time in instrument history, all the features listed above have been combined in a single, low-cost instrument to herald a new era in testing!

Originally designed for radio circuit testing, the RCA JUNIOR VOLTOHMYST has proved unexcelled for use in all electrical fields where extreme sensitivity, accuracy and ruggedness are important factors. It utilizes the famous Rider VoltOhmyst electronic push-pull circuit. Thus, instead of being applied directly to the circuit under test, the meter is driven by the electronic circuit which, in turn, is energized from the circuit being tested.

By this means, the high input resistance of 11,000,000 ohms can be maintained on all d-c voltage scales, giving a maximum sensitivity of 3,666,666 ohms per volt. This extreme sensitivity also allows resistance measurements from 0.1 ohm to 1000 megohms. As maximum meter driving power is limited by the capabilities of the electronic circuit, full meter protection is obtained on d-c voltage and ohms measurements. A shielded lead with an isolated probe is furnished to insure negligible circuit disturbance during d-c voltage measurements.

SPECIFICATIONS

D-C VOLTMETER . . . 6 ranges of 0-3, 10, 30, 100, 300 and 1000 volts with a constant input resistance of 11,000,000 ohms. This permits true dynamic testing under actual operating conditions. Full meter protection.

OHMMETER . . . 6 ranges of 0-1000, 10,000, 100,000, 1,000,000, 10,000,000, 1,000,000,000 ohms. No zero reset required when changing scales. No leads to short. Full meter protection. All ohms read on one scale having low end expanded for greater accuracy.

A-C VOLTMETER . . . 5 ranges of 0-10, 30, 100, 300, 1000 volts. Isolated a-c circuit uses copper oxide rectifier giving 1000 ohms per volt sensitivity.

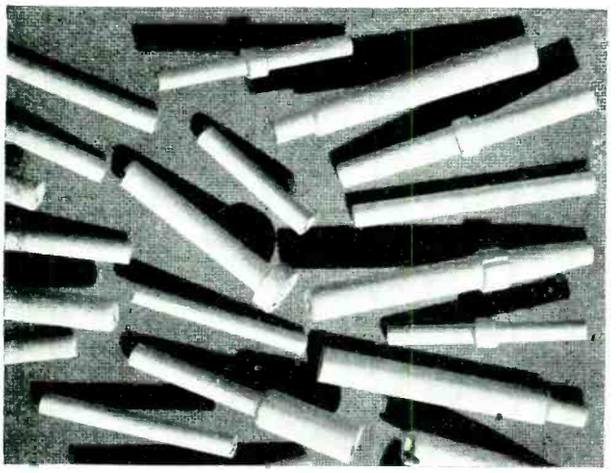
METER ACCURACY . . . 2% at full scale. Matched pair multiplier resistors accurate to 1%. Rugged meter movement; withstands mechanical shocks.

ASK FOR RCA CATALOG NO. 105—*Describes Junior VoltOhmyst, also the full line of RCA Oscillographs and Test Equipment for a wide variety of industrial needs.*

RCA Test Equipment

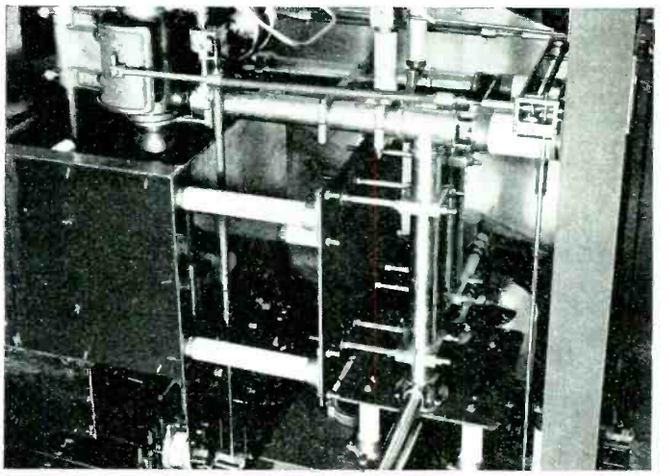
RCA PREFERRED TYPE RADIO TUBES
For Finer Radio Performance

RCA MANUFACTURING CO., INC., CAMDEN, N.J. · A service of the Radio Corporation of America
In Canada: RCA Victor Co., Ltd., Montreal

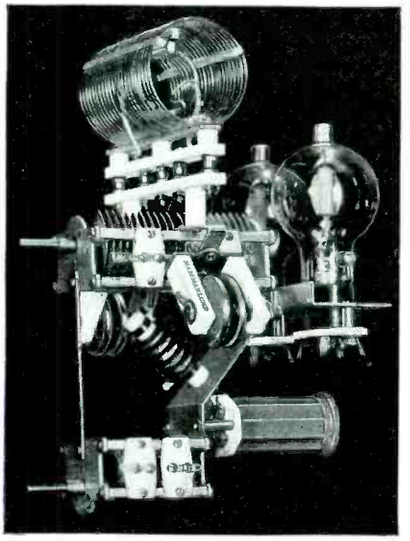


INSULATION HIGHLIGHTS

▲ OIL BURNER IGNITION offers an ideal application for Isolantite*. Its high strength minimizes risk of mechanical failure; its non-porosity and high puncture voltage offer equally important advantages from the electrical standpoint. Vitrified at high temperatures, Isolantite is impervious to oil and moisture. In addition to oil burner ignition insulators of the types illustrated, Isolantite supplies complete ignition assemblies, including electrodes, to many of the leading oil burner manufacturers.

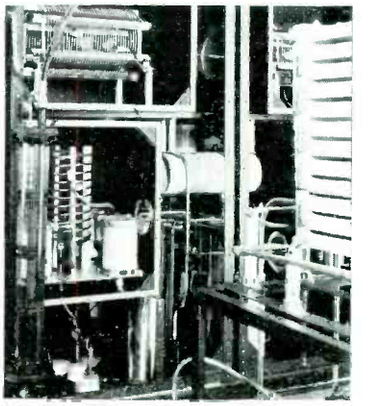


▶ IN FM, TOO, Isolantite is the logical choice. Typical instance of its use is at W1XOJ, the Yankee Network station at Paxton, Mass., which was designed and built by Radio Engineering Laboratories. Photo shows power amplifier unit, with plate lines supported by Isolantite stand-off insulators. Isolantite engineers will be glad to cooperate in solving your special insulator design problems.

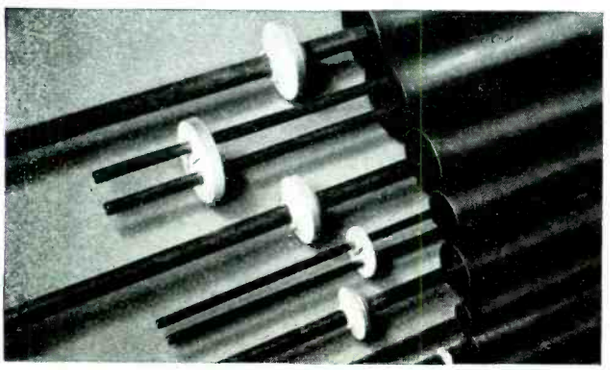


◀ LIBERAL USE OF ISOLANTITE in this Hammarlund transmitting kit is typical of its widespread application in progressive design for both amateur and commercial use. Low loss factor, high strength, and close mechanical tolerances are outstanding advantages of Isolantite, and are important factors contributing to its broad, diversified utility.

▶ VERSATILITY OF ISOLANTITE is illustrated in this photo of the Western Electric 50 kilowatt transmitter at WJSV, Washington, D. C. Stand-off insulators, coil forms, condenser insulation, notched bars for inductance supports, and lead-in insulators are standard Isolantite insulator designs adaptable to many types of equipment.



▼ TRANSMISSION LINES engineered by Isolantite are made in large and small sizes, with single or double internal conductors. Bulletins describing Isolantite's Transmission Line, solderless fittings, and accessories are available on request. Write us outlining your problem and we will send you complete information. (Isolantite Transmission Lines are sold nationally through Graybar Electric Company.)



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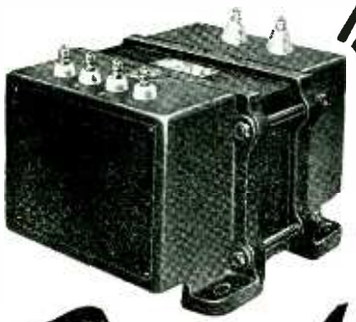

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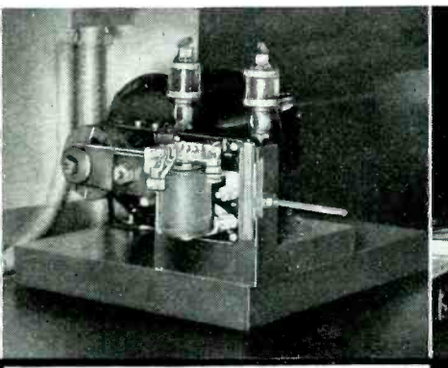

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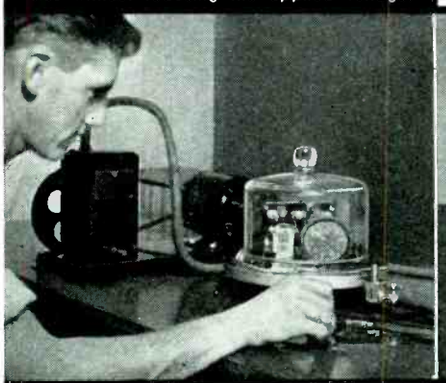

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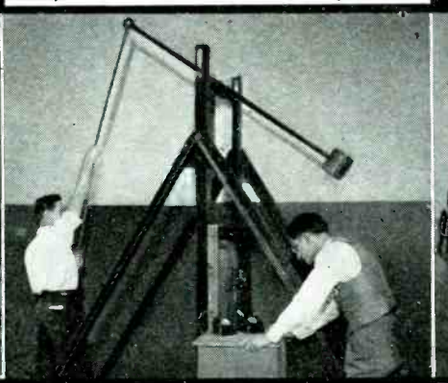

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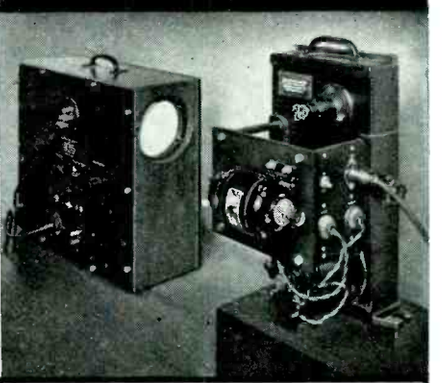

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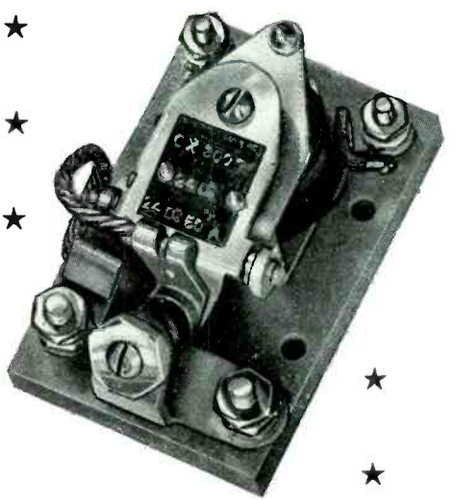

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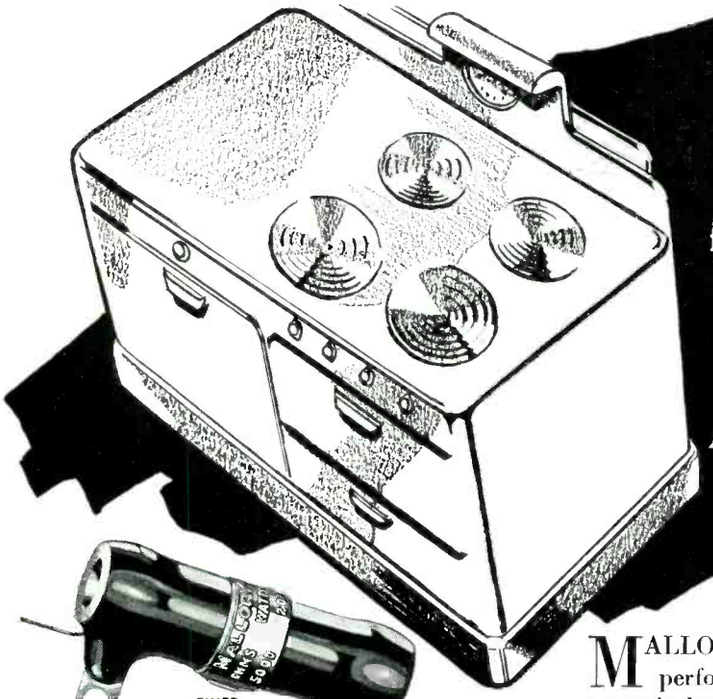

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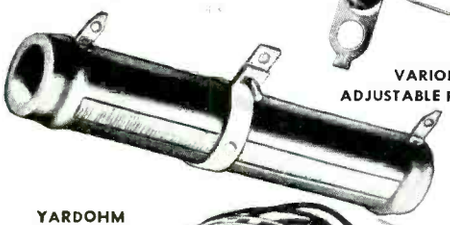

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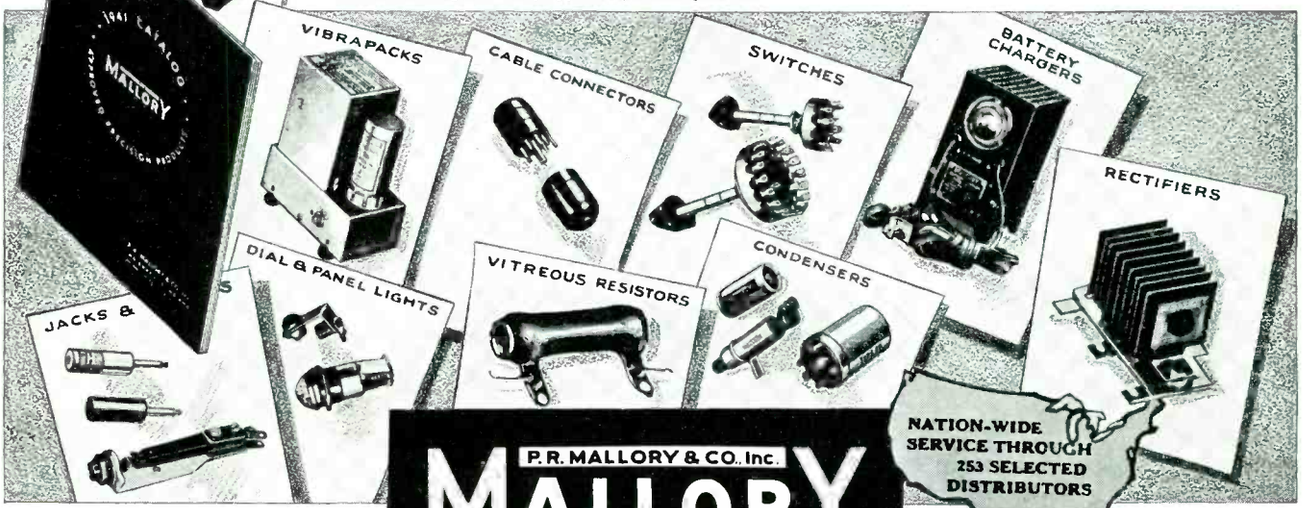

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CROSS TALK

► **ETA KAPPA NU** . . . The 1940 award of Eta Kappa Nu, honorary electrical engineering society, has been given to Jesse E. Hobson, central station engineer, Westinghouse Electric and Manufacturing company, East Pittsburgh. This award is for young engineers graduated not more than 10 years and less than 35 years of age and was inaugurated in 1936 to recognize "meritorious service in the interests of their fellowmen". In making their choice for the award, the judges pay attention to all of the candidates activities, technical, civic, social and cultural.

Two Honorary Mention Awards were given, one to Stuart G. Hight of the Bell Telephone Laboratories and one to Donald G. Fink, Managing Editor of ELECTRONICS.

Without underrating to the slightest degree Messrs. Hobson and Hight, ELECTRONICS is tremendously pleased with the award to Mr. Fink. The Award permits us to say certain things about Mr. Fink which for modesty's sake would otherwise not have appeared here. So that all of the readers of ELECTRONICS may know, we publish what Eta Kappa Nu says about him:

"Donald G. Fink entered the Massachusetts Institute of Technology in September 1929, and graduated in June 1933 with the B.S. Degree in E.E. He continued at the same institution for another year, doing graduate work in various courses in electrical engineering and physics. Since that time

Donald G. Fink

he has done graduate work at Columbia and the Stevens Institute of Technology.

"He developed an early interest in radio, having qualified for an amateur radio license at the age of 16. His interest in television began at M.I.T. where he operated a scanning disc receiver.

"His ability as an editor began at M.I.T. where he progressed through all the subordinate positions on the staff of Tech Engineering News to Editor-in-Chief.

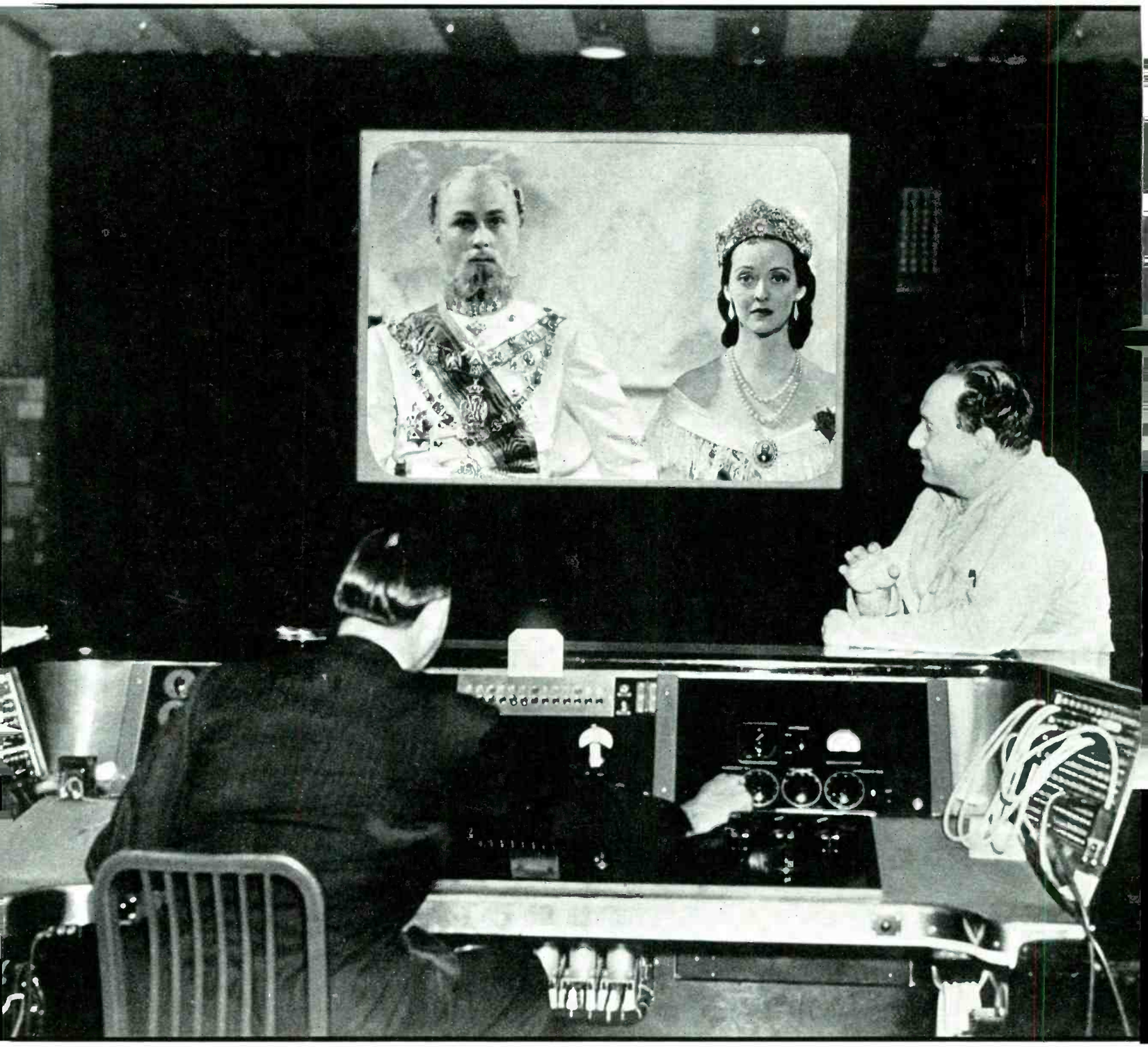
"In June 1934, he became editorial assistant on the staff of ELECTRONICS, a McGraw-Hill publication dealing with the uses of vacuum tubes in commerce and industry. In 1935, he became associate editor of the same publication, and in 1937, managing editor, which position he now holds. He has also served since 1938 as radio editor of *Aviation* magazine.

"He was co-author of a book entitled 'Neon Signs,' and has instructed evening courses in advanced electronics at the New York YMCA Technical School. He delivered a series of lectures on atomic physics and electronics to members of the engineering staff of Westinghouse Lamp Company at Bloomfield. These lectures formed the basis of a book entitled 'Engineering Electronics' published in 1938. It has been used as an introduction to the subject in 60 colleges and universities. Another series of lectures was delivered to the above group on 'The Sources and Uses of Radiant Energy.'

"In January 1940, Mr. Fink published a book entitled 'Principles of Television Engineering'. Since August 1940, Mr. Fink has served as a panel member of the National Television System Committee which is now engaged in setting up standards for commercial television transmission. He is chairman of the Publications Committee, Radio Club of America; member of the Institute of Radio Engineers, Tau Beta Pi, Sigma Xi, and Pi Delta Epsilon. In addition to his technical accomplishments, Mr. Fink has been a particularly active leader in the life of the young people in his home community."

The publishers of ELECTRONICS and his associated editors are proud of this recognition of his accomplishments.

SOUND IN



Synchronizing Sound . . . . In the production of motion pictures, the scene is photographed and the accompanying music recorded separately. Later, in the operation shown above, the two are synchronized as the sound is dubbed on the film

MOTION PICTURES

The first of two installments reviewing progress in the methods and equipment for recording sound in the motion picture industry, from its inception in 1927 to the present

By NATHAN LEVINSON

Warner Brothers Pictures, Inc.

THE sound motion picture has not yet attained such an age that many persons will have completely forgotten the thrill which they experienced at their first viewing of a talking picture. Yet in that brief span of approximately a dozen years since the "Jazz Singer" took the country by storm, the technique of sound recording for motion pictures, and the equipment and film stocks employed in the process, have enjoyed an uninterrupted and almost unbelievable degree of development. The practice of making duplicate or triplicate sound records of a scene to insure a single satisfactory finished record has long since been discontinued, and the type of action portrayed on the screen is today in no way limited in scope by restrictions imposed by the recording equipment.

The sound records of the earlier talking pictures were sixteen-inch disc records, similar in general appearance and composition to ordinary phonograph records. They were recorded at a rotational speed of 33⅓ rpm, to permit a playing time equal in length to the time required for projection of a complete reel of picture. The recording channel proper consisted of several condenser microphones and their associated amplifiers, a mixer table, booster and main recording amplifiers and a number of bridging amplifiers whose input circuits were multiplied across a "bridging bus" formed at the output of the main recording amplifier. The output circuit of each bridging amplifier was connected to the cutting head of a wax recording machine through a calibrated attenuator.

The cutting heads employed in the production of Vitaphone records exhibited a frequency-response characteristic which, for a constant input level, produced a record of constant amplitude for all frequencies in the interval between 40 and 400 cps, and a record of constant velocity in the interval between 400 and 5000 cps. The low frequency response of the cutter was reduced to avoid overloading of the record by the high-energy, low-frequency components normally present in speech and music. The cutter showed a very rapid decrease in response at frequencies above 5000 cps. The curve of Fig. 1 indicates the combined frequency-response characteristics of an early wax recording head and an early disc reproducer head.

The original records were cut on soft wax blanks whose surface had been brought to a high degree of polish by the use of sapphire shaving knives. The production of a good record required the use of a freshly shaven wax blank whose temperature was held within rather narrow limits to prevent smearing or chipping of the wax during recording. The novelty and uncertainty injected in the production of motion pictures by the advent of sound made it necessary to provide means for the director of a picture to check the character of the sound record immediately upon completion of the shooting of each scene. Therefore playback reproducers were provided which permitted reproduction of the record cut in the soft wax. Records which had been so reproduced were, of course, unsuitable for later processing and for this reason, it was necessary to cut two or three records of each scene photographed.

At the completion of shooting and editing of a picture it was necessary to combine the individual recordings of each scene which appeared in the finished picture in such a manner that the single record associated with each reel of the picture would contain just that dialogue, music, and sound effects necessary for the scenes appearing in that reel. The process of combining a number of original recordings of dialogue, music, and sound effects into a single final record is known as "dubbing", or "rerecording". The difficulty of selecting a few words or sentences from a number of individual disc records and combining these in proper order and in exact synchronism with the action taking place on the screen presented no small problem. In fact, the difficulties of this process of selection and combination were so great that only one of the Hollywood studios, Warner Bros., was ever equipped to rerecord from disc records on a large scale.

Nor were the troubles encountered in disc recording ended when the final records for a picture had been completed. The maintenance of synchronism between picture and sound in the theater was dependent upon accurately placing the theater reproducer at the start mark on the record and simultaneously placing the picture start mark in the picture gate of the projector. If the picture film was torn during projection and had to be spliced, it

was necessary to remove one or more frames of the picture from the reel and consequently at each splice in a reel, synchronism between picture and sound was destroyed by an increasing amount. Since the picture and sound record were separate, it was not an unusual occurence to find the record corresponding to one reel of a picture being reproduced with a different reel of that picture. While this may have tended to create audience diversion during the screening of a dull picture, it helped in no way to maintain the dignity of the theater management. Furthermore, after a certain number of playings the records exhibited a very pronounced loss of quality and often became extremely noisy. All of these factors tended to detract materially from the technical and entertainment values of a picture and were responsible in no small measure for the change from disc recording to sound-on-film recording.

Recording on Film

The recording channel employed for producing the early film sound track was practically identical to that employed for producing disc records. The signal output of the bridging amplifiers was merely delivered to the film recording machine instead of to the wax cutting head. While differing in many details, all film recording machines provide a light-tight housing in which the film is exposed, magazines for the unexposed and exposed stock, means for moving the film at a uniform rate of speed past a light beam which exposes the film in accordance with the waveform to be recorded, the light source, modulator unit and optical system. The combined frequency-response characteristic of an early film recording machine and an early film reproducer is shown in Fig. 2.

The sound track produced on film varies in width from 76 to approximately 100 mils and occupies a position adjacent to one set of the film sprocket holes. All track may be broadly classified as being of either the variable density type or variable area type and each possesses certain advantages and disadvantages not possessed by the other. Two methods of producing variable density track were employed during the early period of film recording. In the first, typified by the Aeo-light recording at one time extensively employed by the Fox Studios, the signal to be recorded modulated the light produced by a gaseous discharge tube and the resultant variable intensity illumination was photographed on the uniformly moving film in the recording machine after being passed through a very narrow fixed slit. The second and more widely used method of producing variable density track involves modulating a beam of constant intensity light by means of a light valve and photographing the illuminated variable width slit formed by the light valve ribbons on the moving film. This type of record subjects each point on the sound track to an exposure of constant intensity, but of a duration determined by the character of the signal being recorded.

Variable area track is produced by permitting the light from a constant intensity source to strike the mirror of a galvanometer, and after reflection therefrom, to pass through a narrow slit of fixed width, through a suitable optical system and then upon the sound track being exposed. Oscillations of the galvanometer mirror, which are produced by signal currents corresponding to the sound to be recorded, cause the light beam striking the recording slit to illuminate a greater or lesser length of that slit. The sound track resulting by this process of recording is essentially an oscillographic trace of the signal currents.

Although the average early sound-on-film records were little, if any, better from a quality standpoint than the disc records which they replaced, they so facilitated the production, editing, and projection of sound pictures that by 1931 practically all sound recording was being done on film. Editing the sound record of the finished picture was tremendously simplified, since the process of intercutting various sound track sequences presented no greater problems than intercutting the corresponding picture sequences. This, of course, resulted in enormously simplifying the process of rerecording. It was now only necessary to provide reels of properly intercut dialogue and properly intercut reels of music and sound effects and to rerecord these in synchronism with the picture to provide a single reel

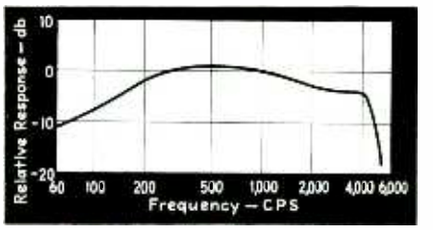


Fig. 1—Frequency response characteristic of typical early wax recorder and reproducer heads

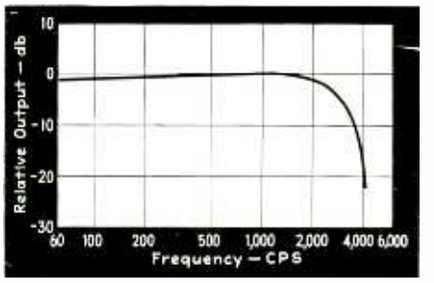


Fig. 2—Frequency response characteristic of an early film recorder and film reproducer

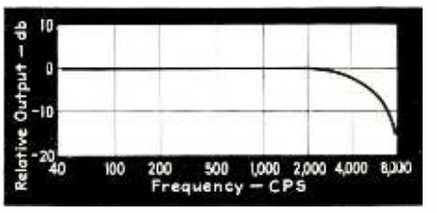


Fig. 3—Frequency response characteristic of a modern film recorder and film reproducer

or final negative. Film recording provided other advantages, however, which were scarcely less valuable than the improvement possible in rerecording methods. Unlike the requirements in wax recording where many precautions were necessary, the film recording machine could be placed at a considerable angle and be used through a wide range of temperatures with no change in quality of the finished record. The light valves or galvanometers, once properly adjusted, are comparatively rugged devices and require much less frequent inspection and maintenance than wax cutting heads. Perhaps the only single outstanding advantage of wax over film records lies in the fact that the wax record may be immediately played back for checking purposes, whereas some interval of time must elapse between the recording process and the time at which completely processed prints

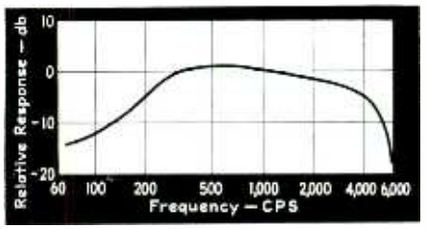


Fig. 4—Frequency response characterictic of an early theater loudspeaker system

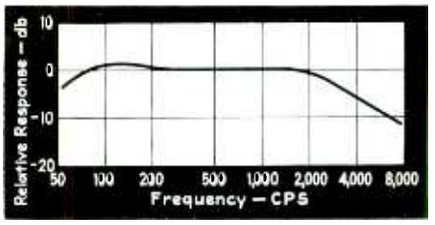


Fig. 5—Frequency response characteristic of a modern theater woofer-tweeter loudspeaker system

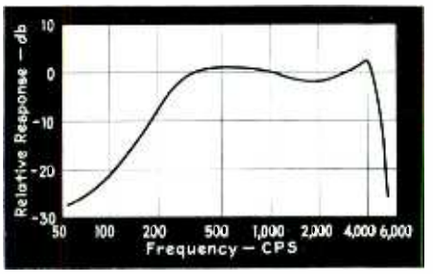


Fig. 6—Overall frequency response characteristic of an early wax recording and reproducing system, including microphones and speakers

from the film record are available.

The introduction of acetate disc recording early in 1934 effectively supplemented film recording by providing playback records of much greater useful life than soft wax records and having the further advantage of possessing more desirable physical properties than wax. Continuous improvements in acetate disc coating, as well as improved designs of cutting heads and reproducers now make it possible to produce acetate records which are almost equal to high quality film recordings.

Playback records are no longer employed for checking the recording of individual scenes of a picture, but find their greatest application for reproduction, on the set, of music which has been pre-recorded for certain scenes of a picture. The process of pre-recording is employed primarily as a means of saving time on the set for such scenes of a picture which involve the photography of action which must be accurately synchronized with the musical score. For example, during the production of elaborate musical numbers involving complicated dance routines, straightforward production technique would demand that the director of the picture divide his attention between the action proper, the performance of the orchestra employed, and the degree of synchronism maintained by the various groups involved in the complete scene being photographed. A flawless performance on the part of the actors could be rendered worthless by a slight error on the part of some member of the orchestra, while a perfectly performed musical score might be rendered valueless by imperfect synchronisation or action on the part of the principals appearing in the scene. It is obvious that the difficulty involved in securing a completely satisfactory record of such a scene is greatly increased by the number of the performing groups. The process of pre-recording the musical score for such scenes in a picture and reproducing these records on the set while the action is being photographed relieves the director of all concern regarding the orchestral performance, and permits both the director and the principals involved to concentrate their attention on securing a perfect performance. Since the record may be reproduced a number of times with the same results, the scene may be reenacted until a perfect performance is secured. The motors employed for driving the playback reproducer and the camera on the set are electrically interlocked, so absolute synchronism between the photographic and sound records is assured.

During the early period of film recording, the quality of the records produced was very much inferior to that of present day sound track, and it is interesting to consider in some detail the numerous improvements in recording equipment, technique, and materials which have made possible the present type of high fidelity recording.

The variable density type of record is essentially a half-tone photograph of the recorded sound wave. It will be evident, therefore, that undistorted reproduction of a variable density record can only be obtained when the entire range of exposures are restricted to the straight line portions of the H & D characteristics of the films employed, and when the over-all gamma of the print sound track, as appreciated by the phototube in the sound reproducing mechanism, is equal to unity. Although the science of sensitometry was well developed long before the advent of the sound picture, little use had been made of it in the processing of motion picture films, and the sudden demand made upon the laboratory for proper processing of sound track necessitated an over night revision of processing control methods. While it was possible for an experienced person to judge the quality of a picture negative by inspection with sufficient accuracy for practical purposes, this method was wholly inadequate for the determination of proper sound

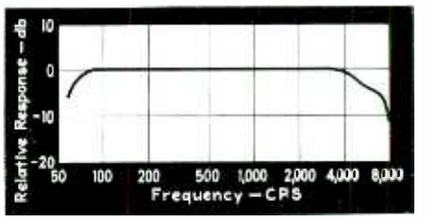


Fig. 7—Overall frequency response characteristic of a modern scoring channel plus a modern theater reproducing system, including microphone and speakers

track processing, and had to give way to accurate sensitometric control of both negative and print development. The introduction of the Eastman type II-B sensitometer in 1931 was of great value in the study of sound track processing, since it provided a means of accurately and consistently impressing a series of known exposures on the film whose characteristics were under investigation. So powerful a tool did sensitometric control provide that within a few years after its introduction for sound track purposes, it was almost exclusively employed for the control of both sound track and picture processing in the laboratory. As a result of this step, the degree of uniformity and general print quality prevailing throughout the motion picture industry today, is almost unbelievably higher than that existing in 1930.

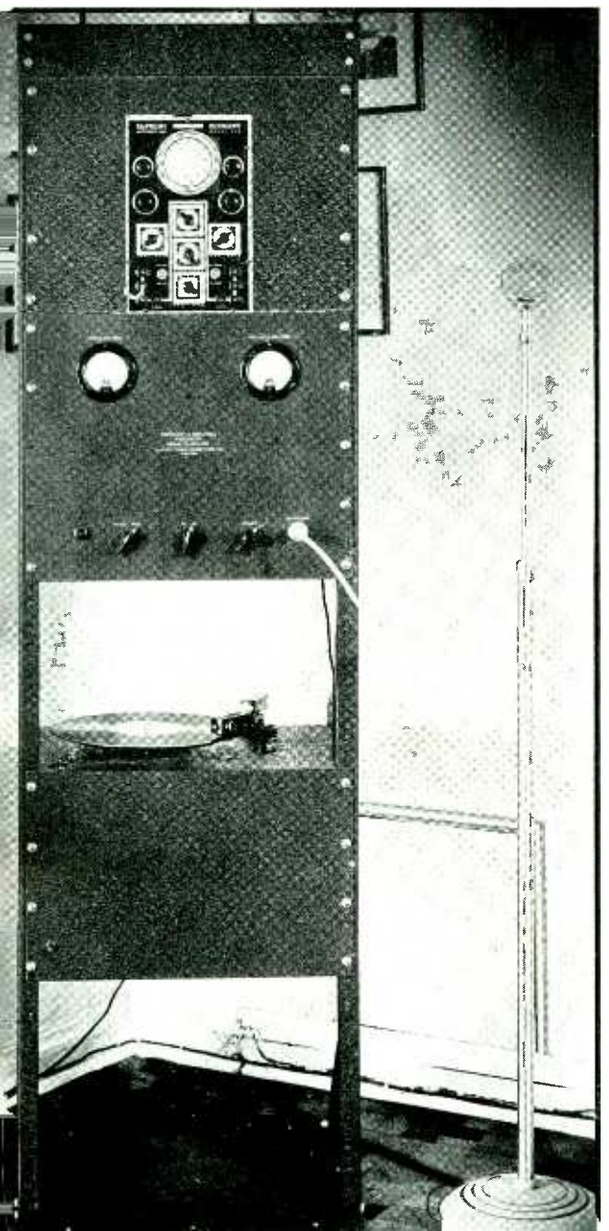
(*Continued on page* 73)

A Low-Power Transmitter for Demonstrating F-M Receivers

Because high fidelity programs are not available at all times on f-m stations at present, engineers of E. H. Scott Laboratories have built a demonstration system with which they can test and demonstrate f-m receivers

By MARVIN HOBBS
E. H. Scott Radio Laboratories, Inc.

THE operation of experimental wideband frequency-modulation transmitters during the past year has given ample proof of the superior audio quality which can be provided with freedom from background noises within the service area of the station. However, through practical necessity many of these f-m stations have not provided a continuous service of program material capable of demonstrating the improved quality possible from the greater range of high audio frequencies. In some cases a large percentage of the programs have been carried by telephone lines of relatively limited frequency range and in other instances most of the material has been derived from transcriptions. While the latter type of program has provided some degree of high fidelity, it is only in the direct studio pickups that an approach to the capabilities of the system has been made.



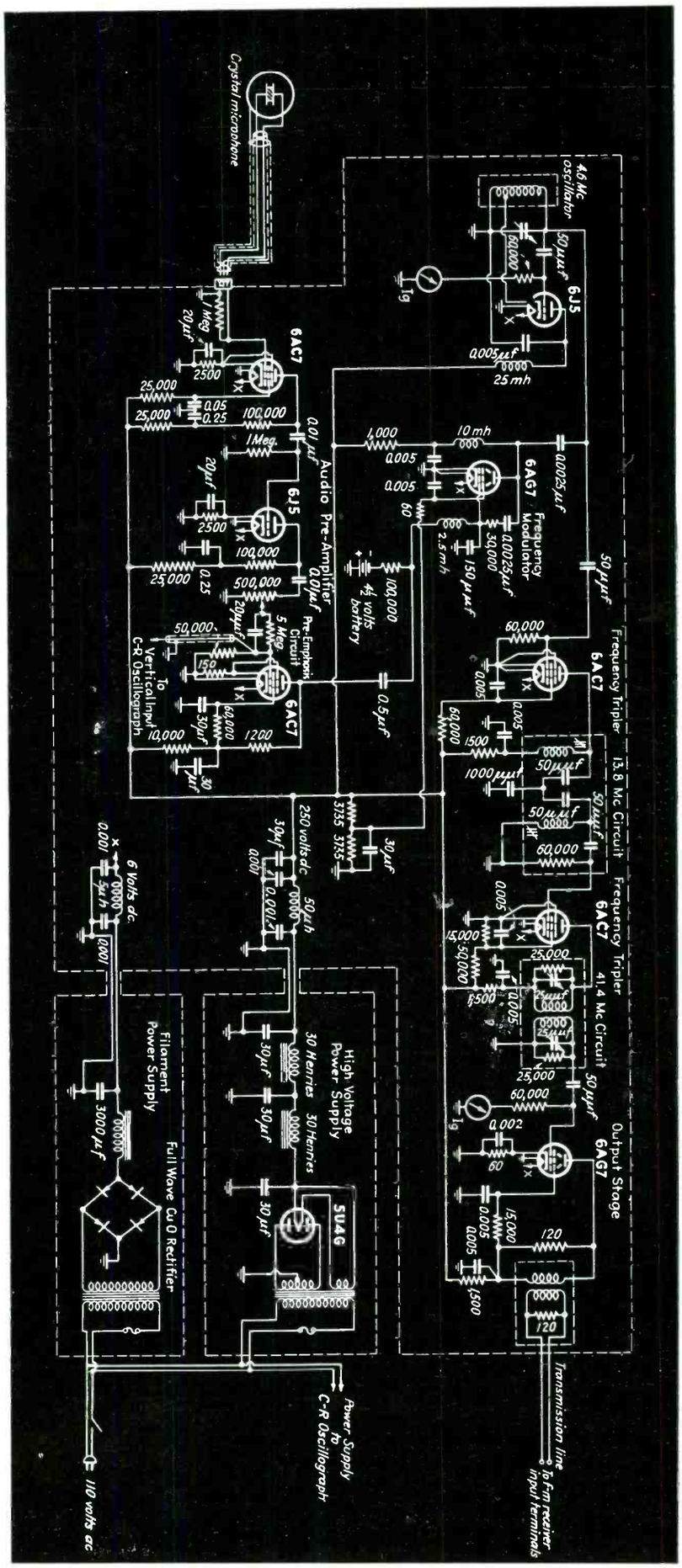
Several f-m demonstration systems similar to the equipment described in this article have been constructed at the E. H. Scott laboratories for the purpose of providing high quality program material, regardless of the availability of regular programs. This equipment has already proved to be of great value and will continue to be for some time to come because it allows complete flexibility in demonstrating receivers.

The basic material for this system consists of a high fidelity microphone and audio preamplifier followed by a linear frequency modulating circuit, a stable oscillator, cascaded frequency multiplying stages, and a means for coupling the output signal to the receivers. The audio and r-f circuits of this system have been built into one unit and have been assembled in a rack and panel arrangement with the separate filament and high voltage power supplies, cathode ray oscillograph equipment and a phonograph turntable, as shown in Fig. 1. This unit may be classified as a signal generator or perhaps more appropriately as a miniature f-m transmitter because of its fixed output level and its fixed central frequency. While provision for an a-m signal at 600 kc was made in the equipment shown here, this feature was not included in all of the systems and is not shown in the circuit diagram. Also the phonograph turntable was omitted on most of the systems, because a good demonstration can be made only with high fidelity transcriptions whose frequency range is much greater than commercial recordings ordinarily available.

Fig. 1—Complete audio and f-m radio frequency facilities are incorporated in this rack mounted unit

As shown in Fig. 2 the r-f signal is generated at a relatively low frequency by a 6J5 oscillator and is frequency modulated by a 6AG7 reactance control tube in a variable inductance circuit. Two frequency tripler stages bring the output signal up to 41.4 Mc and another 6AG7 tube feeds it into a low impedance transmission line which matches the antenna input circuit of the f-m receivers. The basic frequency modulator circuit and tripler tube arrangement were suggested by Mr. D. E. Foster of the R.C.A. License Laboratories. No variable output attenuator is provided, because the signal is treated simply as though it was being received from a local station and no useful purpose would

Fig. 2—Circuit diagram of the audio and f-m radio sections of the demonstration equipment. The modulated oscillator generates a frequency of 4.6 Mc which is tripled twice to the carrier frequency of 41.4 Mc



be achieved by varying its level during a high fidelity demonstration. Since a signal of 5,000 to 10,000 microvolts represents an average f-m signal within the metropolitan service area of a transmitter a level of that order is very suitable for demonstrating noise free high fidelity, although much stronger or much weaker signals will serve the purpose equally well. The basic consideration in this respect is that the f-m carrier-to-noise ratio should be such that a signal-to-noise ratio of at least 60 db is obtained at the receiver output terminals.

The following conditions were found to be essential to the proper operation of these units.

(1) Overall fidelity should be a maximum from the microphone to the loudspeaker of the receiver inclusive.

(2) The correct degree of high audio frequency pre-emphasis should be provided.

(3) Frequency modulation should be linear at all audio frequencies up to and including ± 75 kc.

(4) Microphonism and noise in the modulating tubes should be at a minimum.

(5) The system should be free from hum pickup in the audio and microphone circuits and from hum modulation at the oscillator of the signal generator or the receiver.

(6) The center frequency, as affected by the parameters of either the oscillator or the frequency modulator, should be reasonably stable.

(7) The system should be free from amplitude modulation.

Fidelity and Noise Considerations

In Fig. 3 the frequency response characteristics of the microphone and the loudspeaker system are plotted together and in Fig. 4 these two characteristics are combined with similar data for the complete electrical system from the audio input at the signal generator to the output transformer of the receiver. Although these responses are shown up to 10,000 cps only, listening tests indicate that they hold up well for several thousand cycles beyond this

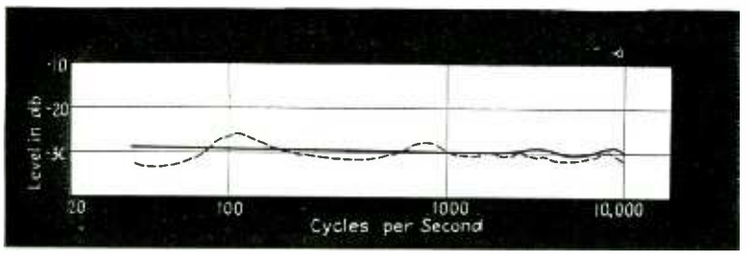


Fig. 3—Frequency characteristics of microphone and loudspeaker system

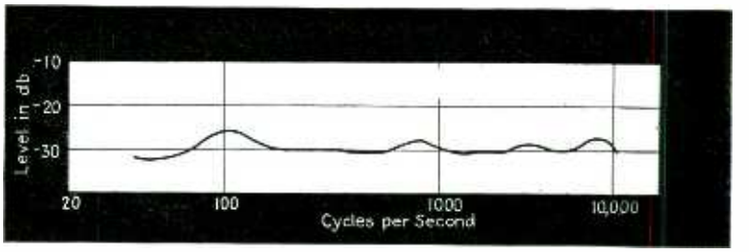


Fig. 4—Overall frequency characteristic of microphone, electrical system and loudspeaker

point. It is apparent that insofar as audible response is concerned the quality performance of this system is comparable with that which may be expected from commercial f-m transmitters using present day audio equipment. The characteristics of the studio are not presented here because this equipment has of necessity been operated under various acoustical conditions, although an effort has been made wherever possible to make an approach to a properly treated studio. However, when comparing actual sounds with those which are reproduced by the loudspeaker it is well to bear in mind that both the transmitting and receiving studios may have a marked effect upon the apparent fidelity.

The audio frequency pre-emphasis circuit, which consists of the parallel combination of a 20 $\mu\mu$f condenser and a 5-megohm resistor in series with a 50,000-ohm resistor in the grid circuit of the 2nd 6AC7 audio amplifier, provides a convenient means of adjusting the overall electrical fidelity and the audio voltage available for modulation. All of the receivers with which this equipment has been used have incorporated audio de-emphasis circuits of the correct time constant to compensate for the pre-emphasis at the transmitter as specified by the F.C.C. standards. Therefore, it was necessary for the pre-emphasis circuit in our demonstration equipment to correct for the receiver de-emphasis and also to make up for any other frequency deficiencies. While this correction might be carried to almost any degree empirically, it appears to be more satisfactory to use high fidelity audio equipment having practically a flat response from 50 to 15,000 cps because of the gain lost by the pre-emphasis circuit. Under these conditions, if the process of modulation can be accomplished without a loss of high frequencies, the degree of pre-emphasis required at the transmitter is of the order which might be expected to compensate for the de-emphasis at the receiver. In the circuit of Fig. 2 the low value of plate load resistor in the second 6AC7 audio circuit ahead of the modulator tube avoids any loss of high frequencies due to the capacity in the modulator grid circuit.

The greatest possibility for unsatisfactory results with a demonstration system of this type rests with the frequency modulator stage. If any appreciable distortion is produced at this point, the quality of the output will be greatly affected and the audible effects will be very noticeable because of the wide frequency capabilities of the system. The 6AG7 tube operates very well in this respect when properly biased and provides linear modulation over an ample range. Cathode ray oscillograph observations of the wave form of the audio output of the receiver, when various audio frequencies are applied to the audio input of the signal generator, reveal that the sinusoidal wave shape is maintained throughout the frequency range. However, because of the pre-emphasis circuit, overloading for the high audio frequencies of equal voltage occurs at much lower levels than for the low audio frequencies. The cathode ray oscillograph provides a convenient means of observing the level of modulation without introducing any distortion of the audio wave form.

To avoid distortion it is also important that the plate circuits of the 13.8 Mc and 41.4 Mc frequency triplers be capable of accepting with a minimum of attenuation the modulated frequency spectrum, which is a total of 50 kc wide in the first tripler stage and a total of 150 kc wide in the second tripler. The circuits tuned to 13.8 Mc are capacitively coupled by a 1000 $\mu\mu$f condenser common to the two fixed condensers, providing a degree of overcoupling which allows the desired bandpass. The inductances of this circuit are tuned by means of brass cores. The coils of the 41.4 Mc circuits, which do not lend themselves so well to capacitive coupling because of lead inductances, are placed about $\frac{1}{4}$ inch apart on a common form to provide the required degree of overcoupling. These circuits are tuned by 25 $\mu\mu$f air dielectric trimmers. Additional loading of 25,000 ohms was added on the plate and grid sides to flatten the response characteristic.

It was found that the 6AC7 tubes and the 6AG7 modulator tube quite often exhibited microphonism and a quiet condition was obtained only by mounting each of these tubes on rubber cushioned sockets and also by selecting the quietest tubes of a given lot. A 6AC7 was used in preference to a 6J7 in the first audio stage following the microphone in order to obtain a considerably better signal-to-noise ratio, which is due largely to the operating condition of low plate current and high mutual conductance. By using this tube many weak sounds, which were completely masked by the first audio tube noise when using the 6J7, could be heard with a fairly good signal-to-noise ratio. It is probable that a still better signal-to-noise ratio could be obtained by using a high g_m triode as the first tube and by adding additional stages to bring the audio gain up to the desired level. The only other defect of the 6AC7 for this purpose, other than microphonism, is a type of transient tube noise of a broken character. This condition was also remedied by selecting quiet tubes, which could be found by going through a lot of six or more. In the quietest con-

dition it was found that the overall signal-to-noise ratio of the system was determined largely by the first audio tube, which seems to be a common characteristic of some f-m transmitters now on the air.

The Power Supplies

The hum problem is so closely associated with the power supply that the two may be discussed simultaneously. In the first model of this equipment an attempt was made to operate the filaments, plates and screens from a common power supply with ac applied to the filaments. However, after a few listening tests it appeared far better to keep all leads having any 60 cps potential completely removed from the audio section of the unit. Also, since there was some possibility of hum modulation due to ac on the filaments of the frequency modulator or oscillator, it was decided to use dc for all of the filaments, except that of the rectifier in the high voltage supply. The filament voltage is obtained from a copper oxide rectifier and is filtered in a conventional manner as shown in Fig. 2. By locating the ac "on-off" switch near the power supplies, there is no necessity to bring any leads from the ac line near the microphone cable or audio system.

The high voltage power supply is well filtered with a dual section inductance-capacity filter and each plate and screen circuit which showed any tendency to be affected by hum voltage was filtered by resistance-capacity combinations. Both power supplies are mounted considerably below the microphone and audio circuits to eliminate induction effects from the chokes and power transformers. As an added precaution the microphone cable has been double shielded to prevent pickup from stray hum fields.

It will be noted that an r-f filter has been inserted in both the high voltage and filament leads entering the chassis from the power supplies. These networks prevent r-f energy from feeding into the power supply cables and radiating through the ac line.

Frequency Stability

The power supplies also have a considerable influence on the frequency stability of a signal generator of this type. It was found that there was very little drift due to the components of the oscillator stage itself when the modulating circuit was completely disconnected from it. However, when the control tube was properly connected and in operation, any variations in the line voltage had a marked effect upon the oscillator central frequency. As the line voltage varied slightly, the potentials of the 6AG7 changed, causing a temporary surge of frequency modulation. It was apparent that this condition could be remedied by providing a voltage regulated power supply which would completely regulate the filament, grid, screen and plate voltages of the control tube.

However, it was found to be sufficient for our purpose to reduce the *L-C* ratio of the oscillator circuit to the point where it was just possible to obtain a $\pm$ 8.33 kc linear deviation, which after two stages of tripling resulted in a net modulation deviation of $\pm$ 75 kc. With the audio signal available and by supplying the bias of the control tube with a 4½ volt C battery, it was possible to reduce the frequency fluctuations to a point where no audible effects were produced, although they were still detectable with a discriminator meter. A certain amount of long period drift was present, due, apparently, to a variation in the mutual conductance of the oscillator and modulator tube and possibly some heating effect. However, this drift is of little consequence in our demonstration work, because it is not sufficient to produce audible effects and if correct tuning is desired the receiver can be retuned after a few minutes of operation. It is apparent that the degree of frequency stability required for a simple f-m demonstration system is not comparable with that required by a commercial transmitter.

Operation of the System and Studio Technique

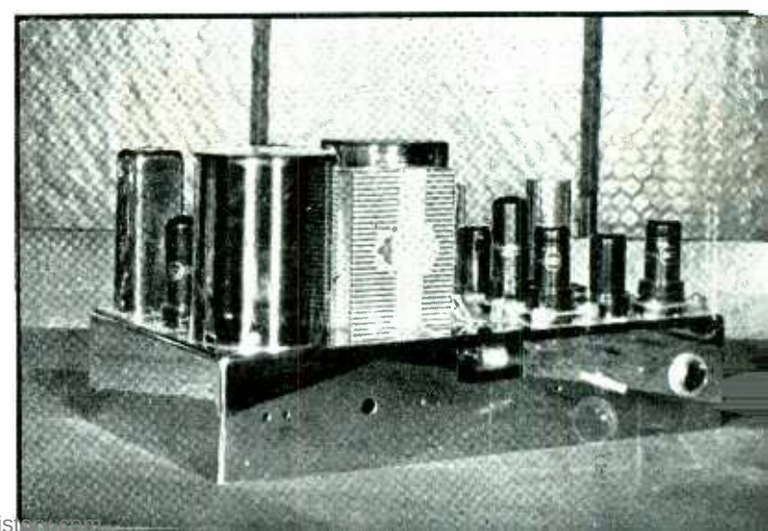
To avoid acoustical feedback it is necessary to locate the signal generator and the microphone in one studio and the receivers in another. The signal is fed by means of a low impedance transmission line, which is connected directly to the antenna terminals of the receivers to avoid radiation. Close proximity of the listening and transmitting facilities allows the listener to compare the actual sounds with those reproduced by the loudspeaker by passing from one studio to the other. An important point to observe in locating the signal generator and microphone is to provide either a sound proof studio or a quiet location. Outside noises or machinery vibration within the building can produce a sufficient background to mask any noise free characteristics.

Several instruments and sound producing devices capable of generating a wide band of frequencies or a series of relatively pure tones

(*Continued on page 86*)

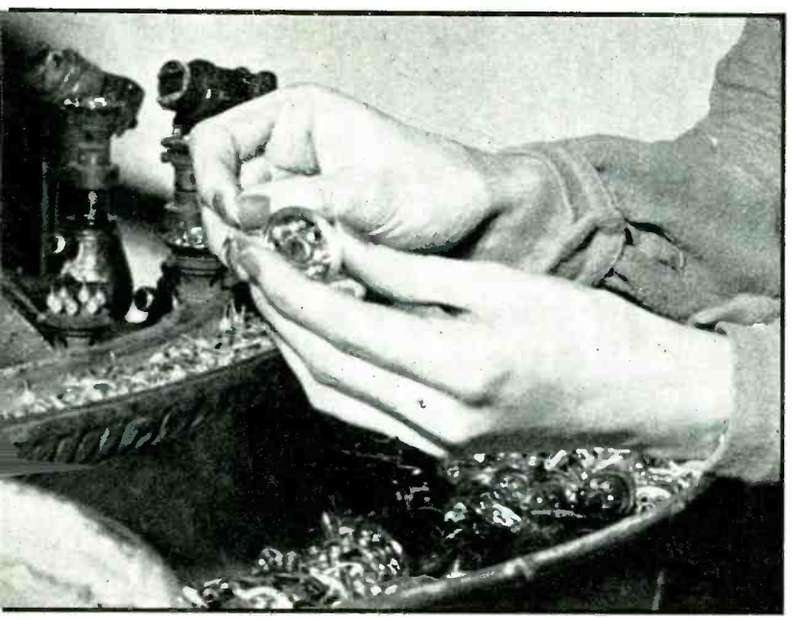
Fig. 5—Power supply which contains a high voltage supply and a CuO rectifier for the tube heaters

Fig. 6—The audio amplifier, modulating, circuit, and high frequency circuits are contained on this chassis



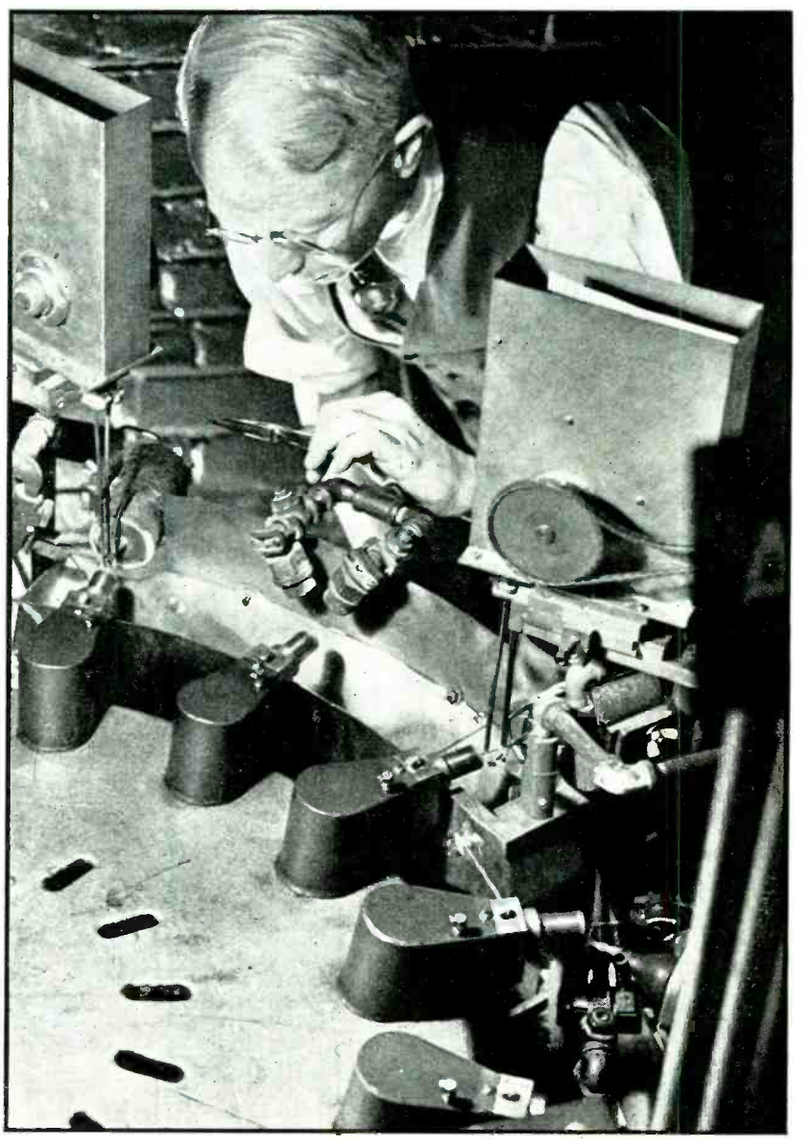
Bell-Jar Exhaust—A New Metal Tube Production Technique

Considerable reduction in material and production costs may result from the radical re-design of the metal tube, plus a simpler and faster method of exhaust and sealing, developed by General Electric engineers in the laboratories at Schenectady and now under production tests



2 (Above) The lead-wire prongs, with the glass beads, are fitted into the iron header and heated until the glass forms a perfect insulating seal between wire and header. A new glass, matching the thermal expansion of ordinary iron, was developed for the beads

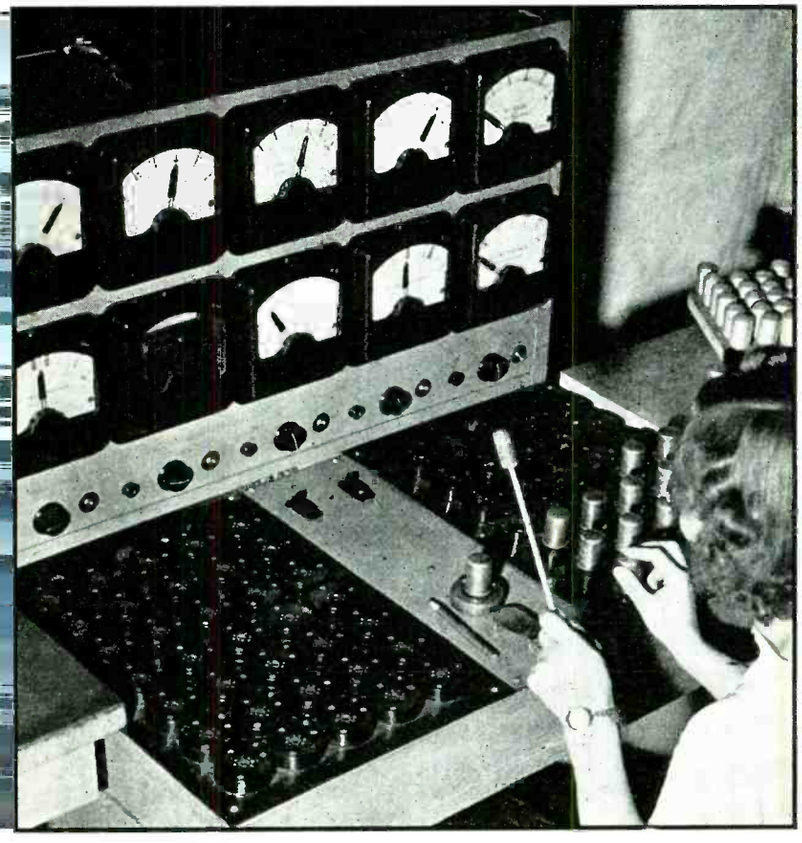
3 (Below) The element structure, the same as used in conventional metal tubes, is then mounted on the prong wires and the metal shell placed over it. The whole assembly is then placed under a bell jar for pumping

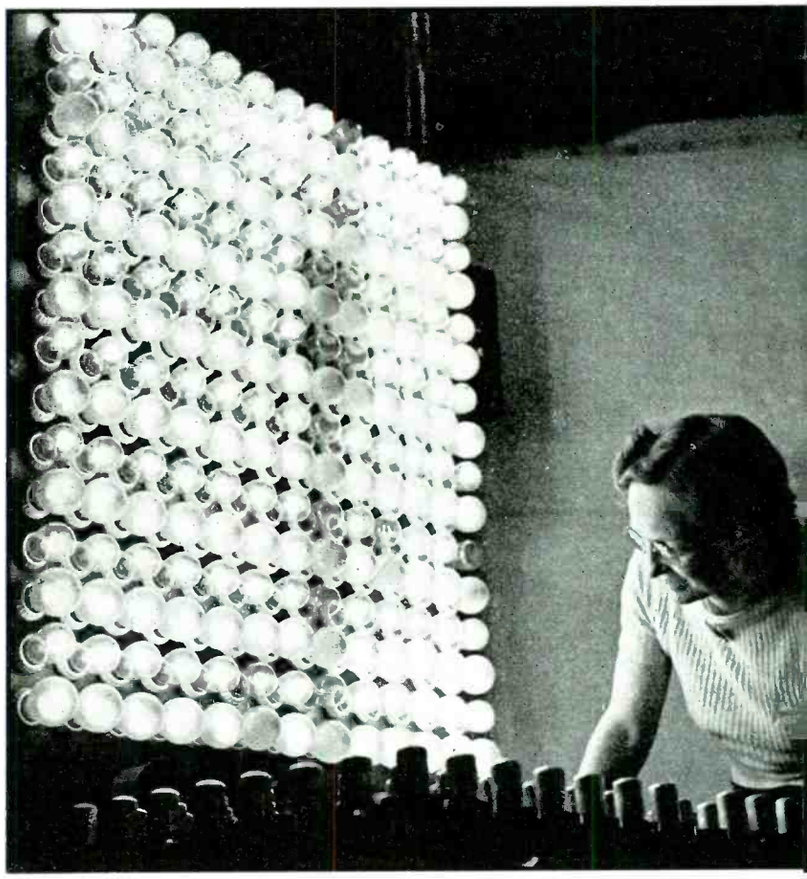


1 (Above) The header of the new tube contains glass beads as lead insulation. Here the lead wires (which serve also as the terminal prongs) are fed into revolving spindles. After each wire is heated, powdered glass drops on it, melts and deposits as a bead on the wire

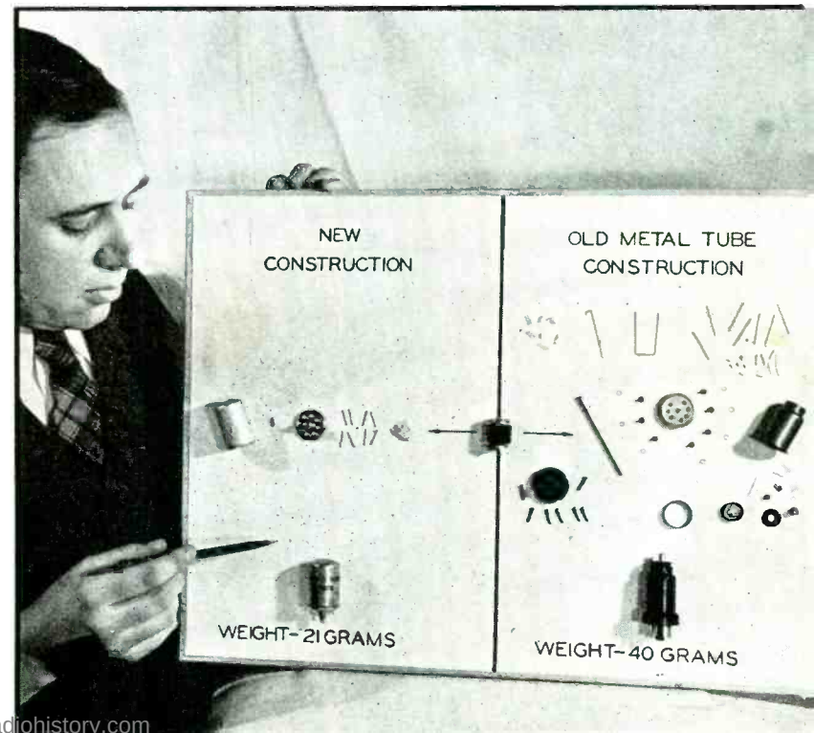
4 (Left) Here the bell jars have been lowered in position. During exhaust the metal envelope is suspended by an electromagnet, allowing the exhaust to occur through the opening between header and shell. The exhaust tubulation is thus eliminated, and pumping speed greatly increased. The reentrant glass cup (third from left) contains liquid air to trap moisture during exhaust. When the exhaust is complete the shell drops onto the header and molten solder seals the gap

5 (Right) After completion of the exhaust, the tubes are aged 20 minutes in this rack at varying over-voltage and over-current conditions. By watching the lamps, the operator can tell the condition of each tube during the aging period





6 (Left) The characteristic check, not unlike that given to conventional metal tubes, includes tests for heater current, gas current, screen and plate current, noise and microphonics. The new tubes are not commercially available but several thousand test samples are now in operation in radio receivers



7 (Right) The simplicity of the new tube structure, compared with a double-ended conventional metal tube of the same type. The same element structure is used in both tubes. J. E. Beggs, at left, played an outstanding part in the development of the new tube, as well as in that of the older metal tube

Loudspeaker

By JOHN K. HILLIARD

Sound Department, Metro-Goldwyn-Mayer Pictures

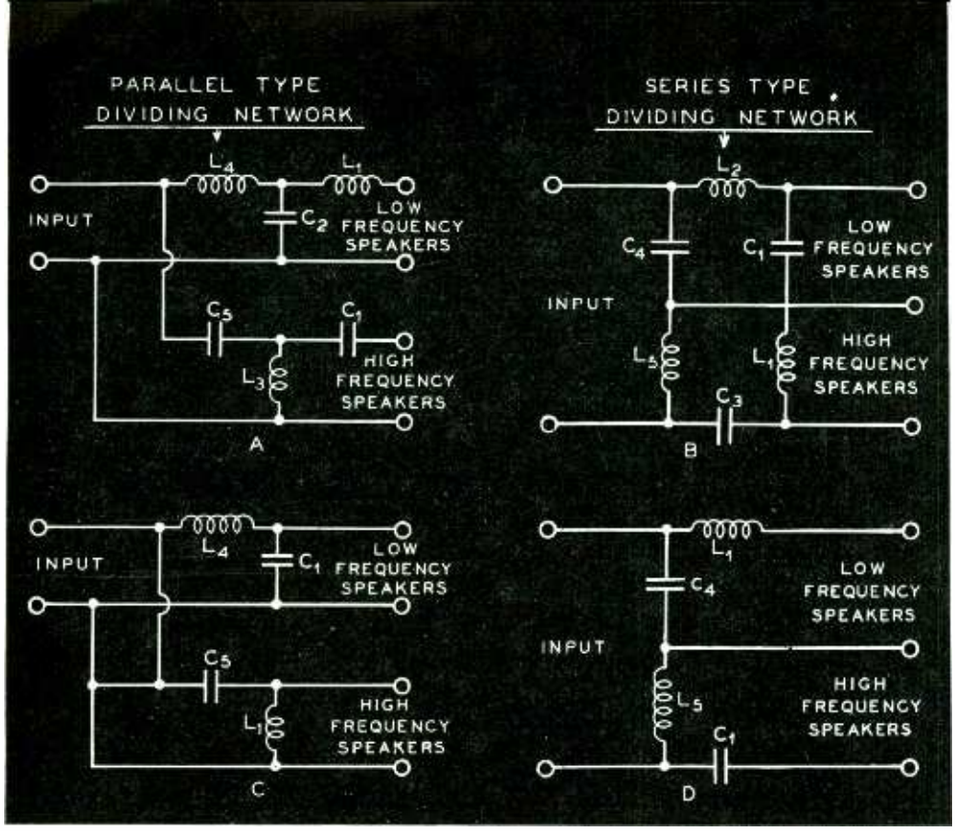


Fig. 1—Parallel and series dividing networks made up of full-section (top) and half-section elements

THE demand for extremely high quality reproduction of sound has created several gradual changes in the design of loudspeakers and their associated equipment. The complexity of the apparatus depends upon the efficiency of the electro-mechanical system, the amount of acoustic power to be radiated, the frequency ranges to be covered, and especially the solid angle through which uniform distribution of sound quality is to be obtained.

In order to satisfy these requirements, the most satisfactory solution to date has been by the use of a two-way system where the frequency range is divided into two parts and one or more loudspeakers are utilized for each of the frequences ranges. The speakers employed are, of course, radically different from each other in design, each unit being particularly suitable for its own intended range. It is not possible to design speakers easily which will efficiently and faithfully reproduce frequencies in one band and provide sharp attenuation for those frequencies outside of the desired band. For this reason it is necessary to supply an electrical network somewhere in the system so that each set of loud speakers will have transmitted to it the correct frequency band. These networks have been commonly known as "dividing networks". Usually the dividing network is placed between the output transformer and the voice-coils of the speakers. The designs given in this article are intended for this type of operation.

The crossover frequency, the frequency at which the power is to be separated between the two bands of frequencies, is governed by several factors. If the frequency is too low, the high frequency unit and horn must also be of comparatively large size which defeats the purpose of the two-way system. On the other hand, if the crossover frequency is too high, there is danger of running into characteristic decrease in response which appears in large cone speakers. Where economy in cost and space is the most important factor, a fairly high crossover should be utilized (approximately 800 cps), whereas a more optimum cross-over for best all around considerations may be in the vicinity of 400 to 500 cps.

Characteristics of Dividing Networks

A dividing network should be chosen which gives fairly rapid attenuation beyond the cutoff point in order to keep any appreciable low frequency energy out of the high frequency unit and to minimize the effect of irregularities due to peaks which exist beyond the crossover frequency.

From an analysis of large numbers of speaker systems, it appears that dividing networks should provide at least 12 db attenuation one octave away from their cut-off. Attenuation of more than 18 db per octave is not necessary or desirable because of the increased losses in the transmitting range and the cost of the additional filtering which would be employed.

The two-way dividing network consists of a low pass filter and a high pass filter designed to operate from a common source at their input terminals. Two general methods are in use, connecting the filters in series or parallel to their input terminals. These two types of networks are (1) the filter method and

TABLE I — DESIGN FORMULAS FOR FIG 1.

$L_1 = \frac{R_o}{\omega_c}$	henries	$C_1 = \frac{1}{\omega_c R_o}$	farads
$L_2 = \frac{2R_o}{\omega_c}$	henries	$C_2 = \frac{2}{\omega_c R_o}$	farads
$L_3 = \frac{R_o}{2\omega_c}$	henries	$C_3 = \frac{1}{2\omega_c R_o}$	farads
$L_4 = (1+m)\frac{R_o}{\omega_c}$	henries	$C_4 = (1+m)\frac{1}{\omega_c R_o}$	farads
$L_5 = \frac{1}{1+m}\frac{R_o}{\omega_c}$	henries	$C_5 = \frac{1}{1+m}\frac{1}{\omega_c R_o}$	farads

Dividing Networks

The current emphasis on high-fidelity reproduction of sound has given the woofer-tweeter combination new prominence. Hence this practical design procedure for frequency-dividing networks, of the low-loss inductance-capacity type should be of interest to engineers in the audio-frequency field

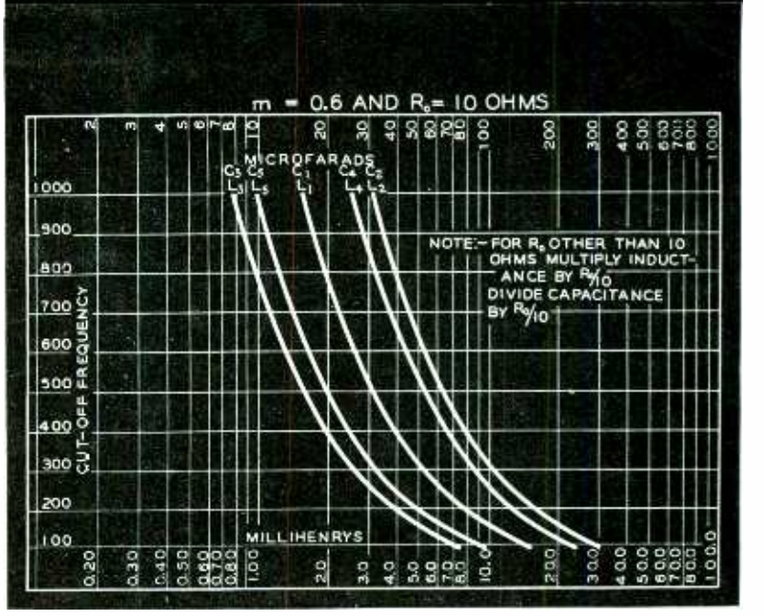


Fig. 2—Graphical data for selecting the L and C elements of the dividing networks in Fig. 1, in terms of the cross-over frequency, assuming a ten-ohm voice-coil impedance

(2) the constant resistance method. Different design methods are used for the two types. The filter method is more commonly used because it is somewhat more flexible. Hence it will be discussed first.

In arranging a lowpass and a highpass filter for series or parallel operation, it is only necessary to employ special design methods in connection with the first half sections in each of the filters. The remaining sections of the filters are designed in accordance with conventional filter practice. For the first half filter sections, *m*-derived types are used. The filters having mid-shunt terminals for parallel operation and mid-series termination for series operation. The number of sections depends upon the rate of attenuation desired in the suppressed frequency bands. Where it is desired to secure an attenuation rate of change of about 18 db per octave one filter section is sufficient. Where a rate of change of about 12 db per octave is satisfactory, half sections can be used.

Figure 1 shows four dividing networks units, two of which are parallel types and the other two series types. Network *A* is secured by the use of a basic type "T" full section of the parallel type, a low pass section being used for the low frequency side and a high pass section for the high frequency side. Network *B* is obtained by the use of π-type low pass and high pass sections with the series type circuit. Networks *C* and *D* are secured in the same manner, except that "L" type low pass and high pass sections are used.

Constant Resistance Networks

A constant resistance dividing network is one whose resistance at the input terminal is constant with change of frequency for the proper resistance loads at the output terminals (see Fig. 3). The constant resistance networks can only be designed for 6 or 12 db per octave and for this reason can only be used in these specific cases. However in the large majority of cases, 12 db per octave is used and these networks can be utilized. One of the features of this design is that in the manufacture of the networks the inductance coils are all of the same value, as are all the capacitors. The parallel method such as Fig. 3D is extensively used. Figure 4 shows the data for these networks for various crossover frequencies.

In preparing the curves it was assumed that the coils and condensers were nonresistive. In practice where the component electrical elements contained some resistance, the curves will be slightly different, especially in the crossover range which in some cases has the effect of shifting the crossover slightly away from the theorectical cut-off point. The added resistance also consumes power in the transmission band and where this loss is an important item, the resistance should be as low as possible.

For instance, in a 100-watt system, 1 db loss in transmission through the corresponds to a reduction of available power to about 79 watts dividing network since 1 db = 10 log (100/79). Ordinarily

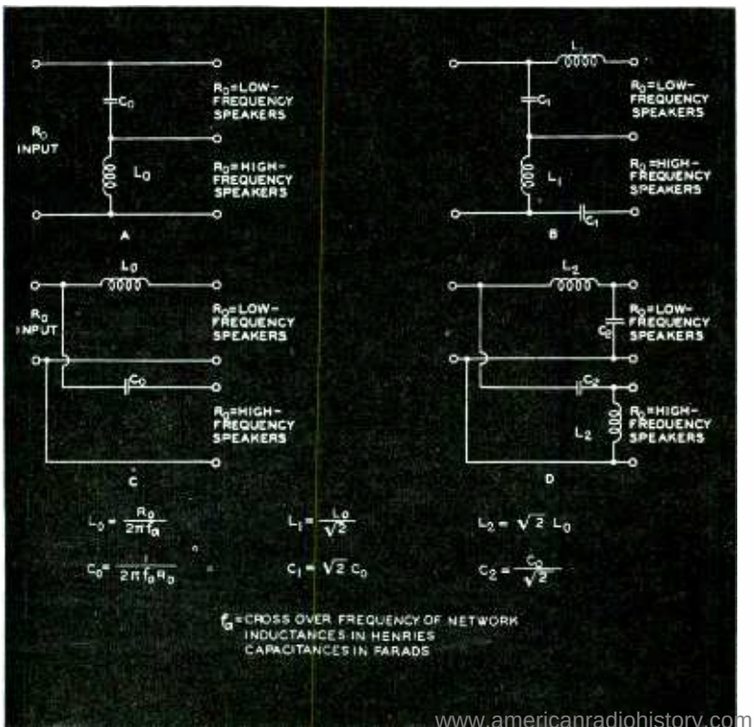


Fig. 3—Simple constant-resistance networks and design equations, limited to 6 or 12 db attenuation per octave outside the pass region

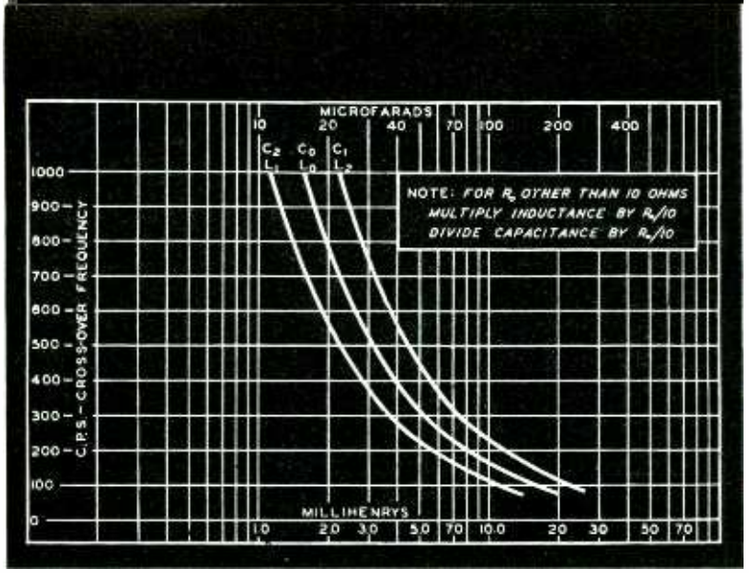


Fig. 4—Graphical data for selecting the L and C elements of the constant resistance dividing network, in terms of the cross-over frequency

the loss can be reduced to about 0.5 db which is about as low as commercially practical. The impedance obtained at the input terminals of the dividing network in Fig. 2 varies from network to network. In general the impedance of any of the corresponding series and a parallel type are inverse to each other. In practice where the speakers are arranged in series parallel combinations to give load resistances as closely as possible to R_o ohms at the high and low range output terminals, the input impedance will not adhere strictly to the image (or reflected) impedance characteristics. However the shape of the attenuation curve is changed very little and for this reason it is usually neglected in design data. Usually the low frequency dynamic speakers have a mechanical anti-resonance at frequencies below 100 cps. This results in the low frequency speakers having a relatively high input impedance at the lower frequencies. For this reason in some cases more uniform overall attenuation results have been secured in connection with low frequency loudspeaker units by using dividing networks of the series type.

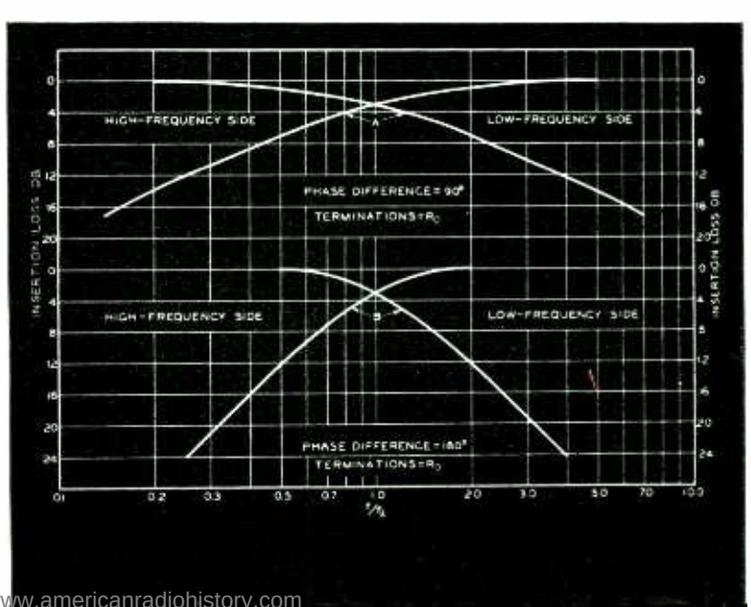
The location of the dividing network in the circuit varies, depending upon the type of system and emergency precautions required. As previously stated, it is customary to place the dividing network between the power amplifier and speaker. This is done primarily to eliminate the need for more than one power amplifier. Where more than one power amplifier is available, the dividing network can be placed ahead of these amplifiers and as a result the network can be considerably smaller in size due to the fact that less power is transmitted by it. In this setup a more favorable impedance characteristic can some times be maintained throughout the frequency range. However, where an accurate balance between high and low frequency units should be maintained, care must be taken to determine that these amplifiers maintain constant gain at all times and with the use of inverse feedback, undoubtedly this condition can be easily maintained. In this connection where it is desirable to radiate more low frequency power than in a balanced setup, more power from several amplifiers in parallel can be used in the low frequency branch.

In well designed two-way horn systems, in most cases it will be found that the distortion present in the system ahead of the speaker is sufficiently great so that a low pass filter will be required to cut off the higher harmonics. This is particularly true in systems which are designed to reproduce records, signals from radio transmitters which are overmodulated or otherwise distorted. These low pass filters are usually constructed so that considerable attenuation takes place above 8000 cps, depending upon the amount of distortion present.

It has been found that only in the highest grade of sound reproducing channels or radio transmission systems can these units be operated without some attenuation at the higher frequencies and this fact must not be overlooked if the best results are to be obtained.

In the design of the two-way loudspeaker system and network, the load impedance is made approximately 2½ to 3 times greater than the source impedance (power amplifier output impedance). For instance, if the individual impedance of the high and low frequency units are each 10 ohms, best results are achieved by operating from a 4 ohm power amplifier impedance (output transformer secondary). The improvement from this method of operation is derived from the damping action caused by the low impedance of the power amplifier transmitted through the network which shunts the loud speakers to a comparatively low value in order that very little counter emf is developed across the terminals. The low impedance also tends to maintain a constant velocity radiation regardless of impedance change of the speaker. The performance of the network is changed only slightly by this unsymmetrical impedance at both ends and can be disregarded up to a 3 to 1 ratio. The network is designed on the basis of the loudspeaker impedance and not the source impedance.

Fig. 5—Curves showing the insertion loss for 90 degree and 180 degree phase difference (6 db per octave and 12 db per octave respectively)



Control Circuits for Industry

Applications of the gas tetrode, type 2050 or 2051, to a variety of time delay and phototube relay circuits, plus a description of their uses in controlling injection molding machinery, printing presses, bells in a church tower, laundry air-doffers and washing machines. Written from extensive experience in the field

By GILBERT SMILEY
General Control Company

THE growing application of electronic devices to industrial problems represents a field of endeavor too often neglected by the engineer and engineering student to whom electronics signifies the radio and allied fields alone. Electronic devices for industry must be sharply differentiated from present radio practice. While price is, naturally, a consideration, the industrial electronics engineer must realize that ordinary cheap radio parts have no place in industrial controls. Industrial equipment, and particularly automatic machinery, imposes requirements vastly more exacting than those of the home radio receiving set. Failure of the receiving set may annoy the family, but failure of a process machine may tie up a whole plant. Couple with this the fact that industrial service is continuous for one, two or even three shifts a day, five or six days per week, year in and year out, and it is obviously foolish to attempt to use inferior or doubtful equipment.

Industrial service also imposes design factors that do not exist in radio receiver practice. Temperature, extreme vibration conditions, exposure to blows and rough handling are all considerations of design that the broadcast receiver manufacturers need barely consider, but which to the industrial electronics engineer, may spell success or failure. Ease and speed of replacement and repair, simplicity and reliability of design, conservative operation and the ability to take punishment must be the qualities engineered into industrial electronic devices.

Control of Plastic Molding

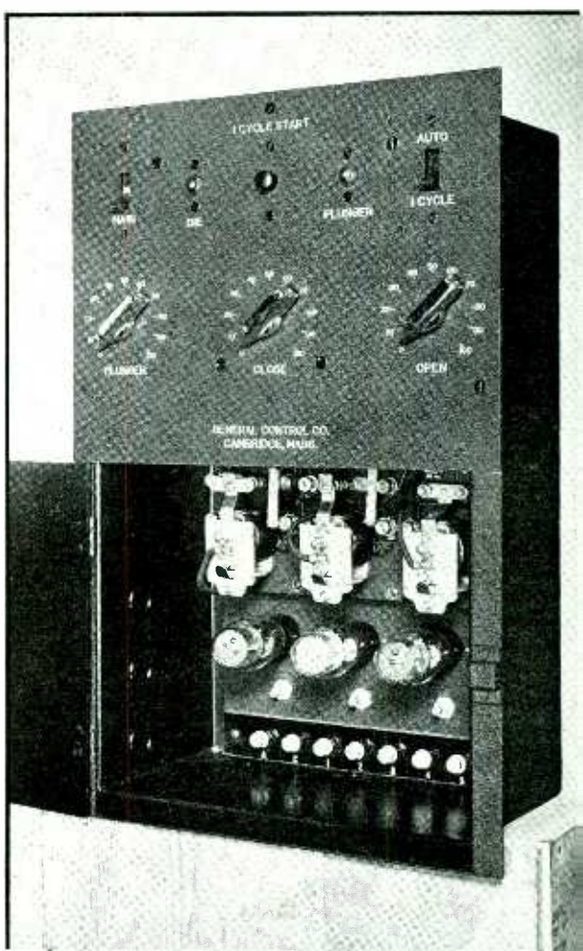
The rapid growth of the plastics industry and the keen competition in this field has stimulated a demand for accurate and reliable control equipment, particularly for injection molding machines in which all phases of the molding cycle must be accurately maintained if a uniform and satisfactory product is to be secured.

Injection molding machines consist of a separable die or mold into which the plastic is injected under pressure after being plasticized by passing through a heating chamber. To secure flow of the plastic into the often intricate recesses of the die, considerable pressure is required. As a rule the die is closed by a hydraulic cylinder operating through a mechanical toggle that locks it shut under very high pressure. The injection plunger, also hydraulically operated, then picks up a measured "charge" of granular plastic, forces it under great pressure into the heating chamber and forcing an equal quantity of already heated and plasticized material through a nozzle and system of gates into the die cavities. The injection plunger then "dwells," keeping the plastic in the water cooled die under pressure during the primary cooling period to prevent excessive shrinkage. To facilitate ejection some slight shrinkage is desirable, so at the termination of the plunger dwell there is a further period of die dwell, after which the die opens and the piece or pieces are ejected. Some further time is then required to complete the plasticization of the charges in the heating chamber, after which the die recloses and the cycle repeats. Thus the complete cycle consists of die closure, plunger advance, plunger dwell, die dwell, and die open period.

Since the molding press is hydraulically operated, control is best effected through solenoid valves operating on the hydraulic system. The solenoid valves are, in turn, controlled by the electronic timing device. Such a timing device is shown in the accompanying illustration and the circuit is given in Fig. 1. Most of the units supplied have been for 230 volt 50 or 60 cps operation. Hence the 2051 gas tetrode was used, as this voltage does not exceed its ratings. To follow the circuit it is best to refer to Fig. 2 which illustrates the simple elementary timing circuit employed.

As shown, the device is reduced to

External appearance of the molding-machine control equipment shown in Fig. 1



its simplest working components. With a source of alternating current connected to L_1 and L_2, the tube heater will be energized by the transformer, T, and rectification will occur in the grid-cathode circuit. As a result, a charge of the indicated polarity will accumulate in C. When the switch is closed the cathode is directly connected to L_1 and the full line voltage is applied to the plate-cathode circuit. However, the grid is biased negative by the charge accumulated in C, which charge effectively blocks space current until sufficient time has passed for the charge to be dissipated through R.

As a matter of fact, the grid-cathode voltage at any instant is composed of an alternating voltage, the magnitude of which is a function of the position of the slider on V, and the voltage across C. T is connected so that, when L_2 is positive with respect to L_1, point B is negative, consequently, movement of the slider toward B increases the negative component of grid alternating voltage when L_2 is positive. Since the tube will "fire" or ionize only when L_2 is positive, the adjustment of the slider on V permits a considerable reduction in the component of grid voltage supplied by C in order to prevent ionization of the tube. Since the time cycle between closing the switch and the instant when the total grid voltage falls to a point permitting space current is expressed by the equation:

$$t = RC \ \ln\frac{E}{E_t}$$

it is obvious that t may be increased by decreasing E_t, other factors being the same. Since E_t is the voltage across C, which may be reduced by moving the V slider towards B, the maximum time period may be adjusted by this slider. E is across C when the switch is closed. Thus, if a maximum time period of, say, two minutes is required, approximate values of R and C are selected and the slider is set to yield two minutes with R at a maximum. R is then varied to secure time intervals between zero and the selected maximum. The phasing of the transformer to make B negative with L_2 positive is used instead of the opposite phasing as it tends to reduce the magnitude of R and C.

The tube fires at the expiration of the time period and supplies the load, L, (which may be a relay) with rectified alternating current within the limitations of the tube, if the constants of L are suitably selected. L remains energized until the switch disconnects K from L_1, at which instant L is deenergized and C starts to be recharged. By properly proportioning C, R, D, and F, recharging of C requires but a few cycles, after which the cycle may be repeated. Resistor D is included to limit grid current during the charge period and during "firing." The screen serves a dual purpose as it increases the control factor (about 100 in the 2050–2051 as compared with 10 in the 884–885) and also takes the brunt of the ion discharge during firing, protecting the cathode and grid, whose functions are more electronic than ionic because of this construction. The resistor F is simply to connect K to L_2.

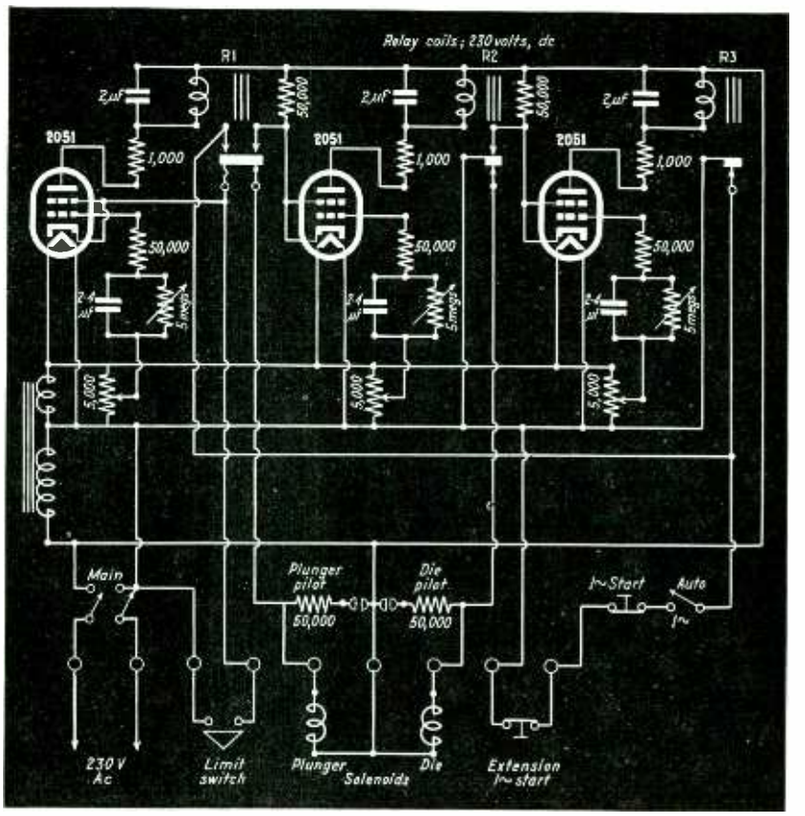


Fig. 1—Time control circuit for an injection molding machine, based on three R-C delay circuits using gas-tetrode relay tubes

Returning to Fig. 1, in the light of the foregoing discussion it can be seen that the circuit consists, essentially, of three units such as the one shown in Fig. 2. In the injection molder cycle, after allowing the tubes to warm up the action is as follows:

1. Unit as shown with a-c switch closed, die solenoid closed through R_2. Die advances.

2. Die closes fully at which point the limit switch closes energizing the plunger solenoid, advancing the plunger and starting the time cycle of the left hand tube.

3. Left hand tube times out, operating R_1, deenergizing plunger solenoid after suitable dwell, returning plunger, establishing a shunt circuit around limit switch through R_1–R_3 and starting cycle of the center tube.

4. Center tube times out, operating R_2, deenergizing die solenoid, opening die and limit switch (now safely shunted) and starting time cycle of right hand tube.

5. Right hand tube times out operating R_3, destroying shunt circuit, recycling left hand tube and deenergizing R_1 which action recycles center tube and R_2, which, in turn, energizes the die solenoid, starting a new complete cycle and, simultaneously, recycles the right hand tube and R_3.

When the "auto-1 cycle" switch is closed the timing out of the right hand tube does not destroy the shunt and all three units remain timed out with relays energized. Pushing

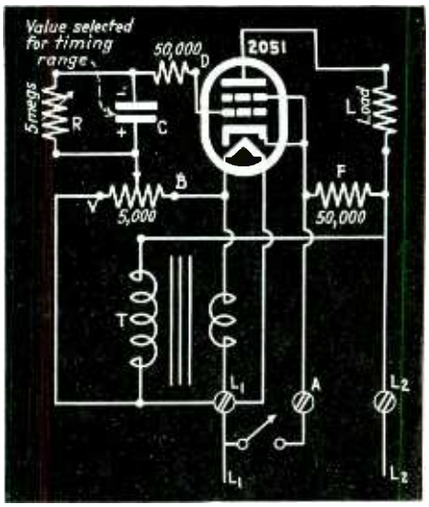


Fig. 2—Basic time-delay circuit. The delay interval is controlled by the size of the *R* and *C* elements and by setting of the potentiometer *V*

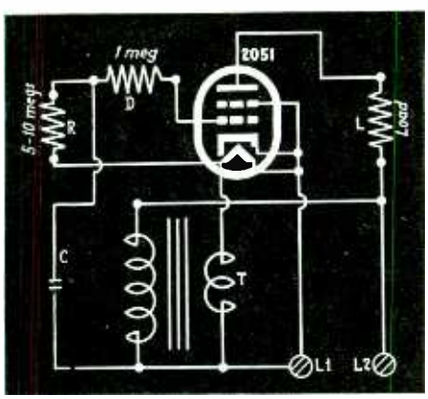


Fig. 3—Non-delay relay circuit for controlling an electromechanical relay from a high-impedance control circuit

either the local or remote "1 cycle start" buttons will destroy the shunt, producing the results as in 5 above, but not before R_3 is operated. Thus the total cycle cannot accidentally be shortened with consequent underheating of the plastic, a condition more serious than overheating.

The actual construction followed shows to some extent in the photograph. The use of grid controlled gas tetrodes permits the direct operation of industrial control relays without intervening sensitive relays, a factor that makes this type of unit industrially usable. Because of the heavy vibration on and about molding presses, the ordinary high vacuum tube, sensitive relay combination is practically useless. A further factor in favor of the gas tubes lies in the definite and abrupt distinction between non-conduction and conduction. The load current comes up promptly from a few micro-amperes to a substantial value at the moment of firing. With high vacuum tubes the load current rises gradually with a consequent gradual increase in armature pull, making accurate timing problematical under severe conditions of vibration.

All components are selected for their mechanical and electrical excellence. Oil-filled, oil-impregnated condensers capable of withstanding extreme temperatures, the best available resistors, transformers, switches and parts are the rule. The writer also wants to go on record as favoring nothing but a good tough wafer socket with a cutting grip on the tube prongs.

A word is not amiss concerning the use of electronic timing equipment versus mechanical, synchronous clock or hydraulic systems, or other timing methods that might conceivably be employed. In the electronic units the only moving parts are the relays. This constitutes a definite advantage over mechanical and synchronous timers as there is so much less to get out of mechanical order. As compared with hydraulic or pneumatic timers, the variables of temperature, humidity, viscosity and wear introduce a degree of inaccuracy far greater than any conceivable from a time constant *R-C* circuit made with reliable components. In fact the mechanical simplicity and high repeat accuracy of the gas-tube timing device is its principal selling point, regardless of cost.

From Printing Presses to Church Bells

This same type of circuit is applicable to a number of industrial problems that otherwise might be much more difficult of solution. A few of these are of sufficient interest to merit mention.

A large envelope printing concern was troubled with failure in automatic envelope printing presses. One envelope would jam and others would rapidly pile up behind it until twenty or thirty were intimately entwined with the entrails of the press before the operator noted the trouble, stopped the machine and cleared up the mess. The machines now are equipped with electronic delay units so arranged that each envelope, on emerging, recycles the timer, the cycle for which is set at ¾ second with envelopes emerging every ½ second. As long as the timer is recycled before timing out by the emergence of an envelope, the machine goes merrily along, but, in the event that an envelope jams and fails to emerge, the time cycle is completed, the relay operates and the machine is stopped, with, at the most, two spoiled envelopes, and greatly reduced clearing time. The circuit of this unit is essentially that of Fig. 2 with the switch normally closed. Each envelope opens the switch for a few cycles, recharging *C*, which prevents operation until the time cycle expires or another envelope recycles the device.

Stop motion devices of this nature are readily applied to any machine from which products emerge at regular intervals. In this particular instance a Microswitch was used to operate the timer, but the method may be extended to a photoelectric recycling for small, light parts or to heavy limit switches where large parts are used.

Similar timing units have been applied to gas fired ovens in which a delay is desirable after starting a blower to permit complete exhaustion of fumes before starting the gas. In this instance the delay is initiated by the closing of wind switches operated by the blower blast, which positively insures exhaust. At the expiration of the delay (in this instance, five minutes) the tube timer operates to condition the gas circuit, which can then be started, but which cannot be started prior to the delay. Failure of the blower blast, even momentarily, completely recycles the timer and shuts off the gas as a safety measure.

Perhaps the most unique tube timer installation was on a motor-driven church bell installation, where bells aggregating many tons were mounted in a somewhat shaky tower. The bells could not be permitted to exceed a normal swing, as the strain of swinging them over and over would be too much for their supporting structure. The desired cycle was briefly:

1. Bell hanging straight down, motor turned on, raising bell, for example, to right.

2. Bell raised to right until cam on bell shaft actuates limit switch, shutting off motor and recycling timer.

3. Bell starts down swing as free

pendulum, reclosing limit switch and starting timing cycle.

4. Bell swings down through dead center, up to left and then back to dead center, at which instant timer times out, restarting motor and hence, restarting the whole cycle. Possible because bell swings at constant pendulum rate.

Incidentally, an additional limit switch was connected across the line so that, should the first switch fail to stop the motor, the second would throw a dead short on the line, blowing the fuses. To date, no fuses have been blown.

The Gas Tube Relay

Another interesting application of the gas tetrode is its use as a relay when an extremely low voltage, low current or high resistance contact must operate a power relay circuit. Figure 3 shows an appropriate circuit that has been found most useful in reducing the load on very light or fragile contacts which are sometimes encountered in instrumental work. The theory of this circuit needs but little explanation. With transformer, *T*, placed as in Fig. 2 the tube is biased through *R* and *D*. When the contacts, *C*, close, the bias is removed and the grid returns to cathode through *D* permitting the tube to fire, energizing load, *L*. The current through *C* can be kept extremely low by making *R* and *D* large, say five or ten megohms.

The utility of the gas tetrode is by no means exhausted by the applications here cited. Its use in photoelectric circuits is equally important, as, due to its high control factor, low grid current and high output it can be worked directly from phototubes to control considerable power. An example is shown in Fig. 4. This circuit illustrates the extreme simplicity made possible by the use of the gas tetrode. The unit is assembled in a single case with a lens for the light source and uses a mirror for the light beam. By using a projector bulb, a sufficiently concentrated light source is provided. The phototube and resistor *R* shunt the heater, the drop in which provides the necessary bias, and the lamp *B* operates in series with the heater, thus killing two birds with one stone, as the lamp becomes the dropping resistor. The resistor *M* serves as a by-pass for the inductive

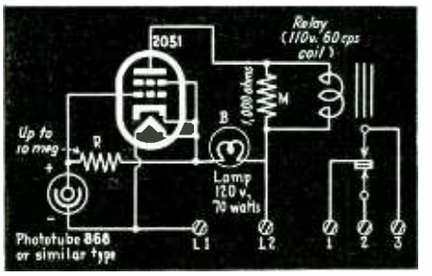
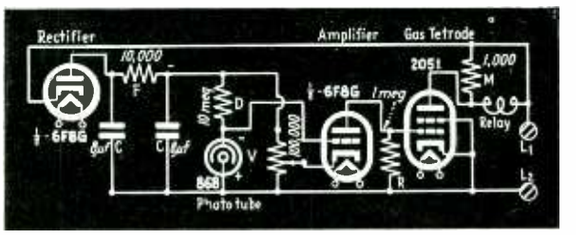
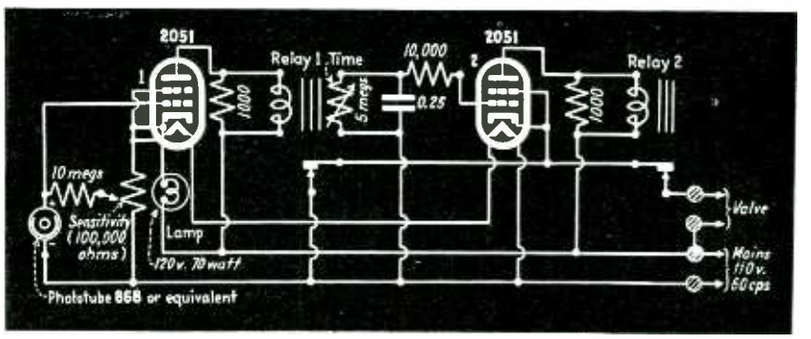


Fig. 4—Left, a phototube relay circuit, employing the 2051 gas tetrode, from which all unnecessary circuit elements have been eliminated

Fig. 5—Below, marginal limit photo-relay circuit which will control the gas-tetrode relay tube within specified limits of incident light

Fig. 6 — Below, combination photo-relay and time-delay circuit used for controlling an "air-doffer" in a laundry which forms neat piles of laundered articles





discharge of the relay coil during the non-conducting half cycle.

The circuit, is, of course, subject to many modifications, but it shows how simply a photoelectric relay can be made. There is so little to the unit that there is practically nothing to go wrong, an advantage in an industrial design. Such photo-relays have operated satisfactorily in many difficult applications, with long light throws and under severe vibration and temperature conditions.

In certain instances where relatively great sensitivity is required, the gas tetrode has been used as an amplifier coupled to the phototube. Along these lines are such applications as the counting of textile threads by a modified sound on film optical setup, and the control of the articulated rails of textile finishing tenter frames by a photoelectric means. In both instances a small light differential is involved making action more positive when amplification is employed.

The basic circuit used includes some rather novel practices, as shown in Fig. 5. In this circuit a diode rectifier is connected "backwards" to produce an output of the polarity indicated. This output is, in turn, applied to the phototube circuit, *D*, the drop wire *V*, and the amplifier tube in such a way that any increase in amplifier plate current will increase the drop in resistor *R*, increasing the negative bias in the gas tetrode grid-cathode circuit. By adjusting the slider on *V* the bias on the amplifier can be adjusted so that the firing point of the gas tetrode will coincide with a desired light value on the cell.

A variation of this circuit is shown in Fig. 6. Here a single phototube is connected to produce a rather unique control function. It will be noted that the circuit is such that increased conductivity of the tube (from increased illumination) will make the grid of amplifier 1 more positive and that of amplifier 2 more negative and vice-versa. Thus, increased illumination will cut off the plate current of amplifier 2, destroying the negative bias on gas tetrode 2 and energizing relay 2. Decreased light energizes relay 1. By proper adjustment of the potentiometers practically any desired range

of illumination can be accommodated and the illumination levels for the energization of the relays can be widely spaced, brought together or even overlapped.

This discussion would be incomplete without a discussion of another rather ingenious circuit, shown in Fig. 6. This device for which this unit was developed is used to stack hot towels, pillowslips, etc emerging from a laundry mangle on a conveyor. The material in question is almost too hot to handle, and girls assigned to this work can stand but a few minutes without being relieved.

The Air-Doffer

The air-doffer, as the device is called, operates by blowing the hot article from the point where they are about to drop off the conveyor belt onto a rack, across which they hang in a neat stack. The conveyor belt consists, actually, of several parallel webs, and through one of the interstices the light source throws its beam up to a mirror and back into the cell. Since the essentials of both circuits have been given in the discussion of Figs. 2 and 4, the operating cycle will be discussed without recourse to theory.

1. The leading edge of the article to be doffed intercepts the light beam energizing relay 1, opening its contacts and recycling gas tetrode 2 and relay 2.

2. The article advances, its leading edge dropping down over the end roll of the conveyor, directly beneath which is a perforated pipe system and in front of which is a rack onto which the article is to be doffed.

3. As the following end of the article is about to leave the conveyor, it restores the light beam, closing relay 1, which energizes the solenoid valve admitting air to the blower pipe, starting the article in its flight from conveyor to rack, and starting the timing period of gas tetrode 2.

4. Gas tetrode 2 times out, opening the solenoid valve circuit, stopping the blast and restoring the circuit to start a new cycle.

By proper design of the pipe system and accurate regulation of air pressure and timing, articles can be stacked with amazing accuracy. After flying several feet through the air, the margins of similar pillow slips will all hang within one-eighth inch. The air blast is a short puff, that, literally, picks the article up and hangs it over the rail. This unit is uncannily accurate in operation and almost unbelievable to watch in action. The simplicity and repeat accuracy of the control contributes much to its effectiveness, for, as can be seen from the diagram, there is very little to get out of order.

Relays for D-c Power Supply

So far this article has been largely confined to extolling the praises of the gas tetrode. If the writer seems to have plugged this development it is because it has proved a most useful electronic tool in industrial control work. Although its utility in alternating current applications is unquestioned, in direct current problems it is often more convenient to use other types of tubes rather than to provide means of extinguishing the gas arc.

A typical example of this situation is illustrated in Fig. 7. This control was developed to operate an automatic dishwasher from 230 volts direct current. The operation may best be understood by a description of the operating cycle with reference to the circuit.

1. At the start of the cycle the unit is connected to the d-c mains as shown. Condensers C_1 and C_2 are charged to the full 230 volt potential of the indicated polarity.

2. The start button is pressed shunting the left hand contacts of relay 1. This establishes a series circuit through relay 1, the two filaments, the pilot light, the stop button and the contacts of relay 4 which series circuit energizes the tube filaments, pilot lamp and relay 1, which latter operates to:

(a) Shunt the start button, left hand contacts
(b) Apply 230 volts to the wash motor, center contacts
(c) Disconnects C_1 from the 230 volt minus and connect R_1 across C_1 starting the discharge cycle.

3. The quick-heating type 30 tubes are ready to operate promptly, but some time (about two and one-half minutes) is required for C_1 to discharge through R_1 to the point where the bias on 30 tube number 1 permits relay 2 to operate.

4. Relay 2 operates, in turn energizing relay 3 which disconnects the wash motor and starts the rinse valve. At the same time C_2 is connected to R_2 for discharge.

5. C_2 discharges in about ten seconds at which time relay 4 operates, opening the holding circuit described in 2 above and turning everything off.

Thus the device provides a complete automatic cycle, circulating the alkaline wash solution with a motor driven pump for 2½ minutes, shutting off the pump and turning on a hot water rinse for 10 seconds and then turning everything off, including itself. Relays 2 and 4 are Sigma type M which have a Microswitch movement giving snap action and as much freedom from vibration as can be found in a sensitive relay. The only load on their contacts is the coil current of relays 1 and 3, which latter are heavy industrial control types with blow-out coils on the contacts carrying motor current.

By operating the filaments, pilot lamp and the coil of relay 1 in series, protection against failure of tubes is insured and such failure is indicated by the fact that the pilot will not light. A stop button is provided to "kill" the entire system in case the operator, for example, forgot to lower the side panels of the washer after loading, which would squirt water all over the lot, including himself.

The various circuits disclosed herein are in the main the subject of patents issued or pending. They have been included to illustrate methods of attack rather than to suggest specific solutions for general problems.

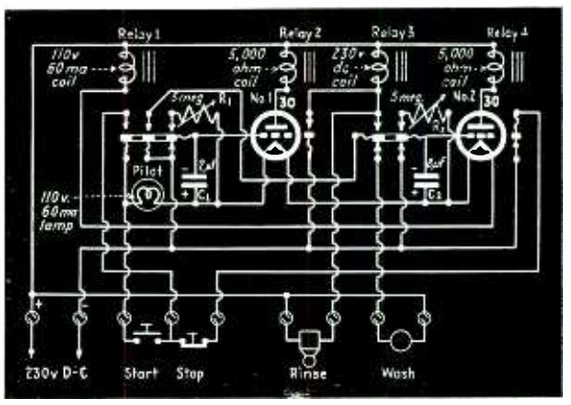


Fig. 7—A time-cycle circuit operated from 230 volts d-c, for controlling rinsing and washing operations in a commercial laundering machine

SINEWAVES IN R-C OSCILLATORS

While it is well known that sinewaves can be produced in circuits containing no inductance, the fundamental principles underlying their generation are not widely understood. This timely article derives expressions for the condition of oscillation and the frequency, and presents experimental confirmation

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THE production of oscillations in circuits without inductance is well known. The relaxation oscillator consisting of condenser and resistance, for example has been studied in detail before. However, production of a sinewave form in such circuits is a comparatively recent development. There are only a few references in the literature to sine form oscillations produced without inductance. Monnier and Bazin[1] studied this type of oscillation produced in a bridge type circuit and derived an expression for frequency. Mention should also be made of the work of Morin[2], Tank and Graf[7] and Van der Mack and Van der Pol[9]. At a recent meeting of the New Orleans Academy of Sciences, Dr. J. C. Morris, reporting on some studies of the transitron[3, 4] oscillator, stated that he had obtained oscillations of sine form from the transitron circuit even when the inductance was removed from the circuit, providing the resistance in parallel with the condenser was sufficiently high.

It is the object of this paper to develop the fundamental basis of operation of this circuit and, in particular, to derive an expression for the frequency of oscillations in terms of the resistances, capacitances and tube constants. An experimental check of the frequency equation was made, together with a study of the conditions for oscillation.

Fig. 1—Fundamental circuit of the inductance-less sinewave generator

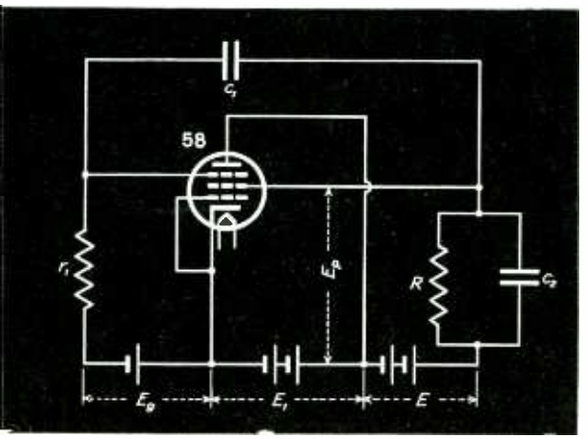
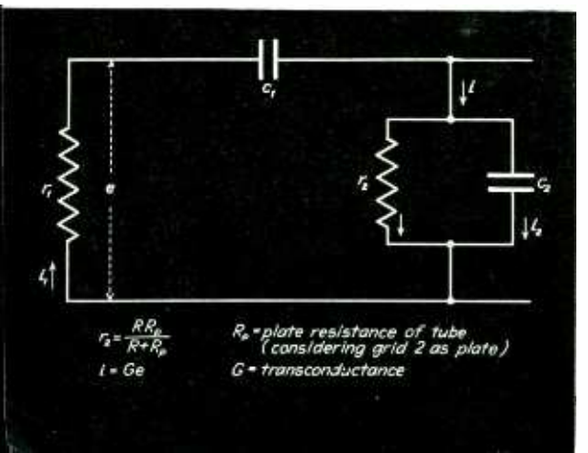


Fig. 2—Equivalent circuit of Fig. 1. The tube is represented by the transconductance G



Theory of the Circuit

The diagram of connections of the circuit is shown in Fig. 1, and the equivalent circuit in Fig. 2. The resistance r_2 is the combined resistance of R and R_p in parallel. The instantaneous alternating currents are assumed to flow in directions shown. By applying Kirchoff's laws to the circuit we have:

$$r_1 i_1 + \frac{\int i_1\,dt}{c_1} + \frac{\int i_2\,dt}{c_2} = 0 \qquad (1)$$

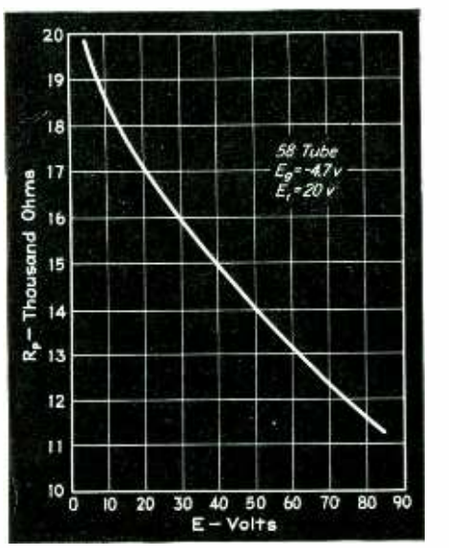


Fig. 3—Plate resistance (grid 2 taken as the plate) as a function of the applied voltage, for the type 58 tube

$$\frac{\int i_2\,dt}{c_2} = (i - i_2)\,r_2 \qquad (2)$$

$$e = r_1 i_1 \qquad (3)$$

$$-e = \frac{\int i_1\,dt}{c_1} + \frac{\int i_2\,dt}{c_2} \qquad (4)$$

from which we obtain by differentiation of Eqs. (1), (2) and (4) respectively:

$$r_1 \frac{di_1}{dt} + \frac{i_1}{c_1} + \frac{i_2}{c_2} = 0 \qquad (5)$$

$$\frac{i_2}{c_2} = r_2 \frac{di}{dt} - r_2 \frac{di_2}{dt} \qquad (6)$$

$$-\frac{d^2e}{dt^2} = \frac{1}{c_1}\frac{di_1}{dt} + \frac{1}{c_2}\frac{di_2}{dt} \qquad (7)$$

Combining the above three equations, it follows that:

$$r_1 \frac{di_1}{dt} + \frac{i_1}{c_1} + r_2\left(c_2 \frac{d^2e}{dt^2} + \frac{c_2}{c_1}\frac{di_1}{dt}\right) + r_2 \frac{di}{dt} = 0 \qquad (8)$$

Substituting $e = r_1 i_1$ and rearranging terms we have:

$$\frac{d^2e}{dt^2} + \left(\frac{1}{r_1c_1} + \frac{1}{r_2c_2}\right)\frac{de}{dt} + \frac{e}{r_1c_1r_2c_2} + \frac{1}{c_2}\frac{di}{dt} = 0 \qquad (9)$$

The above differential equation has two variable e and i, but they are not independent. The following relation holds:

$$i = G\,e \qquad (10)$$

where G is the a-c transconductance of the tube (see reference 5 for discussion on this point). By experiment, G is found to have a negative value. Substituting (10) in (9) there follows:

$$\frac{d^2e}{dt^2} + \left(\frac{1}{r_1c_1} + \frac{1}{r_2c_2} + \frac{G}{c_2}\right)\frac{de}{dt} + \frac{e}{r_1c_1r_2c_2} = 0 \qquad (11)$$

In order that continuous oscillations be present, the coefficient of the second term must be zero or negative. We have then as a condition for oscillation, remembering that G is negative, that:

$$\frac{1}{r_1c_1} + \frac{1}{r_2c_2} \leq \frac{|G|}{c_2}$$

or

$$\frac{c_2}{r_1c_1} + \frac{1}{r_2} \leq |G| \qquad (12)$$

This expression shows why the circuit fails to oscillate when the resistances are not sufficiently high.

If the circuit is adjusted so that it is near the condition of oscillation cutoff, then the coefficient of the second term of equation (11) may be set equal to zero and the equation becomes:

$$\frac{d^2e}{dt^2} + \frac{e}{r_1c_1r_2c_2} = 0 \qquad (13)$$

whose solution, as is well known, is of the form:

$$e = A \sin 2\pi f t$$

and the frequency has the value:

$$f = \frac{1}{2\pi\sqrt{r_1c_1r_2c_2}} \qquad (14)$$

Experimental Check of Frequency Equation

An experimental check of the frequency equation has been made by the writer. The apparatus was connected as shown in Fig. 1. A type 58 tube was used with $E_g = -4.7$ volts, $E_1 = 20$ volts and $E = 84$ volts. Leads across C were loosely coupled to the grid of a stage of amplification whose output was connected to a cathode ray oscillograph. This extra stage was used because of the disturbing effects which the resistances and capacitances in the oscillograph might have had on the circuit.

The other plates of oscillograph were connected to a source of 60 cps ac through a suitable protecting condenser. The resistances r_1 and R were adjusted until oscillation frequency was such that a stationary Lissajous pattern was obtained on the cathode ray screen. Since the ratio of the two frequencies is equal to the ratio of the vertical to the horizontal loops in pattern, the frequency of the oscillator was thereby determined. In making these measurements it was important to adjust the resistances so that oscillations were near the cutoff point, since the equation to be checked [Eq. (14)]

TABLE I

Observed frequency cps	R ohms	Current thru R ma	R_p ohms	E volts	r_1 ohms	r_2 ohms	c_1 μf	c_2 μf	Calculated frequency cps
15	3,900	5.22	12,760	84	408,200	2,987	.1	.9	15.2
30	3,900	5.22	12,760	84	116,400	2,987	.2	.4	30.2
60	3,900	5.22	12,760	84	115,800	2,987	.1	.2	60.8
90	6,040	4.8	13,600	84	30,000	4,170	.1	.25	89.6
300	61,000	1.95	19,170	127	7,900	14,300	.1	.025	299
420	4,810	5.04	13,150	84	16,000	3,510	.1	.025	424
480	9,400	5.92	12,250	127	7,770	5,370	.1	.025	490
600	8,000	4.35	14,700	84	11,040	5,180	.05	.025	596

TABLE II

R ohms	R_p ohms	r_2 ohms	r_1 ohms	c_1 μf	c_2 μf	G by Eq. (12) mhos	G by meas mhos
40,000	19,100	12,900	15,100	.1	.1	.00014	.00018
30,000	17,950	11,200	15,000	.1	.2	.00022	.00021
25,000	17,200	10,200	17,700	.1	.2	.00021	.00023
20,000	16,400	9,020	16,600	.1	.2	.00023	.00026
15,000	15,600	7,650	30,000	.1	.4	.00026	.00029
10,000	14,430	5,900	18,140	.1	.2	.00028	.00032
3,830	12,800	2,950	408,200	.1	.9	.00036	.00035

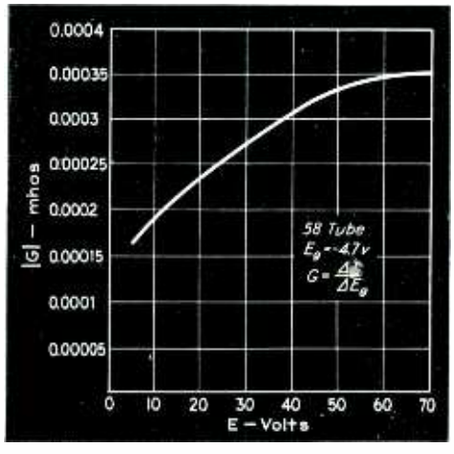
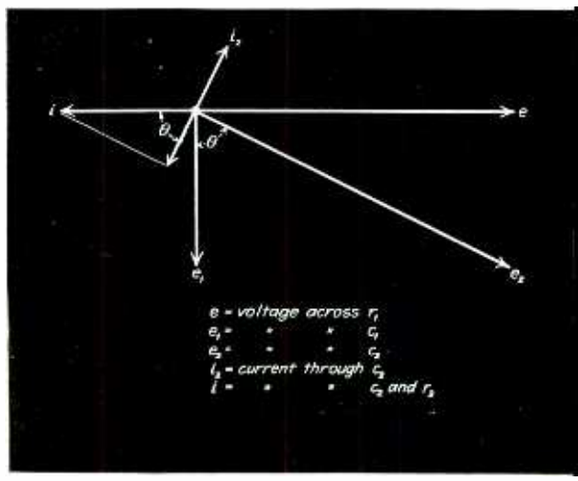


Fig. 5—Transconductance as a function of voltage applied to grid 2 of a type 58 tube

Fig. 4—Vector diagram of the circuit operation (refer to Fig. 2)



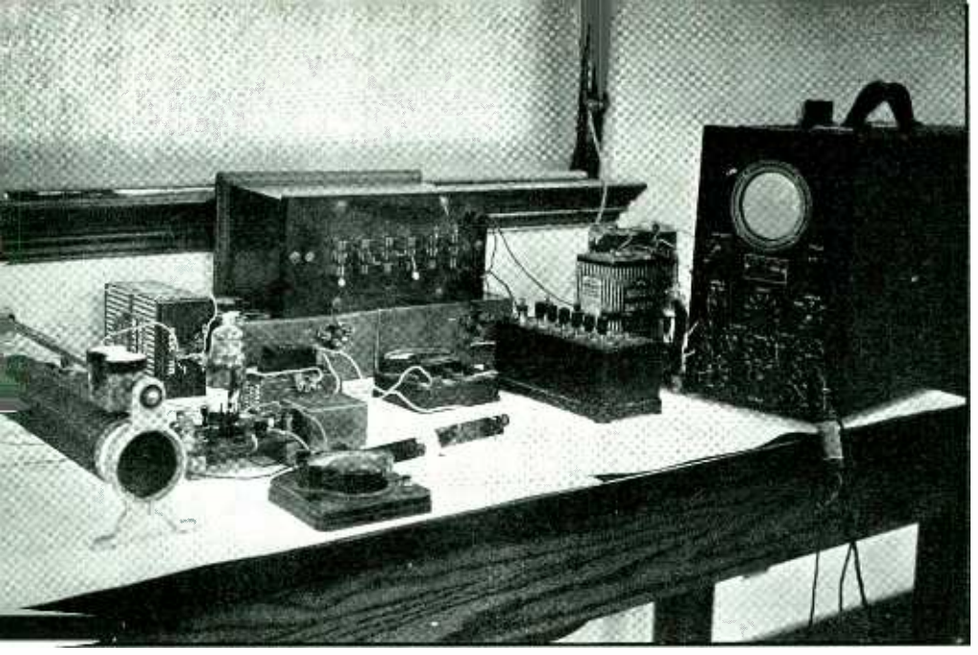


Fig. 7—Experimental set-up of the sinewave oscillator at Southwestern Louisiana Institute

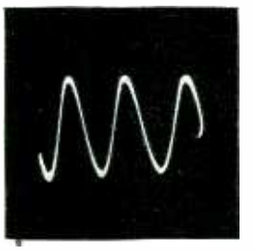


Fig. 6—Oscillogram of the oscillator output when adjusted for sinewave output

holds only for this limiting condition. The observed and calculated values of frequency are given in Table I. As can be seen, there is very close agreement between them, the largest error is of the order of 2 per cent.

It may be well to discuss more fully the details of the calculations. It should be noticed that r_2 is the combined resistance of R and the plate resistance of tube (considering grid 2 as a plate). The value of R_p varies with the voltage applied, so that it is necessary to determine it at various values of voltage. To check this resistance R was removed from circuit and the direct current I to grid 2 measured at various values of E, then $R_p = \frac{\Delta E}{\Delta I}$ was calculated. The values are plotted in Fig. 3. A sample calculation follows.

Observed frequency = 30 cps
R = 3900 ohms
E = 84 volts
Current through R = 5.22 ma
$E_p = 84 - (3900 \times .00522) = 63.6$ volts
From Fig. 3 at 63.6 volts R_p = 12,760 ohms

$$r_2 = \frac{R \times R_p}{R + R_p} = 2987 \text{ ohms}$$

r_1 = 116,400 ohms
$c_1 = 0.2\ \mu f$
$c_2 = 0.4\ \mu f$

$$f = \frac{1}{2\pi\sqrt{r_1 c_1 r_2 c_2}} = 30.2 \text{ cps.}$$

Experimental check of condition for Oscillation

According to Eq. (12), oscillations should cease when:

$$\frac{C_2}{r_1 c_1} + \frac{1}{r_2} = |G|$$

The resistances in the circuit were adjusted until oscillations stopped. The values of the constants are given in Table II, together with the calculated value of G which may be compared with the value of G obtained by measurement of ΔI caused by ΔE_g. By definition $G = \frac{\Delta I}{\Delta E_g}$ where I and E_g are the d-c values. The resistance R was removed from circuit while making measurement of G. I is the direct current to grid 2. It is seen from the table that a satisfactory agreement holds between calculated and observed values of G.

A rather interesting effect takes place when the filament current is cut off while the circuit is oscillating. As the cathode cools, a point is reached at which the oscillations stop, but upon further cooling, another point is reached at which oscillations are resumed. This effect takes place only when R has a high value.

By the above procedure Eq. (14) for the frequency of oscillations of sine form for circuit of Fig. 1 was derived from theorectical considerations and experimentally verified over a fairly large range of values of capacity and resistances.

It is interesting to note, in the mathematical derivation, how a second order term, which is usually associated with an inductance in the differential equation for oscillating circuits, is introduced into the final equation, representing the behavior of a circuit containing only resistances and capacities. For another example of an analogous situation see references 1 and 7. A search of the literature showed that Eq. (14) had been derived by Tank and Graf[7] for a symmetrical two tube circuit. See also references 1 and 2.

Additional insight into the behavior of the circuit in Fig. 1 may be obtained by a consideration of the vector diagram of currents and voltages (Fig. 4): Since G is negative, i is 180° out of phase with e. Consider the component of i perpendicular to e_2. This component is 90° behind e_2 and, therefore, produces the same effect as if an inductance were present.

We can also derive Eq. (14) from the vector diagram if we assume that the currents are of sine form. The condition for oscillation is that:

$$i_2 = i \cos\theta$$

$$i_2 = i\frac{e_1}{e_2}$$

$$i_2 = i\frac{1}{2\pi f e_1\sqrt{r_1^2 + \left(\frac{1}{2\pi f c_1}\right)^2}}$$

$$\frac{e_2}{\left(\frac{1}{2\pi f c_2}\right)} = \frac{e_2\sqrt{(2\pi f c_2)^2 + \frac{1}{r_2^2}\left(\frac{1}{2\pi f c_1}\right)}}{\sqrt{r_1^2 + \left(\frac{1}{2\pi f c_1}\right)^2}}$$

Solving the above equation for f we have

$$f = \frac{1}{2\pi\sqrt{r_1 c_1 r_2 c_2}}$$

which agrees with Eq. (14).

References

1. A. Monnier and J. Bazin, Comptes Rendue, p. 828, vol. 202 (March 1936).
2. H. Morin, Comptes Rendue, p. 1560, vol. 206 (1938).
3. C. Brunetti, Rev. Sci. Inst. 10, p. 85 (1939).
4. C. Brunetti, Proc. I. R. E. 27, 88 (1939).
5. Terman, F. E., "Fundamentals of Radio", p. 95, McGraw-Hill (1938).
6. N. L. Yates-Fish, Proc. Phys. Soc. 48, p. 125 (1936).
7. Tank and Graf, Helvetica Physica Acta, vol. 1, p. 508 (1928).
8. Tank and Zelwer, Helvetica Physica Acta, vol. 3, p. 329 (1930).
9. Van der Mack and Van der Pol, Physica 1, 437 (1934).

Institute of Radio Engineers
Sixteenth Annual Convention

January 9, 10, and 11, 1941, Hotel Pennsylvania, New York, N. Y.

Program of Technical Papers

THURSDAY, JANUARY 9

10:30 A. M.—12:30 P. M.

Address by L. C. F. Horle, retiring president, and introduction of F. E. Terman, president for 1941. Technical session, President Terman presiding.

"Recent Developments in the R.C.A. Electron Microscope," by J. Hillier and A. W. Vance, R.C.A. Manufacturing Company, Inc., Camden, N. J.

"The Handling of Telegrams in Facsimile," by R. J. Wise and I. S. Coggeshall, Western Union Telegraph Company, New York, N. Y.

"Measurements of the Delay and Direction of Arrival of Echoes from Nearby Short-Wave Transmitters," by K. G. Jansky and C. F. Edwards, Bell Telephone Laboratories, Inc., New York, N. Y.

"An Evaluation of Radio-Noise-Meter Performance in Terms of Listening Experience," by C. M. Burrill, R.C.A. Manufacturing Company, Inc., Camden, N. J.

"Resistance Tuning and its Application to the Transitron," by Cledo Brunetti, Lehigh University, and Eric Weiss, R.C.A. Manufacturing Co.

2:30 P. M.—4:30 P. M.

Technical Session, H. A. Wheeler presiding.

"Spurious Responses in Superheterodyne Receivers," by E. Kohler and C. Hammond, Ken-Rad Tube and Lamp Corporation, Owensboro, Ky.

"Intermediate-Frequency Values for Frequency-Modulated-Wave Receivers," by D. E. Foster and G. Mountjoy, Radio Corporation of America, License Division Laboratory, New York, N. Y.

"Signal-Noise Relations in High-Transconductance Tubes," by J. R. Nelson, Raytheon Production Corporation, Newton, Mass.

"Magnetic Recording and Some of Its Applications in the Broadcast Field," by S. J. Begun, The Brush Development Company, Cleveland, Ohio.

FRIDAY, JANUARY 10

10:30 A. M.—12:30 P. M.

Technical Session, O. B. Hanson presiding.

"New 1-Kilowatt Television Picture Transmitter," by J. Ferguson, Farnsworth Television and Radio Corporation, Fort Wayne, Ind.

"Versatile Multi-Channel Television Control Equipment," by D. E. Norgaard and J. L. Jones, General Electric Company, Schenectady, N. Y.

"New Designs of Television Control-Room Equipment," by J. Schantz and W. Ludwick, Farnsworth Television and Radio Corporation, Fort Wayne, Ind.

"A Coaxial Filter for Vestigial-Sideband Transmission in Television," by H. Salinger, Farnsworth Television and Radio Corporation, Fort Wayne, Ind.

"Three New Ultrahigh-Frequency Triodes," by K. C. DeWalt, General Electric Company, Schenectady, N. Y.

"A Recently Developed Circuit for the Generation of Power at U-H Frequencies," by A. L. Nelson, Farnsworth Television and Radio Corporation, Fort Wayne, Ind.

2:30 P. M.—4:30 P. M.

Technical Session, F. R. Lack presiding.

"Radio-Frequency-Operated High-Voltage Supplies for Cathode-Ray Tubes," by O. H. Schade, R.C.A. Manufacturing Company, Inc., Harrison, N. J.

"After-Acceleration and Deflection," by J. R. Pierce, Bell Telephone Laboratories, Inc., New York, N. Y.

"Analysis of Voltage-Controlled Electron Multipliers," by B. J. Thompson, R.C.A. Manufacturing Company, Inc., Harrison, N. J.

"Behavior of Electron Multipliers as a Function of Frequency," by L. Malter, R.C.A. Manufacturing Company, Inc., Harrison, N. J.

"The Orbital-Beam Secondary-Electron Multiplier for Ultra-high-Frequency Amplification," by H. M. Wagner and W. R. Ferris, R.C.A. Manufacturing Company, Inc., Harrison, N. J.

SATURDAY, JANUARY 11

10:30 A.M.—1:30 P. M.

Technical Session, President Terman presiding.

"Some Factors Affecting Television Transmission," by M. E. Strieby and C. L. Weis, Bell Telephone Laboratories, Inc., New York, N. Y.

"Film Scanner for Use in Television Transmission Tests," by A. G. Jensen, Bell Telephone Laboratories.

"Brightness Distortion in Television," by D. G. Fink, *Electronics*, McGraw-Hill Publishing Company, New York, N. Y.

"A Simple Optical Method for the Synthesis and Evaluation of Television Images," by R. E. Graham and F. W. Reynolds, Bell Telephone Laboratories.

"A Phase-Curve Tracer for Television," by B. D. Loughlin, Hazeltine Service Corporation, Little Neck, N. Y.

"Special Oscilloscope Tests for Television Waveforms," by A. V. Loughren and W. F. Bailey, Hazeltine Service Corporation, Little Neck, N. Y.

2:30 P. M.—4:30 P. M.

Technical Session, C. M. Jansky, Jr., presiding.

"Program-Operated Level-Governing Amplifier," by W. L. Black and N. C. Norman, Bell Telephone Laboratories, Inc., New York, N. Y.

"Drift Analysis of the Crosby Frequency-Modulated Transmitter Circuit," by E. S. Winlund, R.C.A. Manufacturing Company, Inc., Camden, N. J.

"Frequency-Modulated Emergency Equipment," by G. M. Brown, General Electric Company, Schenectady, N. Y.

"Commercial 50-Kilowatt F-M Broadcast Transmitting Station," by H. P. Thomas and R. H. Williamson, General Electric Company, Schenectady, N. Y.

FIRE PROTECTION IN BROADCASTING

Fire fighting in broadcast studios and transmitters is a specialized problem because of the electrical equipment involved and because shutdown must be avoided if at all possible. The action of carbon dioxide on electrical fires is discussed and the apparatus for applying it to the fire is described

A portable carbon dioxide fire extinguisher in a studio control room at Radio City. The tank contains 15 pounds of carbon dioxide, sufficient to extinguish any fire which might start in the control panels

By HARRY GRANT

Walter Kidde & Co., Inc.

ALTHOUGH serious fires do not occur as frequently in radio broadcasting as in many other industries, the problem of fire extinguishing is a very live subject among broadcasting engineers. In few other industries is there such a vital need for quick extinguishing and for extinguishing agents which are harmless to delicate electrical equipment and which, therefore, do not interrupt broadcasting service.

Every radio and television station is vulnerable to three types of fire, which have been designated by fire protection engineers as Class A, Class B, and Class C.

Class A—Fires in wood, paper and rubbish. Fires in this class require cooling and wetting to quench embers.

Class B—Fires in flammable liquids, gasoline, oil, etc. This class requires smothering and cutting off of the oxygen supply.

Class C—Fires in electrical equipment, insulation, etc. This class also requires smothering and cutting off of the oxygen supply.

Despite the fact that it is the Class C or electrical fire that causes the most trouble, every well equipped station must be prepared to cope with Class A fires. The extinguisher recommended by leading broadcast engineers for these fires which occur most often in studios and theaters and involve carpets, drapes or other furnishings, is the 2½ gallon water-type. This unit, with which almost everyone is familiar, consists of a copper or brass cylinder which must be inverted before use.

Water extinguishers are of two general types. The older type contains a quantity of water in which is dissolved some sodium bicarbonate and a vial of sulphuric acid. When in use, the extinguisher is inverted and the acid is spilled from its vial to mix with the sodium bicarbonate solution thus forming a large volume of carbon dioxide gas. The water is then expelled under pressure sufficient to form a stream of about 25 or 30 feet. The extinguishing effect is due entirely to the water and not to the carbon dioxide which acts only as a propelling agent for the water. In this type of extinguisher, sulphuric acid and sodium sulphate are mixed with the water. Because of the effect of these chemicals on certain materials, radio engineers specify a newer type of extinguisher which does not use acid, but obtains the same propellant action by the use of a cartridge containing carbon dioxide under high pressure. In this type the cartridge is punctured when the extinguisher is inverted, thus releasing the gas which forces the water out of the tank. The water, containing no acid, does no chemical damage to the premises.

Under no circumstances should water extinguishers be played on electrical equipment, and very rarely can they be used on flammable liquid fires. Electrocution of the operator may result when the energized apparatus grounds through the stream and the fire-fighter's body. Also, wetting of insulation is always to be avoided. Using water on burning liquids usually succeeds only in spreading the fire, so these water units must be considered only for carbonaceous materials.

Carbon Dioxide as a Fire Extinguisher

So predominant is the electrical fire in radio work, that extin-

guishers for these Class C fires occupy the center of interest in almost every station. And, as far as N.B.C. and C.B.S. are concerned, the only recommended type is the carbon dioxide gas unit.

Carbon dioxide, as a fire extinguishing agent, was originally developed to smother fires in ships' cargo spaces and its early applications were all in this field. Its successful use came when strong steel cylinders to hold the gas under high pressure and non-freezing valves to release it very quickly, were developed.

Its principle is simply the rapid dilution of the normal 21 per cent oxygen content of the air to a point where combustion of a given material cannot continue. For example, gasoline requires an atmosphere of about 16 per cent oxygen in order to burn. Discharging carbon dioxide gas over burning gasoline cuts the oxygen content below this point and the fire dies instantly. The same principle applies to burning insulation in the case of electrical fires.

Telephone engineers discovered this phenomenon in the days when radio had given little thought to fire. Switchboards in exchanges had proved a definite fire hazard that called for radical new methods of extinguishing. Any agent that wet or attacked insulation materials was obviously unsuitable so carbon dioxide was tried. Because the gas penetrates crevices and passes around obstructions, it proved ideal for switchboards, especially in view of the fact that the gas leaves no residue or dampness and has a higher dielectric strength than air.

When carbon dioxide is compressed in the extinguisher (usual pressure is 850 lbs per sq in at 70° F) it becomes a liquid. When released, it comes from the discharge nozzle in the form of gas and snow. The liquid carbon dioxide expands to 450 times its original volume when released. Which accounts for the penetration of the gas. The fact that the gas comes from the cylinder at a temperature of 110° below zero F helps somewhat to cool burning materials, but the dilution of the oxygen content of the air is mainly responsible for the rapid extinguishing. Clouds of the gas, which resemble steam in appearance, can be used on energized equipment without danger and without the need of first switching off the potential.

In specifying carbon dioxide extinguishers for broadcasting properties, one can safely follow the recommendation of the larger networks. They are as follows:

Studio control room—One 4-lb carbon dioxide unit.

Projection boards and switchboards—One 10-lb carbon dioxide unit.

Transmitters, motors and switches —One 20-lb carbon dioxide unit.

Transmitter stations—One 75-lb carbon dioxide unit in basement, one 10-lb carbon dioxide unit near attic entrance.

Transformer vaults and large switchboards—One 75-lb carbon dioxide unit.

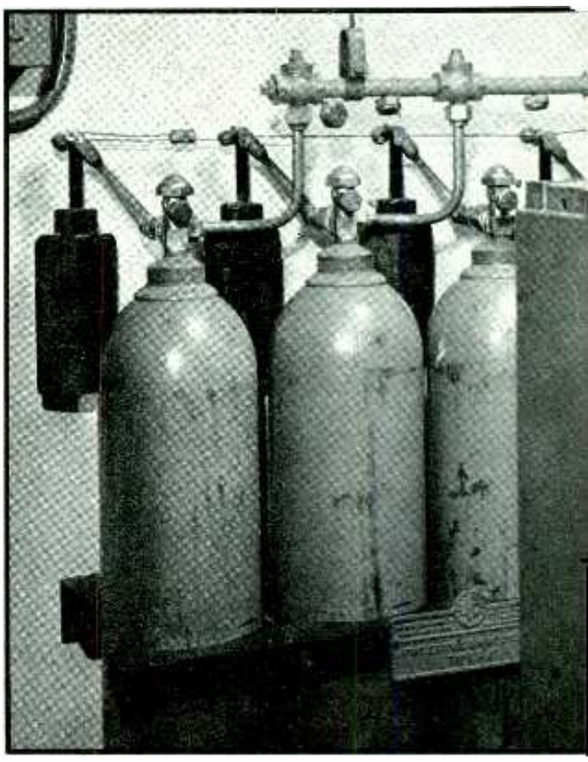
Fire corridors—One 20-lb carbon dioxide unit.

The capacity of carbon dioxide extinguishers which is given in pounds refers to the weight of the liquid carbon dioxide stored in the cylinder and not to the pressure. These capacities range from the smallest type, a two-lb unit equipped with pistol-grip and trigger, through several medium-sized units which are set on the floor when in use and carried by a handle on top, to the large size which is usually equipped with a wheeled carriage and long extension hose. Although 150-lb units are available for fighting large fires, the 75-lb unit is the largest unit commonly used in radio work.

Built-In Systems

At certain points in broadcasting equipment where the fire hazard is concentrated and exists in an enclosed space, built-in systems discharging carbon dioxide without human direction are sometimes used. One notable example is in the main terminal room of N.B.C. in Rockefeller Center, through which all of the programs of the Red and Blue networks must pass. The importance of rapid extinguishing of fire in this terminal room is obvious and a fixed automatic system was decided upon as the quickest and most effective way of coping with the fire problem. In this type of installation, carbon dioxide cylinders are fixed at a point a short distance from the enclosed area to be protected. A simple piping system leads to the space and discharge nozzles are located in the piping at various points in the room. When the gas is released, it billows from the discharge nozzles into the room, quickly flooding it with a high concentration of gas from ceiling to floor, making it impossible for fire to burn.

Automatic door closers and dampers are usually employed with such flooding systems to prevent escape of the gas until the cause of the fire can be located and removed. Discharge of the gas is usually made automatic through the use of air-filled actuators located over the hazard. When fire breaks out, the rapid temperature rise expands the air in the actuators and a release device opens the cylinder valves. Gas supplies are sufficient to bring the oxygen content of the air below 14 per cent, at which point combustion cannot take place in the insulation or windings. This system of flooding with carbon dioxide eliminates completely the human element in fire fighting and is the ultimate in protection of hazardous points. Originally developed for protection of processing rooms where flammable liquids were involved, it has since been adapted to other uses, including electrical applications.



Carbon dioxide tanks of the built-in fire control system of the main control room of the N. B. C. studios at Radio City. Each tank holds 75 pounds of CO_2 which is automatically released in case of fire

A Phototube Absorption Analyzer

To determine the concentration of solvent vapors in chemical processing, a stable absorption-type ultraviolet photometer utilizing two phototubes and balancing amplifier has been constructed. The device is capable of detecting a fraction of one part in a million

By
V. F. HANSON

E. I. du Pont de Nemours and Co., Niagara Falls

AN instrument known as the "Tri-Per-Analyzer" has been developed to determine micro quantities of trichlorethylene and perchlorethylene in air. It consists of an extremely sensitive and stable ultraviolet photometer with a built in sampling and standardizing system. Its operation depends on the partial opacity of solvent vapors to certain bands of light in the ultraviolet region of the spectrum. It has demonstrated the value of electronics in solving a difficult chemical control problem.

The instrument is used extensively for checking the operation of solvent extraction, degreasing and dry cleaning equipment using these solvents in order to preclude improper operation of such equipment. Such improper operation often results in economic losses and hazards to health.

It is common practice to make two determinations per minute of trichlorethylene vapor in concentration as low as 10 ppm (parts per million by volume) or as low as 0.3 ppm of perchlorethylene vapor in air. The analyses are made as rapidly as samples can be pumped through the instrument. While the instrument was developed primarily for these solvent vapors, it may be used equally well on many toxic vapors, some of which are listed in the table below:

Substance to be detected	Sensitivity Parts /Million of Vapor Per Scale Division
Mercury	0.0001 (approx)
Xylene	0.2
Monochlorobenze	0.3
Aniline	0.3
Perchlorethylene	0.5
Toluene	1.0
Benzene	1.2
Phosgene	5
Acetone	5
Ethylbenzene	5
Pentachlorethane	7
Hydrogen Sulphide	8
Trichlorethylene	10
Carbon Disulphide	12
Gasoline (Blue Sunoco)	50

It is possible to check readings within one scale division. It is normally necessary to know if interfering substances listed under Table I are present when analyzing for a component of a mixture.

All substances absorb light at some region of the spectrum. If a special region exists where a vapor has a high absorption (opacity) and the diluent a high transmission, the concentration of the vapor can be measured in terms of light absorbed. The ideal instrument would be one using a monochromatic source of light of wavelength corresponding to the maximum absorption of the vapor and a minimum absorption of the diluent and a highly sensitive and stable light measuring device sensitive only to this wavelength.

Under these ideal conditions the Beer-Lambert law of absorption holds. This law states that the light absorbed in traversing a distance d through a light absorbent having an extinction coefficient e and a molar concentration c is

$$I = I_o 10^{dce}$$

where I_o is the intensity of the light traversing the empty cell and I is the intensity of the light traversing

Fig. 1—Diagram of the vapor sampling system and phototube detection circuit

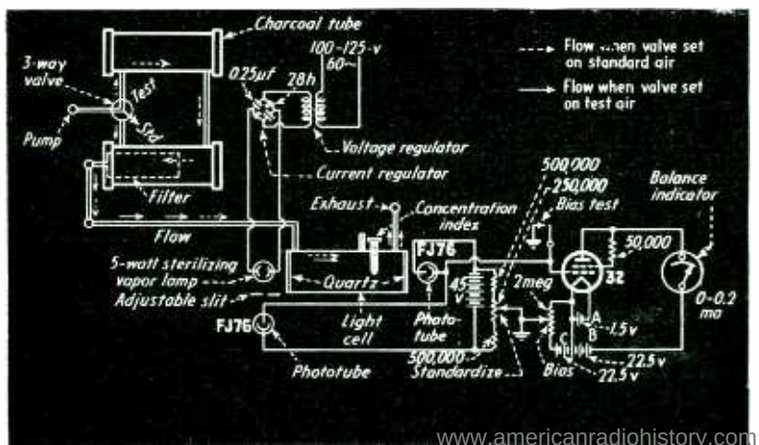
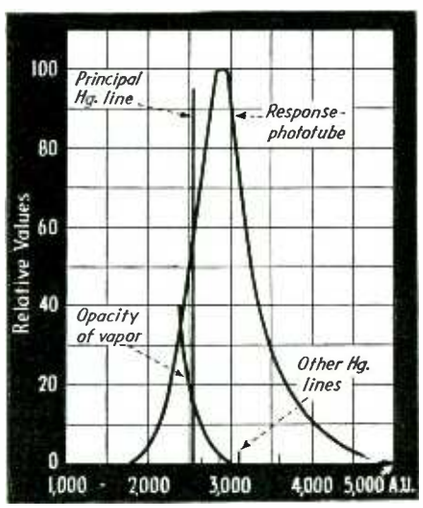


Fig. 2—Relative response of the FJ76 ultraviolet-sensitive phototube, the opacity of trichlorethylene and the radiation lines of the mercury lamp



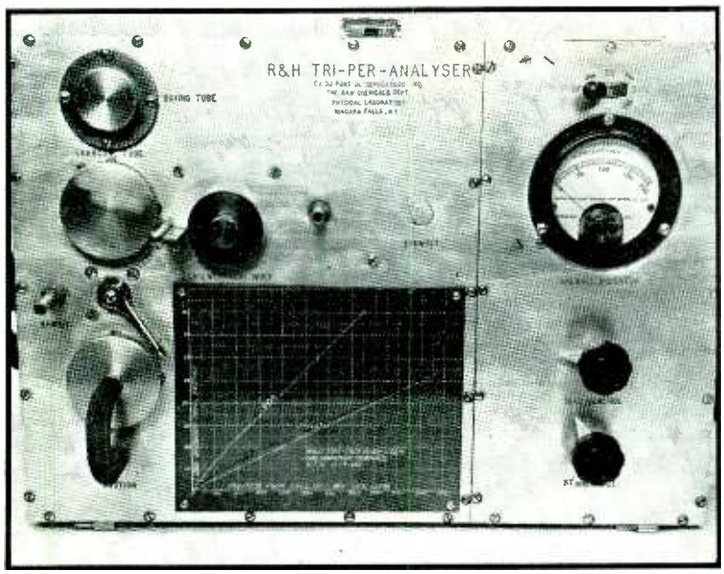


Fig. 3—Left, front view of the R. and H. "Tri-Per-Analyzer" which combines the sampler, standardizer and phototube detector

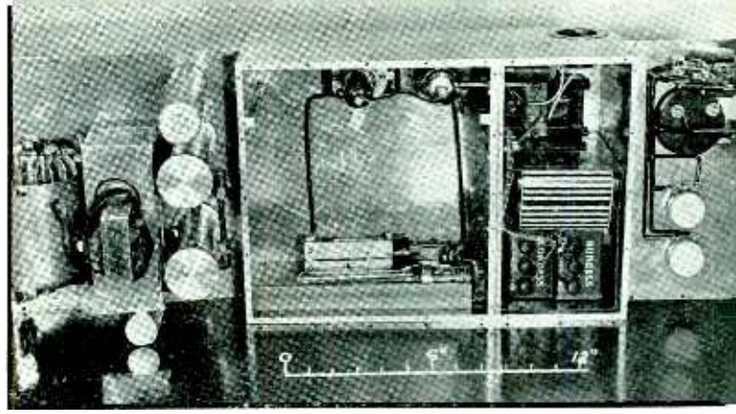


Fig. 4—Above, the instrument with front panels removed. The two phototubes appear at the top and bottom of the larger compartment

the cell containing the substance being measured.

When the logarithm of this expression is taken

$$\log \frac{I}{I_o} = dce$$

it is evident that this relationship is ideal for measuring small quantities of the absorbing substance. Other analytical methods such as refractive index, thermal decomposition, etc. formerly used depend on a linear relationship resulting in an equal sensitivity over the entire range of concentrations.

Figure 1 shows the schematic arrangement of the instrument with wiring diagram and lamp control networks. Figure 2 shows the relative response of the G.E. FJ76 phototube, spectral output of the G.E. 5-watt sterilization lamp and the light absorption spectra or relative opacity of trichlorethylene.

The analyzer is self contained in a carrying case weighing 35 lbs. Figure 3 shows the instrument set up for use. Figure 4 shows the instrument with panels removed.

A 15-cm sample cell, which is provided with quartz windows is rigidly mounted on a heavy duralumin panel. One-eighth-inch pipe connections are made near the cell ends for circulating the sample. A micrometer screw is inserted in the cell to cast a shadow on the measuring phototube. The top of the screw is provided with a micrometer index. When solvent laden air is passed through the cell, the light absorbed by the solvent, is compensated for by reducing the shadow on the phototube by turning the screw. The reading of the screw is thus an index of the light absorbed. The instrument is calibrated in terms of solvent concentrations in ppm and the micrometer screw setting. Calibration curves are provided on the instrument panels.

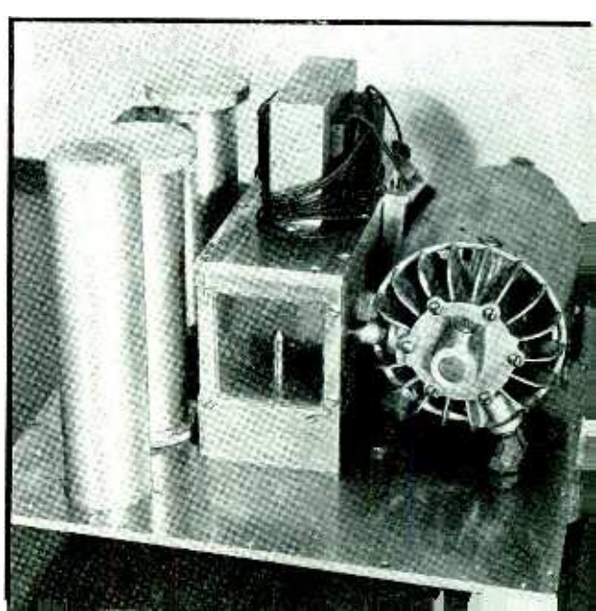
A porous Alfrax filter is inserted between the light cell and the sampling line to keep dust from entering the light cell. An absorbent carbon tube controlled by a three way valve is used to remove solvent vapors from the air in order to set the zero point of the instrument. This absorbent carbon is effective in reducing the concentration of solvents from as high as 1000 ppm to less than 1 ppm. After the zero point is established the valve position is changed, by-passing charcoal tube so that the air sample passes directly into the light cell. A pump operating continuously circulates the sample at a rate of about 10 liters per minute.

The large compartment of the instrument contains the measuring phototube, which is mounted so that light from the low pressure mercury vapor lamp passes through the light cell onto the photosensitive surface of the tube. Below the lamp is a reference phototube to compensate for minute fluctuations of lamp intensity. A coarse adjustment to equalize the light to the phototubes is made by a variable slit which is adjusted by means of a screw on the outside of the case. A potentiometer in the phototube battery circuit is used for the fine balancing adjustment. A constant voltage transformer and a monocyclic square resonant constant current network deliver a constant light output in spite of wide changes in line voltage and lamp temperatures and pressures.

A type 32 tube operating at reduced filament and plate voltages is used as a sensitive electrometer light balance indicator. The tube control leads pass through the partition into the battery compartment. Grid bias control and phototube balancing potentiometers with the plate microammeter are mounted in the battery compartment. A switch is provided to ground the grid to standardize the electrometer.

The combination of voltage and current control with the compensating reference phototube, integral sample cell and light valve and rapid sampling and standardizing systems were all found necessary to provide the sensitivity and stability to measure changes in light intensity of less than .003 per cent.

Fig. 5—The gas-sampling chamber section. The chamber is fitted with quartz windows and contains a micrometer screw whose shadow falls on the phototube cathode



FOURTH ANNUAL
BROADCAST ENGINEERING CONFERENCE

OHIO STATE UNIVERSITY, COLUMBUS, OHIO . . . FEBRUARY 10-21

FIRST WEEK — FEB. 10-15

	9 a.m. to 11 a.m.	11 a.m. to 1 p.m.	2:30 p.m. to 4:30 p.m.
Monday Feb. 10	SPEECH INPUT SYSTEMS C. M. Lewis - RCA J. D. Colvin - RCA	SOUND REPRODUCTION FROM RECORDINGS F. V. Hunt Harvard University	TELEVISION STANDARDS W. R. G. Baker General Electric Company
Tuesday Feb. 11	STUDIO ACOUSTICS Paul J. Washburn Johns-Manville		COLOR TELEVISION Peter C. Goldmark Columbia Broadcasting System
Wednesday Feb. 12		GENERAL DISCUSSION AND QUESTION BOX Andrew Ring - FCC Lynne C. Smeby - NAB	THE STATUS OF TELEVISION Harry Sadenwater Radio Corporation of America
Thursday Feb. 13	POLYPHASE BROADCASTING Paul Loyet Central Broadcasting Company		TELEVISION STATION OPERATION Robert M. Morris National Broadcasting Company
Friday Feb. 14	ROUND TABLE ON RECEIVERS J. Kelly Johnson Hazeltine Corp. E. B. Passow Zenith Radio Corp. W. L. Dunn Belmont Radio Corp.	LOUD SPEAKERS H. F. Olson Radio Corporation of America	TELEVISION FIELD PICKUPS Harold P. See National Broadcasting Company
Saturday Feb. 15			

SECOND WEEK — FEB. 17-21

	9 a.m. to 11 a.m.	11 a.m. to 1 p.m.	2:30 p.m. to 4:30 p.m.
Monday Feb. 17	THE STATUS OF FREQUENCY MODULATION Edwin H. Armstrong Columbia University	F-M ALLOCATION AND COVERAGE Stuart Bailey Jansky & Bailey	HEARING, THE DETERMINING FACTOR FOR HIGH FIDELITY Harvey Fletcher Bell Telephone Laboratories
Tuesday Feb. 18	F-M RECEIVERS M. L. Levy Stromberg-Carlson	U-H-F ANTENNAS AND TRANSMISSION LINES Andrew Alford Mackay Radio and Telegraph Company	U-H-F TRANSMISSION Kenneth A. Norton Federal Communications Commission
Wednesday Feb. 19	F-M FIELD TESTS Raymond F. Guy National Broadcasting Company		
Thursday Feb. 20	OPERATING PROBLEMS IN F-M TRANSMITTERS I. R. Weir General Electric Company	ROUND TABLE ON F-M PROBLEMS E. J. Content - WOR Paul deMars - Yankee Network Dan Gellerup - WTMJ	U-H-F TUBES E. D. McArthur General Electric Company
Friday Feb. 21	F-M BROADCAST TRANSMITTER CIRCUIT DESIGN John F. Morrison Bell Telephone Laboratories		

SPECIAL FEATURES

Tuesday, February 11 — 8 p.m. Chittenden Hotel — E. K. Jett, " Communication in National Defense "
Thursday, February 13 — 6:30 p.m. — Dinner, Ft. Hayes Hotel
Saturday, February 15 — Basketball Game — Ohio State vs. Purdue
Tuesday, February 18 — 8 p.m. Chittenden Hotel — G. C. Southworth, " Wave Guides "
Thursday, February 20 — 6:30 p.m. — Banquet, Ft. Hayes Hotel

R-F Matching Sections

A graphical method of computing the shunt and series elements of L-type matching sections for matching a complex impedance to a resistance such as those of an antenna and its transmission line, in terms of the antenna and line impedances

By A. C. OMBERG
WSM, Nashville, Tennessee

WHEN a resistive impedance is to be matched to a complex impedance, for example, a transmission line to an antenna, a simple means of effecting a proper impedance match is the use of the L-type section, consisting of a series inductance and a shunt capacitance. A typical matching section of this type is shown in the accompanying circuit. The charts printed below have been prepared to allow a rapid determination of the shunt and series elements in terms of the terminating impedance values.

It is assumed that the complex terminating impedance (that of the antenna) is of the form $R + jX$, that the reactance of the series inductance arm is X_s, while that of the shunt capacitive arm is X_c. Then X and X_s can be combined in series to form the total inductive reactance X_L. The impedance looking into the L-section, terminated by $R + jX$, will then be

$$Z_{in} = \frac{-jX_c(jX_L + R)}{R + j(X_L - X_c)}$$

When the input of the L-section is terminated in a pure resistance R_o, the surge impedance of the transmission line, a proper match is obtained when the reactive component of Z_{in} is zero, and when the resistance component is equal to R_o. With these conditions specified, the reactances X_L and X_c may be computed from

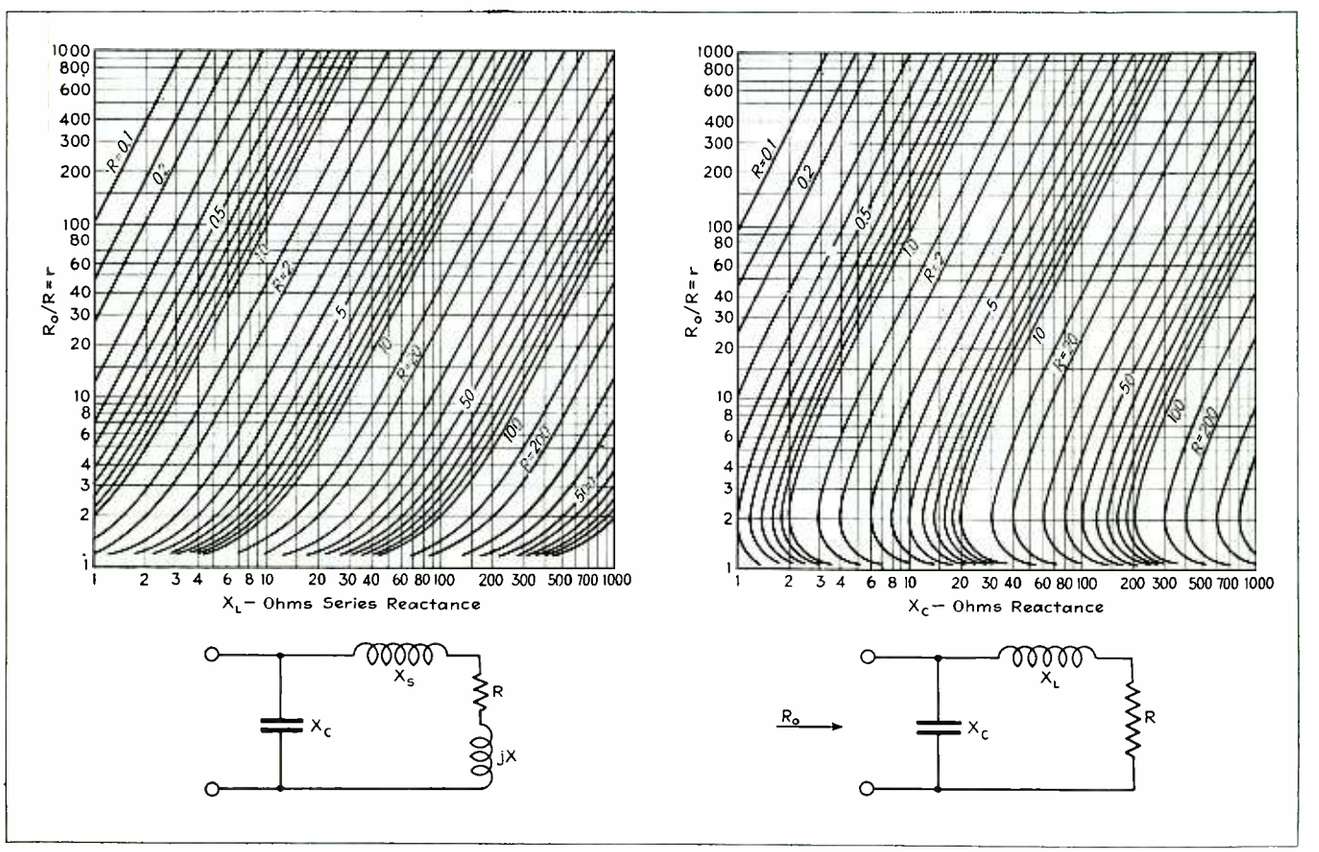
$$X_L = R\sqrt{r - 1}$$

and

$$X_c = Rr/\sqrt{r - 1}$$

where r is the ratio R_o/R. The curves printed below give X_L and X_c in terms of r and R. As an example, suppose the antenna displays an impedance of $25 + j50$ ohms, and the surge impedance of the line is 250 ohms. Then $r = 250/25 = 10$, and $R = 25$. From the curves $X_L = 75$ ohms and $X_c = 90$ ohms. The shunt reactance is accordingly $-j90$ ohms, and the total series reactance is $+j75$ ohms, $+j50$ ohms of which is contributed by the antenna inductance. Hence the necessary additional series inductance is $+j25$ ohms. It should be noted that this type of network is useful only when r is greater than 1.

Charts for determining total series inductance and shunt capacitance in r-f matching sections



ELECTRONICS REFERENCE SHEET

TUBES AT WORK

A color organ which automatically synchronizes light with music according to pitch and volume, a low cost percentage modulation meter, and a solenoid whip antenna to increase the field strength of a transmitter by a factor of four

Color-Music for the Home

By ROBERT D. BURCHFIELD

IN SPITE OF MUCH OPINION to the contrary, the author believes that color-music, synchronized with audible music, will meet with favor in the average home. Luminous color effects automatically controlled by radio and phonograph music will be called here "automatic color-music."

Electronic equipment is most suitable for synchronizing color effects with music. A popular automatic color-player, the Patterson-RCA instrument, is essentially a large-scale machine, using saturable reactors and thyratron tubes in connection with frequency filters and, of course, audio amplification. The color changes produced by it represent the variations in pitch of the music being interpreted, with red and orange for the low notes, yellow and green for the medium ones, and blue and violet for the high pitches. This "frequency analogy" of sound and light is widely accepted by workers in the art, since it has some psychological basis.

Equipment of the Patterson-RCA type was used in the Firestone "Singing Color Fountains" at the Chicago Century of Progress and at subsequent expositions (including New York World's Fair). In this spectacular exhibit a row of fountains serves as the display medium for the play of colored light—an arrangement that benefits by the added appeal of moving water. The popular success of such color-music presentations is evidence that some form of automatic color-organ would be appreciated by the average radio set owner—especially if he has a phonograph unit.

In U.S. Patent No. 2,131,934 the author describes a color player in which three small low-voltage lamps (red, green and blue), disposed behind a translucent screen, give a luminous interpretation of music according to the frequency analogy of sound and light. If a type 42 power pentode is used, the number of tubes in the circuit can be reduced to two.

The results produced by apparatus of this type are marked by the presence of excessive flicker and low luminous output. By means of modification of the circuit, the author has simultaneously eliminated both of these shortcomings. The improved color-organ utilizes five receiving-type tubes and three 15 watt 110-volt lamps. Figure 1 shows this unit installed in a radio-phonograph. The lamps are inside the translucent glass sphere. Low, medium and high tones of music actuate the red, green and blue 15-watt lamps. The

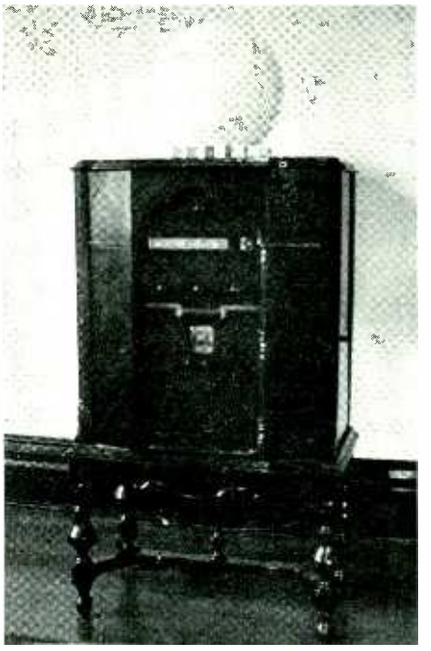


Fig. 1—Lights controlled by the color organ are enclosed in the translucent globe atop the cabinet

lights operate without the flicker evident in the early two-tube form. Mixtures of the primary colors produce all the other hues of light, and loudness of the sound or music governs the overall brightness of the luminous display.

After thoughtful and critical observation of this color-player in action, the author realized that it somehow is inadequate for a satisfying interpretation of music. Although such a home color-organ is technically suited for its purpose, aesthetically it is lacking. It appeared to be necessary to add something in order to achieve luminous effects which more nearly give the impression of music-made-visible.

Reasoning that a dual instrument might be the answer, the author added a separate circuit and a separate group of lamps. The lamps of this supplementary group are disposed as indicated in Figure 2, and are served by a circuit similar to the first, but functioning according to the *amplitude* of the audible music. The lamp pairs 2 to 4 gradually light up in succession as the sound amplitude increases, and vice versa. The pair 1 is on with zero signal and dims as pair 2 brightens. The effect of such action is one of mounting and subsiding motion, beside color change. In this manner, crescendoes and diminuendoes are strikingly interpreted.

To the unaccustomed eye, the single-acting (color-change with pitch) instrument is adequate for musical accompaniment; but to the same eye the dual color-organ seems many times more remarkable.

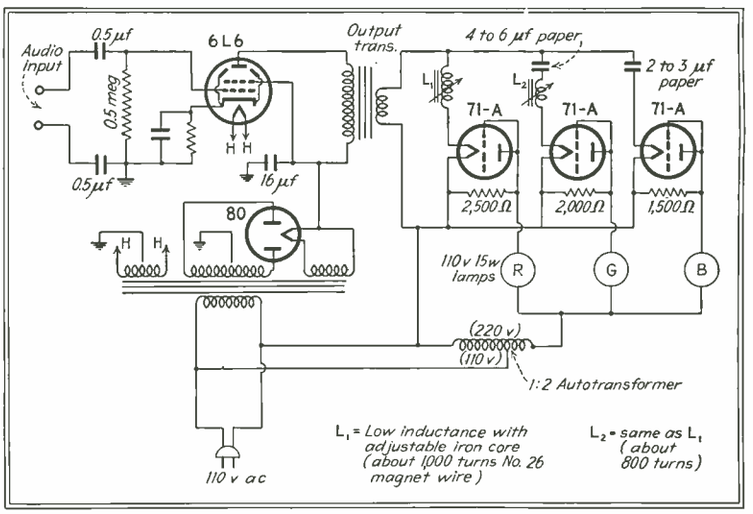
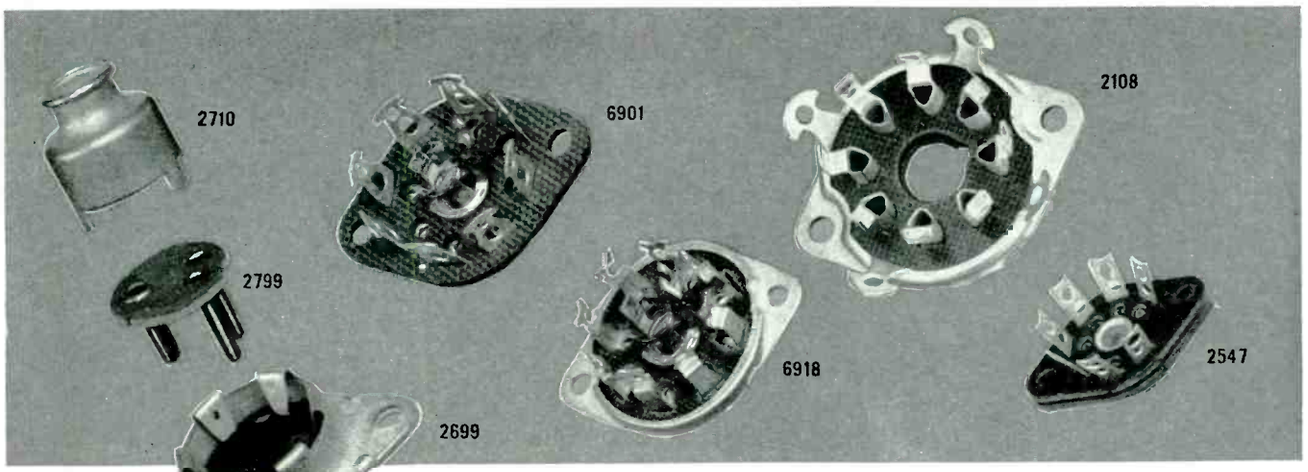


Fig. 4—Circuit diagram showing how amplified signal is divided into three portions by filters according to frequency to light lamps of the proper colors



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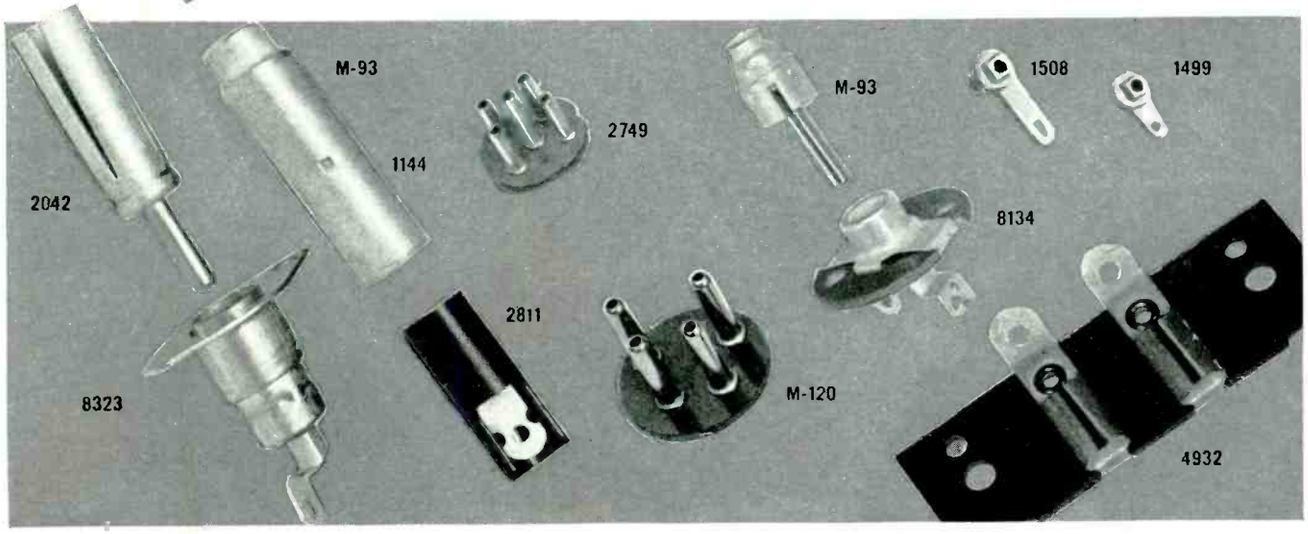


Figures 3, 4, and 5 show the circuit diagrams of the author's color instruments. Figure 3 is the original two-tube circuit. Figure 4 gives the circuit of the improved apparatus employing 110 volt lamps. Figure 5 illustrates the circuit of the new dual-action instrument.

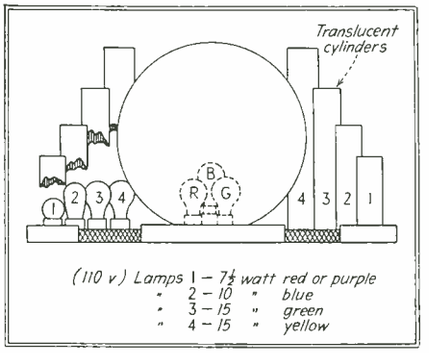
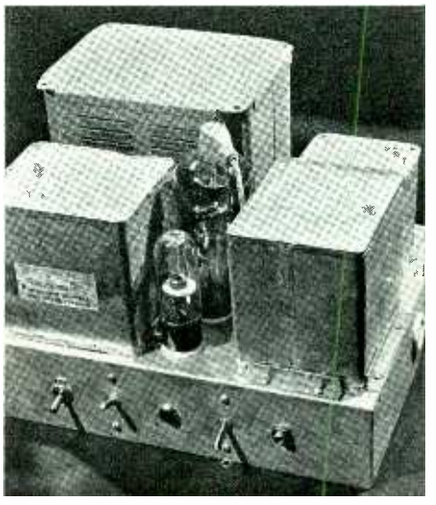


Fig. 2—Arrangement of lamps in unit which changes illumination with both pitch and volume

In Fig. 4, the low-voltage high-current audio signal delivered by the low-impedance secondary of the output transformer is separated into three frequency ranges by the branch filters, and passes through the three 6-volt lamps. Each lamp therefore responds to its own particular range of audio frequencies in the music being interpreted. The red lamp, being in series with an inductive reactor, responds to those frequencies representing deep tones; the green lamp, with its series resonant circuit, responds to an intermediate band of tones, and the blue

• • •

HIGH-SPEED LIGHT CONTROL



This compact, simple equipment uses a Strobotron as the timing and flashing mechanism for flashing a gaseous discharge tube used in high speed photography, after the method developed by Edgerton and his associates at M.I.T.

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● *At Left*—The Westinghouse Mazda Photolamp Exposure Calculator is made of tough white National Vulcanized Fibre with a special surface for printing ink. (Weston Emulsion Ratings appear on the reverse side.)

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● The National Vulcanized Fibre and Phenolite, laminated bakelite, insulating parts—thanks to their high electrical, mechanical properties and durability—are key factors in the perfect synchronization and long life of the Chardelle Meteor Flash. Both Phenolite and National Vulcanized Fibre possess outstanding qualities which make them practical in countless uses. They are available in sheets, rods, tubes and special shapes.

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lamp is actuated by the high audio frequencies passed by its series condenser.

The inductors can be small solenoids with about 1000 turns of No. 26 covered magnet wire provided with adjustable sliding cores of laminated iron, and the condensers (paper) used by the author are around 4 or 5 μf for the green lamp and 2 or 3 μf for the blue. The inductance in the "red" branch is, of course, less than that in the green. If the right number of turns for each is found, cores are not

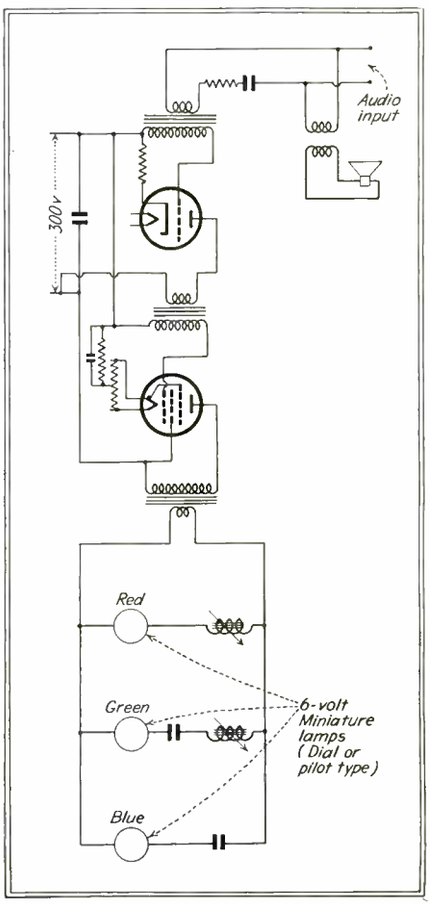


Fig. 3—Circuit using only two tubes to light colored lamps according to frequency of signal

necessary. All the values of the filter components are best determined by trial—the object being to get a balanced color effect. For the amplifier, a single 42 will, as mentioned before, serve in place of the two tubes shown.

In Fig. 4 the three 6-volt lamps of Fig. 3 are supplanted by the filaments of diode-connected 71-A tubes, and the lamps in this case (110 volt, 15 watt) are in the anode circuit of the "control" tubes. The thermal inertia of the 71-A filaments irons out the fluctuations that cause annoying flicker and at the same time a power amplification is afforded by the unusual control method. It will be seen that the load conditions imposed upon the 71-A tubes are rather severe, and therefore a special tube might well be designed

for this application. However, the author's model has been in intermittent use for several months and the performance of the 71-A's has not changed to date.

In the circuit of the dual-action color-organ (Fig. 5) the circuit of Fig. 4 is combined with a similar circuit employing taps on the output transformer secondary instead of

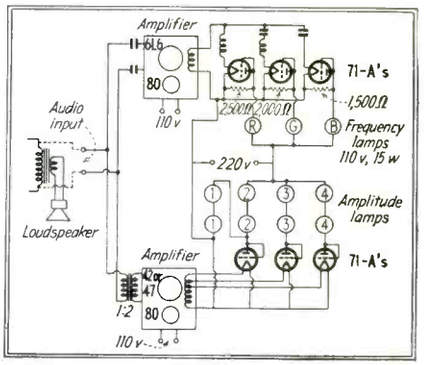


Fig. 5—Circuit of dual action color-organ in which the color of the lights vary with pitch and the intensity with volume

series filter elements. The action of this "intensity" or "amplitude" section is apparent from the diagram and from the previous description in connection with Fig. 2.

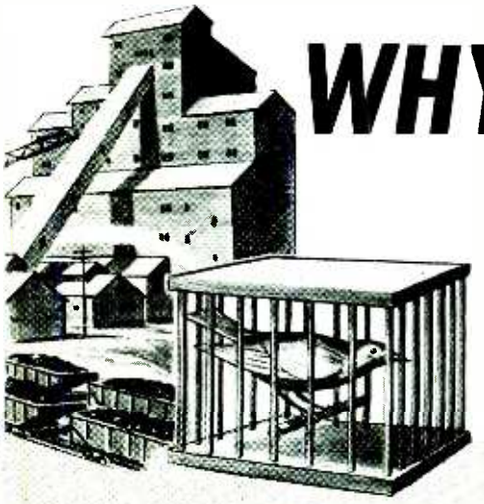
Although the idea of having two (or more) kinds of color changes in one display is not new in the realm of color-music, the author believes that it is new in connection with automatic color-music. Many variations of presentation and action are possible with multiple instruments, but the form described is practical and impressive. It features just enough complexity of effect to give the observer the impression of "seeing" music.

• • •

A Percentage Modulation Meter

By S. T. Carter

A DEVICE FOR THE MEASUREMENT of modulation percentage is generally too costly to warrant its use for purposes other than those of regular broadcast stations. While for services other than broadcast the use of an instrument of the type used at broadcast stations may be desired it is not generally necessary, while most composite units are in themselves often costly and more often have several adjustments to be made before actual measurements are made. The instrument described makes use of one meter for reading both the carrier current and the actual percentage of modulation through a switch arrangement, has no calibrating voltage to adjust and has only one variable control, the r-f or carrier input potentiometer. In addition to its use as a modulation meter and carrier shift indicator the



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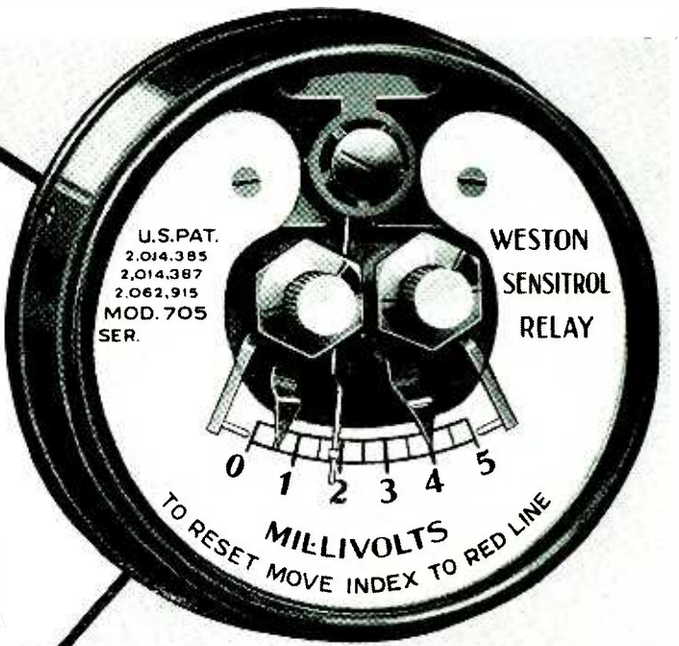

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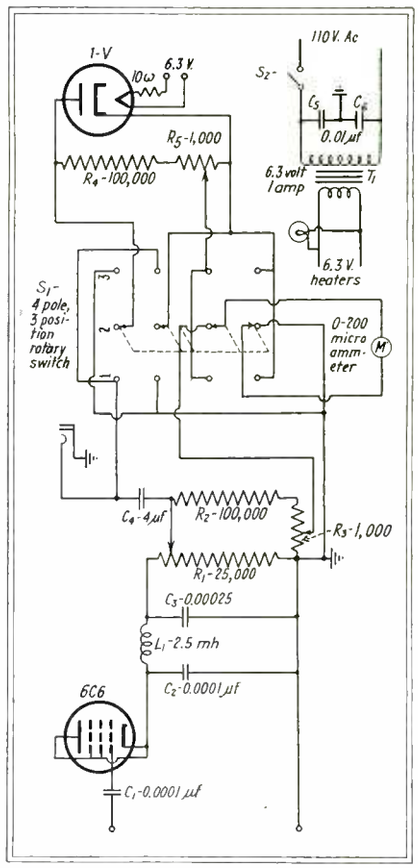

Fig. 1—Circuit diagram of percentage modulation meter

instrument may be used as an audio monitor by inserting a pair of headphones or an amplifier in the monitor jack.

This instrument may be constructed in any manner suited to its use, as a panel unit or for portable use in a small metal can. In either case the cost should be under $30.00, including the cost of the indicating meter.

The actual construction should present no problem, since in three different units constructed by the writer, all gave about the same results as far as sensitivity and frequency response were concerned. The frequency response is within 1 db from 30 to 9,000 cps, more than adequate for any purpose to which the meter may be put.

Figure 1 shows the circuit used. The r-f lead from its termination at the binding post through the 0.0001 μf condenser to the grid of the tube should be short, direct and well clear of all other wiring in order to minimize r-f in the second diode circuit.

After construction the resistors R_3 and R_5 should be adjusted. A minimum amount of coupling should always be used to the final amplifier stage of the transmitter, when making these adjustments, as well as in actual use. For the adjustment of R_3, set the peak- carrier switch S_1 to the center position (number 2). This position reads the carrier voltage. Advance the potentiometer control R_1

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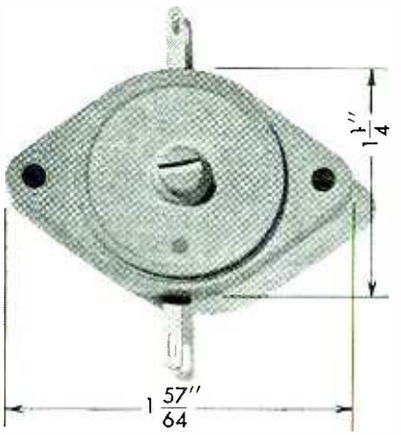
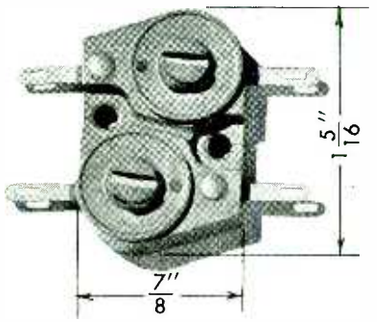
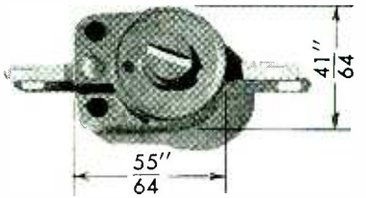


TYPE	CAPACITY MIN.	MAX.
STYLE TS5D		
NPO	< 5	> 30
N300	< 7	> 50
N500	<10	>110



STYLE TD2A		
NPO	< 3	> 12
N300	< 5	> 20
N500	< 7	> 45



STYLE TS2A		
NPO	< 3	> 12
N300	< 5	> 20
N500	< 7	> 45

BASED on the principle of the well-known fixed-capacity Erie Ceramicons, these Ceramicon Trimmers provide a uniform, straight-line capacity change per degree of rotor rotation.

Erie Ceramicon Trimmers consist essentially of a silver electrode fired on the top surface of a steatite base, and a circular ceramic dielectric rotor with a coating of silver fired on its upper surface. Both the under surface of the rotor and the silvered ceramic base are lapped and held in close contact by a constant pressure spring, making the assembly dust proof. Due to the mounting base being made of a low dielectric-constant steatite, Ceramicon Trimmers may be mounted on a metal chassis with only a slight increase in the minimum capacity.

These units are made in three standard styles, illustrated at the left, each of which is available in three temperature coefficients of capacity; 0, $-300 \times 10^{-6}/°C$ and $-500 \times 10^{-6}/°C$.

The design and excellent operating characteristics of Erie Ceramicon Trimmers have been well proven in thousands of cases of actual operation. A data sheet has been prepared describing the characteristics and ranges of Ceramicon Trimmers in detail. Write for your copy.

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to about three fourths scale and with a minimum amount of coupling to the final r-f stage of the transmitter, adjust R_3 until the meter indicates half scale. This reading will always be the carrier reference point and any deviation from this value will effect the accuracy of the instrument.

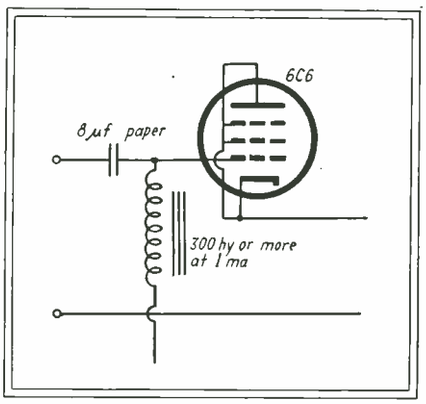

Fig. 2—Method of calibrating percentage modulation meter

The adjustment of R_5 and the actual calibration of the peak indication part of the instrument may be made in several ways. If a calibrated modulation meter is available it may be made directly from this source. A steady tone should be used to modulate the transmitter to some convenient value, 70, 80 or even 100 per cent. Then the carrier is adjusted so the meter position shows a reading of half scale with the switch in position 2. The peak-carrier switch is then set to read the proper positive or negative peak (position 1 or 3). Adjust R_5 until the meter indicates the proper percentage. In the event the two meters cannot be made to read the same value, the coupling to the final amplifier should either be tightened or loosened and the value of R_3 changed to again bring the carrier reading back center scale. The instrument may be calibrated with the aid of an oscilloscope, using 100 per cent modulation as a calibration point.

In the event there is no oscilloscope or calibrated meter at hand, Fig. 2 shows another method of calibration. An 8 μf paper condenser is shunted across the 0.0001 μf mica unit of Fig. 1. A variable source of direct voltage is connected to the input of the 6C6 tube through the audio choke as shown. With the carrier input control set at three-fourths of full scale the d-c voltage is adjusted until the meter indicates the half-scale required. Then a variable source of alternating voltage is connected to the r-f input terminals and adjusted until the carrier meter just starts to show an upward movement. This value is 100 per cent modulation. The carrier-peak switch is then shifted to read peaks and the value of R_5 adjusted until the instrument indicates 100 per cent modulation. The alternating voltage used in this adjustment should have

The AMERICAS in '41

Naturally, the United States of America must assume leadership in solidifying the New World, so that all outside nations must respect its Peoples. A United States industrially strong, is the bulwark by which this vision shall become a reality.

Superior Tube Company is a young organization, but measured by its service to all types of industry, we have achieved a position that compels us to look to the far distant future.

An addition to our buildings and equipment is under way, so that by the second quarter of this year the output of Superior small tubing will be as much as 75% greater than in the year just closed.

We believe that, while we have a vital place in the Defense Program, we are obligated to maintain a continuous flow of tubing to the many customers who have helped so earnestly to establish us. Regardless of their line of business, they need us and we propose to see to it that their trust in Superior has not been misplaced.

Our plant by April should be a rather extraordinary production unit. We expect to make things hum in '41.

SUPERIOR TUBE CO.

["*Small Tubing is our only business, and we know it.*"]

NORRISTOWN, PENNSYLVANIA

Tubing from 5/8" OD down . . . SUPERIOR Seamless in various analyses. WELDRAWN Welded and drawn Stainless. BRAWN Welded and drawn "Monel" and "Inconel". SEAMLESS and Patented LOCKSEAM Cathode Sleeves.

"FOR FINE SMALL TUBING"

good wave form. The 110-volt 60-cps supply should serve very well.

If a beat frequency oscillator or other source of variable frequency voltage is available the frequency characteristics of the instrument may be determined. With the direct voltage used to simulate the carrier and the a-c input voltage constant, the frequency of the a-c voltage is varied through the audio range. The deviations may be read on the instrument itself, with the peak-carrier switch set to read peak values.

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A Solenoid-Whip Aerial

By WILLIAM R. WILSON
Royal Canadian Mounted Police

A SOLENOID-WHIP AERIAL was developed over a year ago for the Royal Canadian Mounted Police intermediate frequency two-way police radio system in the Province of Manitoba. This aerial produces an increase in field strength of four times as compared to a whip aerial of the same height, or, in other words, it is equivalent to an increase in transmitter power of 16 times.

Before proceeding to describe the solenoid-whip aerial, it might be well to examine the problem of feeding a very short aerial on the medium frequencies. The aerial at its base will look like a highly capacitive reactance in series with a very small loss and radiation resistance. Measurements made on an 8-foot whip aerial on 4165 kc would indicate that the aerial

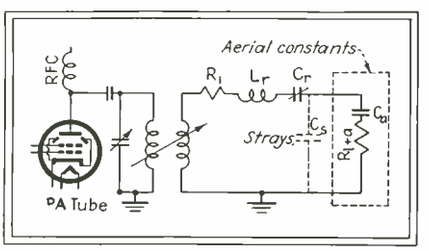
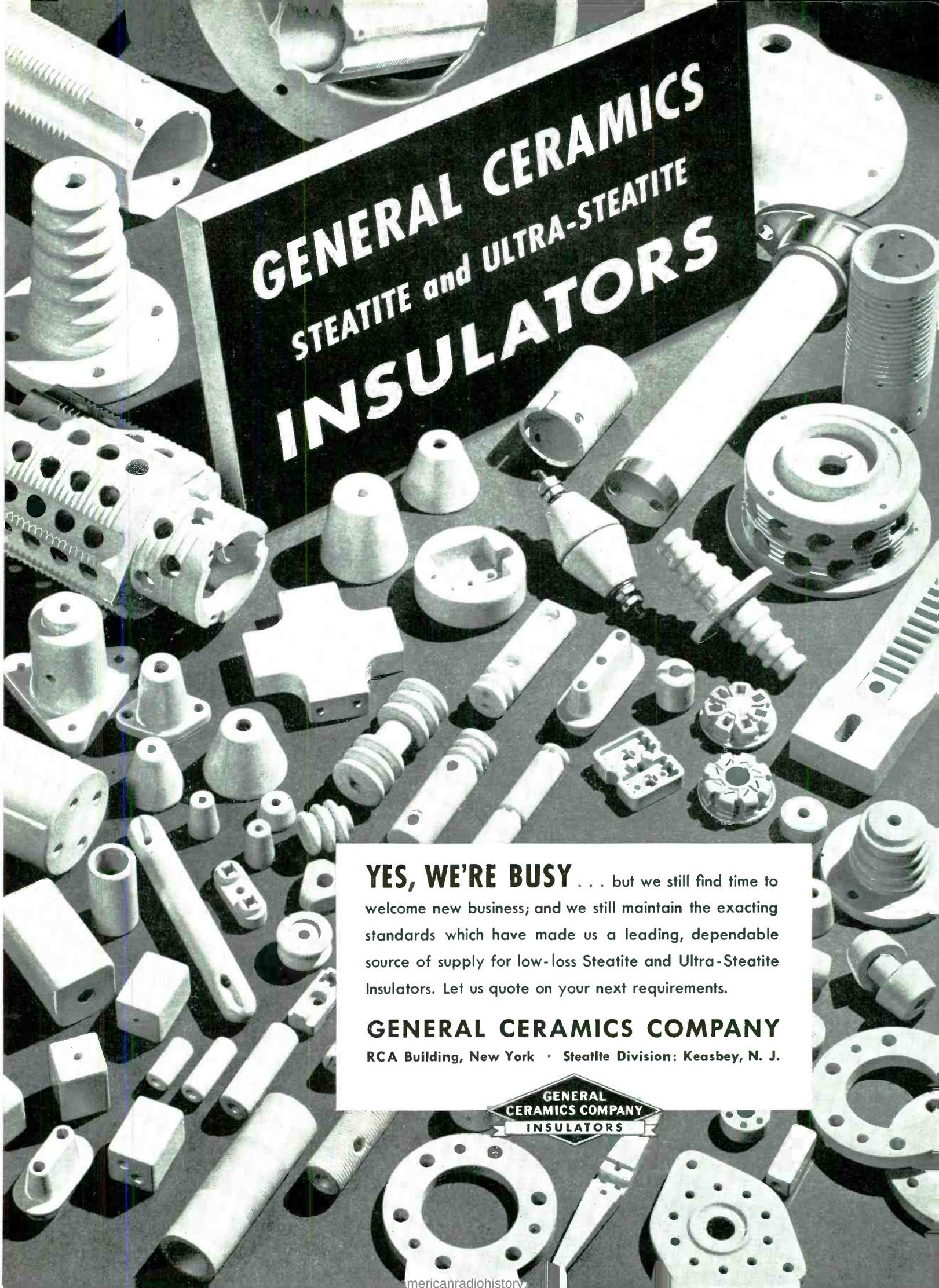


Fig. 1—Circuit of conventional whip antenna

was simulated by 15 $\mu\mu$f in series with a resistance of less than 1 ohm. Difficulty was experienced in measuring accurately the loss and radiation resistance of the aerial due to its very small value. We may then draw the aerial circuit as in Fig. 1.

It will be observed that if C_s is large compared with C_a that most of the r-f current will circulate through C_s and not through C_a and the antenna radiation and loss resistance. Most of the output power will then be dissipated in R_1. It was found by experiment that it was possible to increase the field strength from 700 microvolts per meter to 1200 microvolts per meter at one mile by reducing the capacity across the aerial base insulator from approximately 8 $\mu\mu$f to 3 $\mu\mu$f. It is obvious



YES, WE'RE BUSY . . . but we still find time to welcome new business; and we still maintain the exacting standards which have made us a leading, dependable source of supply for low-loss Steatite and Ultra-Steatite Insulators. Let us quote on your next requirements.

GENERAL CERAMICS COMPANY

RCA Building, New York · Steatite Division: Keasbey, N. J.

GENERAL CERAMICS COMPANY
INSULATORS

from the above description that it is most important that the capacity between the base of the aerial and the car be kept as low as possible by careful consideration to its mounting and stray wiring capacities.

As a result of these measurements it was thought desirable to mount the resonating inductance at the base of the aerial and coaxial with it so that the stray capacities could be kept to a minimum and also so that its field would produce useful radiation. The

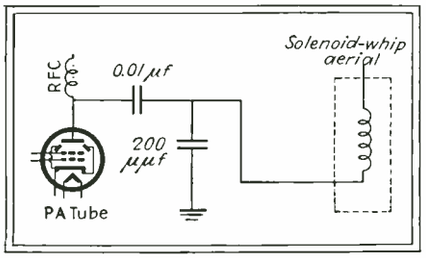


Fig. 2—Circuit of solenoid whip antenna

gain in field strength on 4165 kc resulting from this change was found, however, to be only 10 per cent. The size of the resonating coil was 3½ inches diameter by 3½ inches long wound with No. 12 wire on a bakelite form.

The diameter and length of the resonating inductance mounted at the

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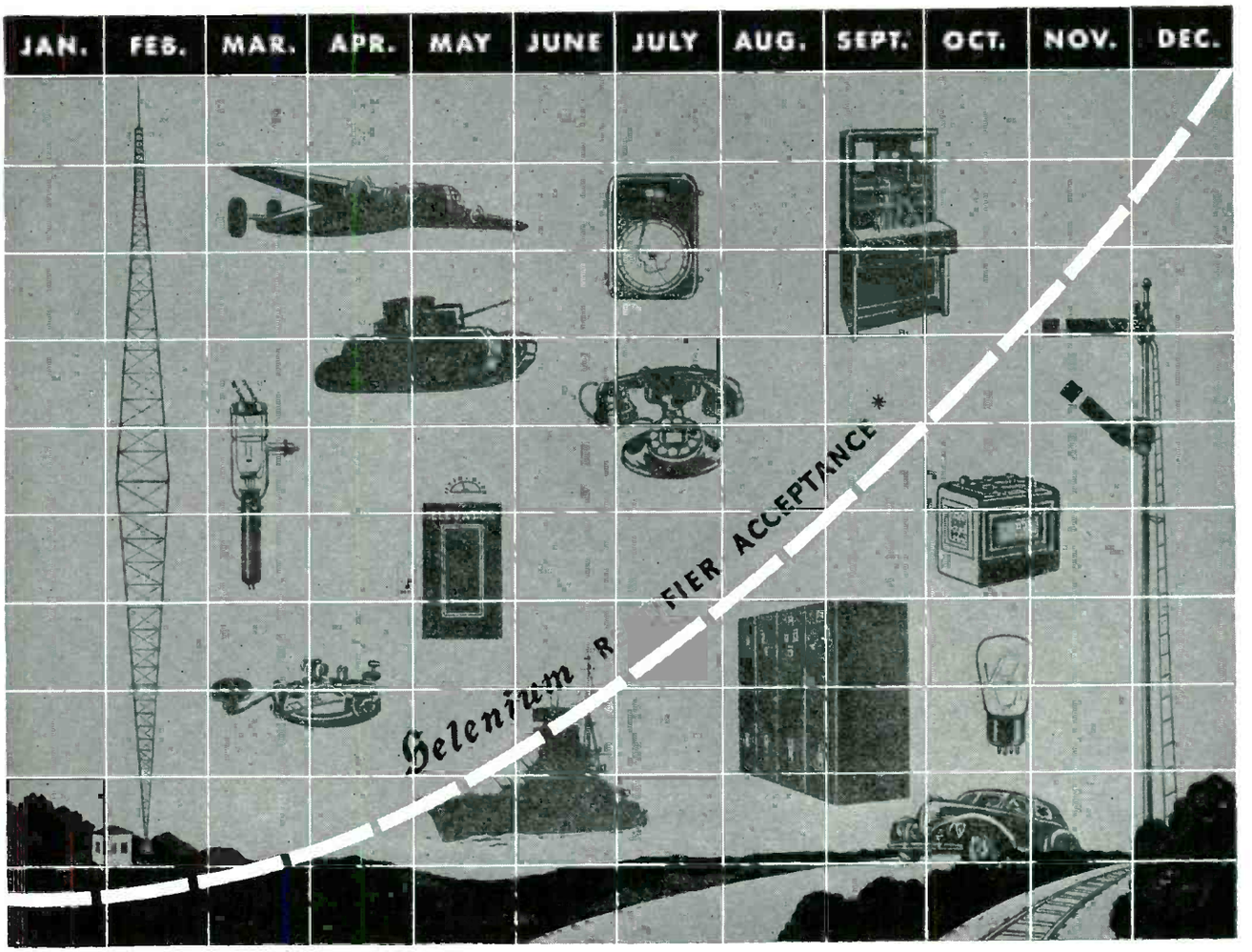
LIGHT ON A NOVELTY

Shown recently at Chicago's Merchandise Mart was this combination lamp and radio receiver with tuning dial in the base and the volume control immediately above. The main upright is of moulded bakelite and—in case you're interested—the shade is of celanese taffeta



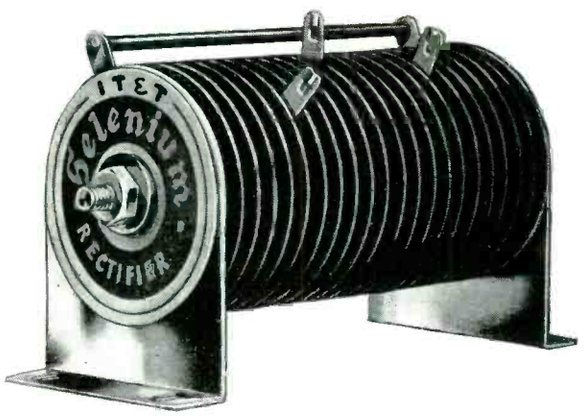
ACCOMPLISHMENT

the growth of a new product in the United States

During the year 1940 the I. T. & T. Selenium Rectifier has quickly found popularity over a wide range of applications wherever continuous current is obtained from alternating current sources.

With its remarkable efficiency, ruggedness, wide temperature range, low back leak, compactness and light weight, the I. T. & T. Selenium Rectifier looks forward to 1941 with confidence for still wider ranges of application.

**Curve shows actual monthly growth in sales during 1940.*



INTERNATIONAL TELEPHONE DEVELOPMENT CO., INC.
137 Varick Street, New York, N. Y.

base of the aerial were then varied and the field strength measured keeping a constant power output from the transmitter all subsequent measurements being made on 4165 kc. It was necessary to vary the height of the whip aerial which was mounted on the top of the solenoid as the length of the solenoid was varied so that the overall height from the bottom of the solenoid to the top of the whip aerial remained constant at 8 feet. The solenoid was mounted on the same base insulator as was used for the whip aerial. The solenoids were wound on dry wooden dowels which had been boiled in paraffin for several hours. The wire size was No. 12 B. & S. and in all cases they were wound at 6 turns per inch and their inductance was adjusted so that the electric length of the solenoid and whip aerial was $\frac{1}{4}$ wavelength. It was found that by making

Fig. 3—Solenoid whip antenna attached to rear of patrol car

the solenoid long and slender that the field strength could be increased by 2.4 times. A solenoid 2 inches in diameter and 2 feet long wound with 141 turns was about the optimum size and resulted in the maximum gain in field strength. By increasing the length of the solenoid to 4 feet and making its diameter 1.25 inches, the field strength was reduced 8 per cent. This would appear to be due to the rather rapid reduction in the Q of the coil due to its large ratio of length to diameter. There are two factors contributing to this large increase in field strength: one is that the stray capacities to the base of the whip aerial are reduced considerably and the other reason is that useful radiation is obtained from the resonating coil when its length is made long.

It has been found that by winding the 2-foot solenoid on a bakelite form and making it inductive at its base, i.e.,

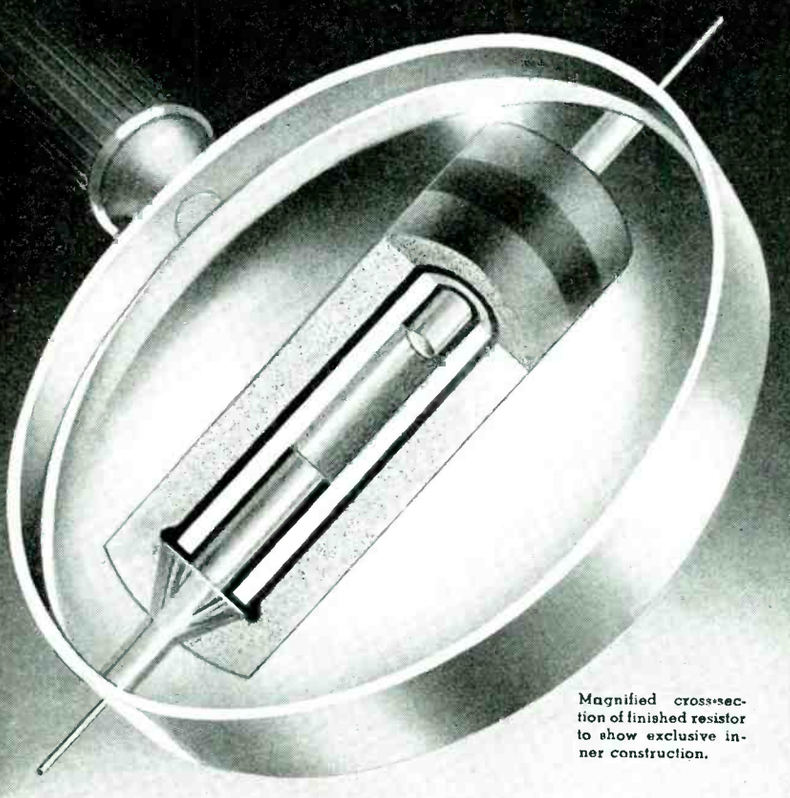
The COLONEL'S LADY and JUDY O'GRADY Are NOT Sisters Under Their Skins!

1. A glass tube, continuously drawn with utmost precision to the size of a small pencil lead, is the beginning of an IRC Type BT Insulated Resistor.

2. The tube with a coating of Metallized type resistance material permanently bonded to its outer surface, and stabilized by a baking process.

3. Special leads for easy soldering have enclosed, positive contact to element which cannot open. Insertion of leads *inside* the element tube aids rapid heat dissipation, drawing heat out of the resistor.

A finished 1-watt unit. Element is *completely* sealed by molded insulating phenolic. Moisture cannot enter. No possibility of grounding. Leads anchored *inside* insulation cannot turn or pull loose.



Magnified cross-section of finished resistor to show exclusive inner construction.

Flattering and widespread imitation following IRC's development of the Insulated Resistor with its obvious advantages as compared with old-style, non-insulated units has resulted in such uniformity of appearance that it is difficult to distinguish one make from another. *This similarity, however, is only skin deep—only as deep as the insulation.*

What lies beneath is of the utmost importance from the standpoint of performance. The outside insulation is important only because it protects the inside resistance element, prevents shorting and facilitates rapid and economical assembly. Not this protection *but what it protects* is the final determining factor of quality—and it is *underneath* this insulation that insulated resistor similarity ends.

As an outstanding example, the IRC type BT insulated resistors, comprising the unique "Metallized" filament element and specially developed insulating phenolic covering, have humidity characteristics hitherto unobtained. More than 10 cycles of alternate two hour immersions in 100°C. and 0°C. salt solution followed by two hour loadings at normal rating result in an average change in resistance value of less than 10%.

In connection with the present defense program such performance is essential for dependable communication equipment but it is also obviously very important for all commercial applications.

TYPE BT INSULATED RESISTORS

INTERNATIONAL RESISTANCE CO., 403 N. BROAD ST., PHILA.

slightly longer electrically than a ¼-wave aerial so that it would resonate a condenser of approximately 200 $\mu\mu$f connected between the plate of the power amplifier and ground as shown in Fig. 2, that a gain in field strength of 4 times results as compared to a whip aerial the same height. This is equivalent to an increase in transmitter output power of 16 times. There are a number of factors contributing to this increase in field strength over the former solenoid-whip aerial. They are:

(a) The bakelite construction.
(b) The base of the aerial is now a high impedance high voltage point.
(c) Useful radiation is obtained from the field set up by the tank current flowing through the solenoid.

Figure 3 shows the method of mounting the solenoid-whip aerial on the car. The steel brackets are isolated from the solenoid by a 10-inch length of bakelite for the reasons as already outlined.

At the present time the Royal Canadian Mounted Police have ten police cars in the rural districts around Winnipeg equipped with intermediate frequency two-way radio using the solenoid-whip aerials. The approximate maximum daylight ranges which may be obtained from police cars using solenoid-whip aerials and a 13-watt telephone transmitter are somewhat greater than the following figures; the ground conductivity values are also indicated.

West of Winnipeg 70 miles 170×10^{-15} emu.

North-East of Winnipeg 60 miles 100×10^{-15} emu.

South of Winnipeg 60 miles 150×10^{-15} emu.

North of Winnipeg 46 miles 60×10^{-15} emu.

These ranges are obtained when the atmospheric noise on 4165 kc could be classed as average daylight conditions. The ranges are naturally variable over a period of time due to the variability of atmospheric noise and under conditions of very heavy static which may occur on some nights, they may be reduced approximately 50 per cent. The percent intelligibility on telephony at these ranges is very high under the average conditions as mentioned.

The ranges using a standard 8-foot whip aerial with a 10-watt telephone transmitter are as below. The decrease in transmitter power from 13 to 10 watts would result in only a 12 per cent decrease in field strength, a negligible amount.

West of Winnipeg 50 miles.
North-East of Winnipeg 40 miles.
South of Winnipeg 37 miles.

The ranges using the 8 foot whip aerial were not tested under identical conditions but they serve sufficiently well for comparative purposes. The signal level at these ranges is not as high as the signal level at the limits of the range with the solenoid-whip aerial as listed above.

Variations in ground conductivity

STACKPOLE HAS THE BIG LINE OF LITTLE SWITCHES

DESIGNERS—if you've got a job on your hands that calls for cost-cutting and space-saving, look to Stackpole for your switches. The four compact, inexpensive types illustrated here have innumerable applications for handling small power circuits.

TYPE SS-1

—a single pole, single throw switch with Underwriters' Approval for .75 amp. 125 volts. Also supplied as Type SS-2 with three terminals and double throw for: Two-position tone control; Sensitivity control; Change-over switch for AC-DC sets; Line switch for small sets; Small motor control; Tap switch for power transformers; etc.

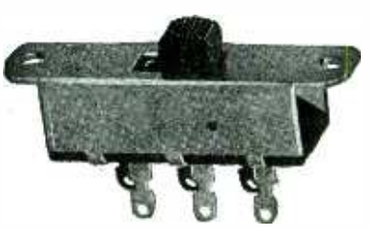
TYPE SS-7

—a three position slide switch which may be used as a three position tone switch, two speed small motor switch with off position or as a bright—dim—off light switch.

Illustrations are actual size

TYPE SS-9

—a single pole, double throw slide switch for use as a record reject switch or any other application requiring a momentary contact switch which is returned to its normal position when operating pressure is removed.



TYPE SS-3

—a double pole double throw switch with Underwriters' Approval which suggests itself for the following uses: Change-over switch for 110 volt battery sets; Band change switch; Phono-radio switch, and many other uses. Supplied also as SS-4—a double pole single throw type.

STACKPOLE MAKES:

1. VARIABLE RESISTORS—For use as volume controls, tone controls, potentiometers for controlling voltages, rheostats for controlling current.
2. FIXED COMPOSITION RESISTORS — Insulated resistors rated at 1/3 watt, 1/2 watt and 1 watt. Noninsulated resistors rated at 1/2 watt, 1 watt and 3 watt. Resistance range 10 ohms to 20 megohms.
3. SLIDE OPERATED SWITCHES—A complete line of slide operated switches either indexed or momentary contact type ranging from single pole, single throw to six pole, double throw. Many of these types have been approved by the Underwriters'.
4. ROTARY INDEX SWITCHES — For use as tone control, sensitivity controls, or any other application requiring indexed switch positions. Available only in single pole type with maximum of four positions.
5. TOGGLE SWITCHES — Tab mounting snap switches with external toggle. Approved by the Underwriters'.
6. IRON CORES — Compressed powdered iron cores for use in permeability tuning, inductance trimming or fixed inductance IF coils.

WRITE FOR SAMPLES AND PRICES

In addition to the above radio products the Stackpole Carbon Company manufactures every known type of carbon products.

FIXED RESISTORS • SWITCHES

STACKPOLE CARBON COMPANY

ST. MARYS, PENNA., U.S.A.

These products are sold only to manufacturers of original equipment.

VOLUME CONTROLS • TONE CONTROLS

over a radius of 70 miles about Winnipeg have a small detuning effect on the tank circuit comprising the solenoid-whip aerial as shown in Fig. 2 but it is low enough to be neglected.

The polar characteristics of the solenoid-whip aerial shows that the field strength is 40 per cent higher in a direction through the aerial and the head lamp on the opposite side of the car from which the aerial is mounted, the field strength being greater in the forward direction gradually decreasing to a minimum at an angle 180 from this line of maximum field strength. In practice the directional effect is small enough to be neglected.

This work indicates some of the possibilities of aerials of this and similar types and it is believed that there is a fertile field for useful and practical development in aerial design along the general lines as indicated. In those cases where the length of the aerial is small compared to a $\frac{1}{4}$ wavelength on the operation frequency this aerial built on a suitable scale would have an application for reception and transmission. Some of the obvious applications are for transmission and reception, for mobile units, for portable radio equipment and especially on low frequencies aboard aircraft where, due to certain considerations, it is not possible or desirable to use trailing wire aerials. It is believed these principles might also have application to aerials for low frequency fixed stations where it is desired to limit the aerial height.

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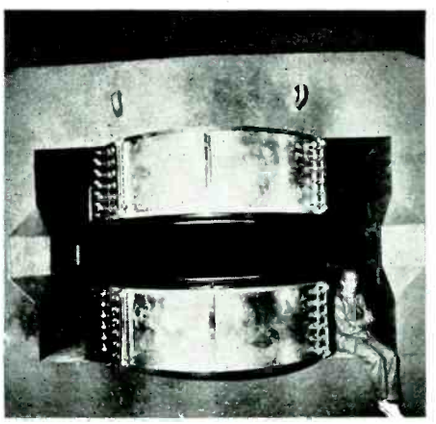
ATOM SMASHER IN THE MAKING



What looks like the jaws of a monster are two exciting coils for a cyclotron being assembled in the Department of Terrestrial Magnetism at the Carnegie Institution at Washington, D. C. The coils are mounted on a cast steel magnet pole 72 inches in diameter with tips 60 inches in diameter. Each coil has an outside diameter of 109½ inches, is 29 inches high and weighs about 15 tons

Tube Registry

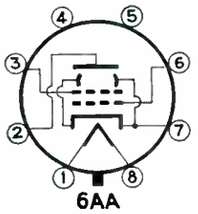
Tube Types Registered by R.M.A. Data Bureau During November 1940

Type 50A5 (GL)

Prototype 50L6GT

BEAM power amplifier, heater type; T-9 integral glass envelope base; seated height 2⅝ inches, 8-pin lock-in base.

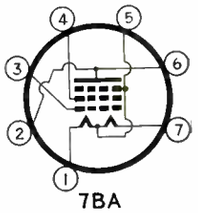
E_h = 50 v
I_h = 0.15 amp
E_b = 200 v (max)
E_{c2} = 110 v
E_{c0} = −8 v
I_{b0} = 50 ma
I_{c20} = 1.5 ma (nom'l)
r_p = 35,000 ohms
g_m = 8250 μmhos
R_l = 3000 ohms
P_o = 4.7 watts (10%)
Basing 6AA-L-O



Type 3S4 (GB)

POWER amplifier pentode, filament type, T-5½ glass envelope-base; seated height 1⅞ inches (max) 7-pin button base.

E_f = 2.8 or 1.4 v
I_f = 0.05 or 0.1 amp
E_b = 67.5 v
E_{c2} = 67.5 v
E_c = −7 volts
I_b = 7.2 ma
I_{c2} = 1.5 ma
g_m = 1550 μmhos
r_p = 0.1 megohm
R_l = 5000 ohms
P_o = 180 milliwatts (10%)
Basing 7BA-O-O

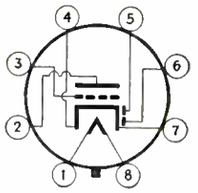


Type 14E6 (GL)

Prototype 7E6 (GL)

DOUBLE-DIODE, medium-mu triode; heater type T-9 integral glass envelope-base; seated height 2¼ inches, 8-pin lock-in base.

E_h = 12.6 v
I_h = 0.15 amp
E_b = 250 v
E_c = −9 v
I_b = 9.5 ma
μ = 16
r_p = 8500 ohms
g_m = 1900 μmhos
Basing 8W-L-7

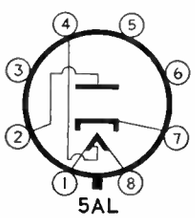


Type 35Y4 (GL)

Prototype 35Z5GT

HALF-WAVE rectifier; heater type (tapped), T-9 integral glass envelope-base; seated height 2⅝ inches, 5-pin lock-in base.

E_h = 35 v
I_h = 0.15 amp
E_{tap} = 7.5 v
E_{rms} = 700 v (max)
E_{kk} = 350 v (max)
I_{dc} = 100 ma (max)
I_p = 600 ma (max)
E_{drop} I_p (200 ma) = 20 v
Basing 5AL-L-O



Tubes registered with the R.M.A. Data Bureau during the month of November, 1940 and during 1934, 1935 and 1936

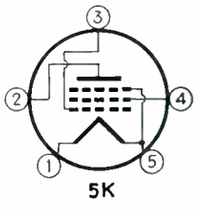
SEVERAL readers have inquired why tubes released as early as 1934 are listed currently in this Department. While it is true that the primary purpose of the list is to bring new tubes to the attention of readers, the secondary purpose is to compile ultimately a complete list of all tubes, receiving, transmitting and industrial, for reference use. The latest tubes are listed first each month. A semi-annual index is published to aid readers in locating data on the new as well as the older types—The Editors.

Tube Types Registered by R.M.A. Data Bureau in 1934, 1935 and 1936

Type 1F4

POWER amplifier pentode, filament type, ST-14 glass envelope, seated height 4 1/16 inches, 5-pin octal base.

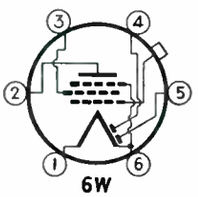
E_f = 2.0 v
I_f = 0.12 amp
E_b = 135 v
E_{c2} = 135 v
E_c = −4.5 v
I_b = 8.0 ma
I_{c2} = 2.4 ma
R_l = 16,000 ohms
P_o = 0.310 watt (5%)
Basing 5K



Type 1F6

DUPLEX diode pentode, filament type, ST-12 glass envelope, seated height 3 3/32 inches, 6-pin base.

E_f = 2.0 v
I_f = 0.06 amp
E_b = 180 v (max)
E_{c2} = 67.5 v (max)
E_c = −1.5 v
I_b = 2.2 ma
I_{c2} = 0.7 ma
r_p = 1 megohm (approx)
g_m = 650 μmhos
Basing 6W



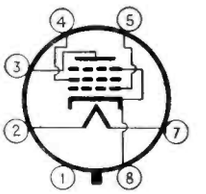
TELEVISION PROGRESS SHOW

Exhibits of television progress featured the opening of the first national convention of the Television Engineers' Institute of America in Hollywood. C. Fred Wolcott, chief engineer of the Gilfilan Laboratories and George H. Seward, president of the T. E. I. A. are shown as they arranged a convention demonstration

Type 6F6

POWER amplifier pentode, heater type, metal envelope, seated height 2 1/16 inches, 7-pin octal base.

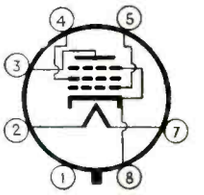
E_h = 6.3 v
I_h = 0.7 amp
E_b = 250 v
E_{c2} = 250 v
E_c = −16.5 v
I_b (zero signal) = 34 ma
I_{c2} (zero signal) = 6.5 ma
R_l = 7000 ohms
P_o = 3.2 watts (8%)
Basing 7S



Type 6F6 (G)

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

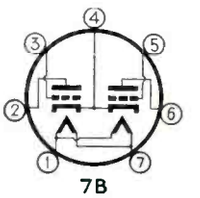
E_h = 6.3 v
I_h = 0.7 amp
E_b = 250 v
E_{c2} = 250 v
E_c = − 16.5 v
I_b (zero signal) = 34 ma
I_{c2} zero signal) =6.5 ma
R_l = 7000 ohms
P_o = 3.2 watts (8%)
Basing 7S



Type 6E6

DOUBLE triode power amplifier, heater type, ST-14 glass envelope, seated height 4 1/16 inches, 7-pin base.

E_h = 6.3 v
I_h = 0.6 amp
E_b = 250 v
E_c = −27.5 v
I_b = 18 ma per plate
r_p = 3500 ohms per plate
R_l = 14,000 ohms per plate
P_o = 1.6 watts
Basing 7B



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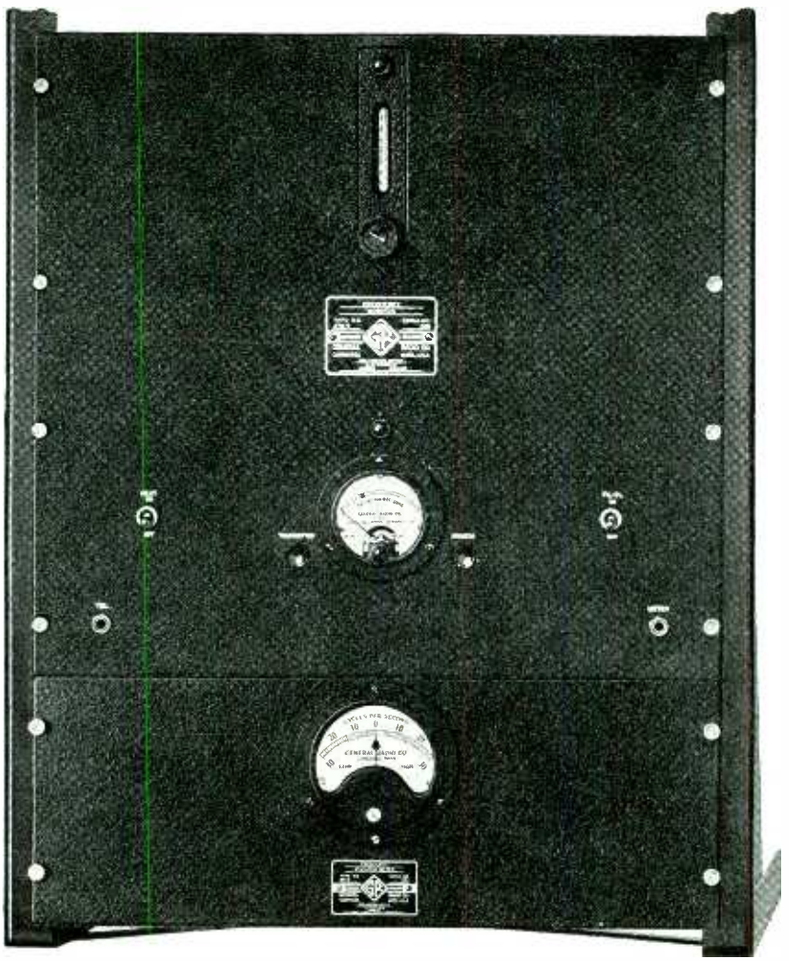
UNCLE SAM MONITORS THE ETHER

Unlicensed stations carrying on illegal communications have made it necessary for the F.C.C. to cope with this problem in a simple but effective manner. Here Lewis K. Meriwether is shown driving the radio monitoring automobile which not only is equipped to record illegal transmissions on wax cylinders, but has apparatus for direction finding to spot the sought station to within 100 yards.



Why Not Modernize NOW!

IN MARCH of next year, most broadcasting stations shift to new frequencies, requiring a corresponding change in frequency in their frequency monitor. In preparation for this shift, why not modernize your entire monitoring equipment to take care of the F.C.C. Rule allowing only 20-cycle tolerance for all broadcasting stations? The G-R Type 25-A Frequency Monitor is approved by the F.C.C. for the new Rule and bears F.C.C. Approval No. 1461.

So why don't you kill two birds with one stone and shift to the new frequency and to the new tolerance in your monitoring equipment and get it over with?

Many new electrical and mechanical features are incorporated in the G-R Frequency Monitor. Some of these are:

1—Large deviation meter with 30-0-30 cycle scale
2—High-stability oscillator circuit as used in primary standards
3—Amplifier to isolate crystal oscillator
4—Input amplifier to isolate transmitter
5—New foolproof temperature-control system
6—Improved high-stability frequency deviation-meter circuit
7—AVC circuit on deviation meter
8—Simplified operation
9—New simplified layout for easy replacements
10—Diode voltmeter to adjust input level

G-R Monitors are equipped with dress panels so that you can now secure a monitor to match any of five standard broadcast-equipment panel finishes from stock. Unfinished panels can be supplied for finishing by the user and subsequent assembly by us so that your monitor can have ANY panel finish you desire.

You can't go wrong in selecting a G-R Monitor. G-R has pioneered in broadcast frequency measuring equipment since broadcasting started. G-R Monitors are used by hundreds of the leading stations.

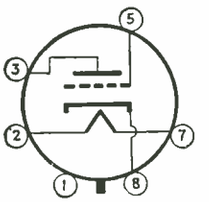
Type 175-C	**Frequency Monitor**	**$330.00**
Type 681-B	**Frequency Deviation Meter**	**145.00**
Type 376-L	**Quartz Plate**	**85.00**
Type 25-A	**Frequency Monitor**	**$560.00**

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

Type 6D5 (G)

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

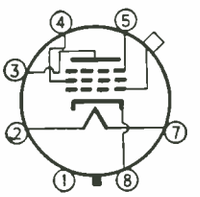
E_h = 6.3 v
I_h = 0.7 amp
E_b = 275 v
E_c = − 40 v
I_b = 31 ma
R_l = 7200 ohms
P_o = 1.4 watts
Basing 6Q



Type 6K7

TRIPLE-GRID super-control amplifier, remote cutoff, heater type, metal envelope, seated height $2\frac{9}{16}$ inches, 7-pin octal base.

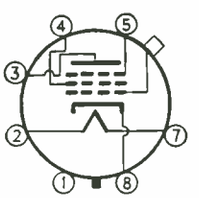
E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_{c2} = 100 v
E_c = − 3 v
I_b = 7.0 ma
I_{c2} = 1.7 ma
r_p = 0.8 megohm
g_m = 1450 μmhos
Bang 7R



Type 6K7 (G)

TRIPLE-GRID super-control amplifier, remote cut-off, heater type, ST-glass envelope, seated height $3\frac{33}{32}$ inches, 7-pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_{c2} = 100 v
E_c = −3 v
I_b = 7.0 ma
I_{c2} = 1.7 ma
r_p = 0.8 megohm
g_m = 1450 μmhos
Basing 7R



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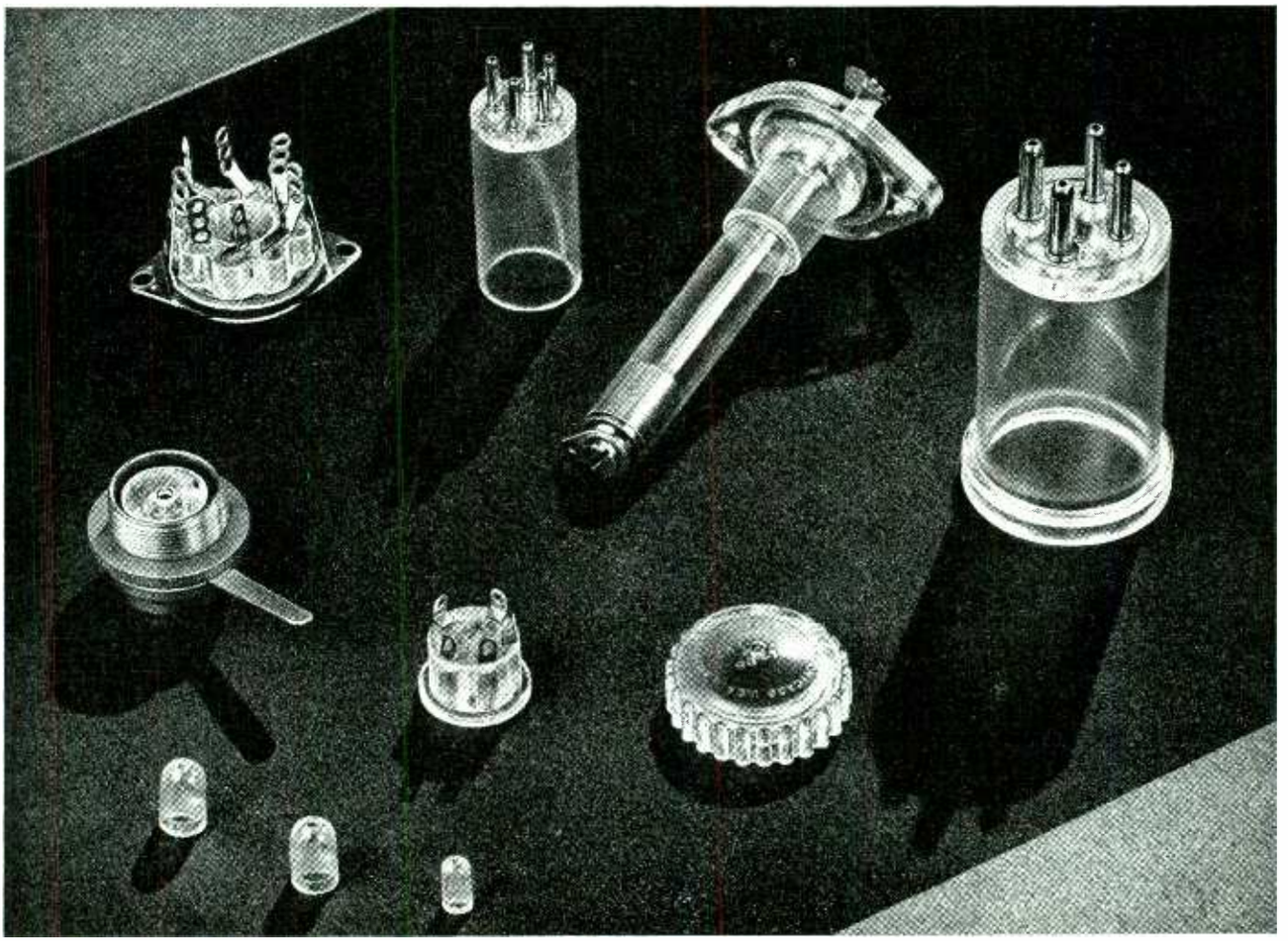
MEASURING SOUND IN AUTOMOBILES

An engineer of the Ford Motor Co. making readings of sound levels in an automobile as part of the regular routine research entering into the automotive industry's research program

Minimum Power Loss — Maximum Efficiency

FOR HIGH FREQUENCY APPARATUS

with Bakelite Polystyrene Insulation



UNEXCELLED by any other organic insulation, because of superior low-loss characteristics and exceptional resistance to moisture, Bakelite Polystyrene plastics present unlimited opportunities for greater efficiency in high frequency apparatus.

Among the numerous Bakelite Polystyrene parts providing improved dielectric performance, there are many made by American Phenolic Corporation. These include low-loss coil forms for high frequency receivers and low power transmitters, as well as sockets that eliminate draft at tube bases. There are also sturdy insulators for stand-off and feed-through purposes that reduce surface leakage to a minimum. Outstanding, too, are specially designed low-loss insulating beads permitting flexing of high frequency or high voltage leads without uncovering the wire.

Learn how Bakelite Polystyrene plastics can be profitably employed in your own electronic equipment by enlisting the cooperation of Bakelite Research and Development Laboratories.

BAKELITE CORPORATION
Unit of Union Carbide and Carbon Corporation
UCC
30 EAST 42ND STREET, NEW YORK

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TRADE MARKS
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PLASTICS HEADQUARTERS

Consider these advantages of BAKELITE POLYSTYRENE for high frequency equipment

POWER FACTOR
(60 to 50,000,000 cycles)
.0002—.0003

DIELECTRIC CONSTANT
(60 to 50,000,000 cycles)
2.50—2.60

LOSS FACTOR (60 to 50,000,000 cycles)
.0005—.0008

DIELECTRIC STRENGTH (60 cycles)
500 to 525 volt/mil

VOLUME RESISTIVITY
Over 10^9 megohm cms.

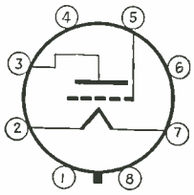
ARC RESISTANCE
(proposed A.S.T.M. method)
120 to 140 secs.

Type 1H4 (G)

Prototype 30

TRIODE detector amplifier, filament type, ST-12 glass envelope, seated height $3\frac{29}{32}$ inches, 8-pin octal base.

E_f = 2.0 v
I_f = 0.06 amp
E_b = 180 v
E_c = − 13.5 v
I_b = 3.1 ma
g_m = 900 μmhos
r_p = 10,300 ohms
Basing 5S

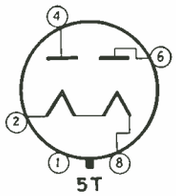


Type 5W4

FULL-WAVE, high-vacuum rectifier, filament type, metal shell, seated height, $2\frac{1}{16}$ inches, 5-pin octal base.

E_f = 5.0 v
I_f = 1.5 amps
CONDENSER INPUT TO FILTER
E_{ac} (per plate, rms) = 350 v (max)
I_{dc} = 100 ma (max)
CHOKE INPUT TO FILTER
E_{ac}(per plate, rms) = 500 v (max)
I_{dc} = 100 ma (max)

E_{drop}(I_{dc} = 100 ma per plate) = 45 v
Basing 5T



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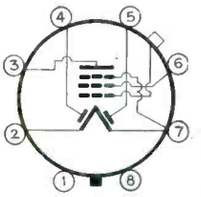
LIGHTNING DISMANTLED

Workmen dismantling the 40-ton lightning generator used at Steinmetz Hall, the G-E exhibit at the New York World's Fair. A portion of this equipment is to be sent to the high voltage laboratory of the United States Bureau of Standards for further studies in high voltage phenomena

Type 1F7 (G)

DOUBLE diode pentode, filament type, ST-12 glass envelope, seated height $3\frac{23}{32}$ inches, 8-pin octal base.

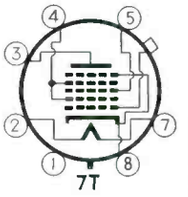
E_f = 2.0 v
I_f = 0.06 amp
E_b = 180 v (max)
E_{c2} = 67.5 v (max)
E_c = −1.5 v
I_p = 2.2 ma
I_{c2} = 0.7 ma
r_p = 1 megohm (approx)
g_m = 650 μmhos
Basing 7AD



Type 6L7 (G)

PENTAGRID mixer converter, heater type, ST-12 glass envelope, seated height $3\frac{23}{32}$ inches, 7-pin octal base.

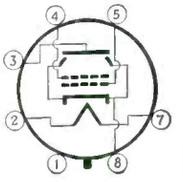
E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
$E_{c2,4}$ = 100 v
E_{c1} = − 3 v
E_{c3} = − 10 v
I_b = 2.4 ma
$I_{c2,4}$ = 7.1 ma
r_p = greater than 1 megohm
g_c = 375 μmhos
Basing 7T



Type 6L6

BEAM power amplifier, heater type, metal shell, seated height $3\frac{3}{4}$ inches, 7-pin octal base.

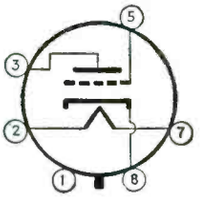
E_h = 6.3 v
I_h = 0.9 amp
E_b = 350 v
E_{c2} = 250 v
E_c = − 18 v
I_b(zero signal) = 54 ma
I_{c2}(zero signal) = 2.5 ma
R_l = 4200 ohms
P_o = 10.8 watts
Basing 7AC



Type 6J5 (G)

DETECTOR amplifier triode, heater type, ST-12 glass envelope, seated height $3\frac{9}{16}$ inches, 6-pin octal base.

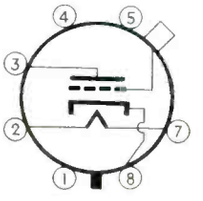
E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_c = −8.0 v
I_b = 9.0 ma
r_p = 7700 ohms
μ = 20
Basing 6Q



Type 6K5 (G)

HIGH-MU triode, heater type, ST-12 glass envelope, seated height $3\frac{13}{32}$ inches, 7-pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_c = − 3 v
I_b = 1.1 ma
μ = 70
r_p = 50,000 ohms (approx)
Basing 5U

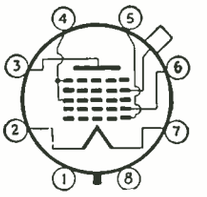


Type 1C7 (G)

Prototype 1C6

PENTAGRID converter, filament type, ST-12 glass envelope, seated height $3\frac{29}{32}$ inches, 8-pin octal base.

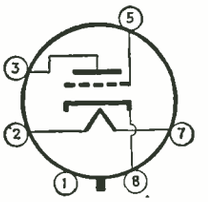
E_f = 2.0 v
I_f = 0.12 amp
E_b = 180 v max
$E_{c3,5}$ = 67.5 v (max)
E_{c2} = 180 through 20,000 ohms
E_{c4} = − 3 v
I_b = 1.5 ma
$I_{c3,5}$ = 2.0 ma
I_{c2} = 4.0 ma
g_c = 325 μmhos
Basing 7Z



Type 6C5

DETECTOR amplifier triode, heater type, metal envelope, seated height $2\frac{1}{16}$ inches, 6-pin octal base.

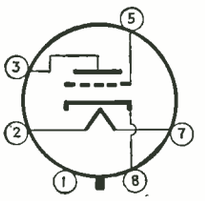
E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_c = − 8 v
I_b = 8.0 ma
μ = 20
g_m = 2000 μmhos
Basing 6Q



Type 6C5 (G)

DETECTOR amplifier triode, heater type, ST-12 glass envelope, seated height $3\frac{9}{16}$ inches, 6-pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_c = − 8 v
I_b = 8.0 ma
μ = 20
g_m = 2000 μmhos
Basing 6Q



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ENGINEERS BROADCAST

Thomas F. Joyce, RCA vice president, conducts a round table discussion with a group of RCA engineers over WFIL. Seated left to right are Dr. G. A. Morton, electronic research engineer, Mr. G. L. Beers, television research engineer, Mr. Joyce, and Dr. H. F. Olson, acoustic research engineer

Sound in Motion Pictures

(*Continued from page 19*)

One of the most disturbing characteristics of the earlier film sound records, was the high level of film background noise. The average level of this noise was determined by the unmodulated track density in the case of the variable density record, and by the width of the clear portion of the unmodulated sound track in the case of the variable area record. The noise level of a typical unmodulated sound track was seldom more than 30 to 35 db below the maximum sound level that could be obtained from a fully modulated track. As a consequence, those intimate scenes in a picture which required the use of relatively low level dialogue or background music suffered greatly during reproduction. The introduction of sound track employing noise reduction in 1930 extended the volume range of the sound record by 10 to 15 db and made possible sound-on-film recording with a much greater volume range than that which could be obtained on discs. Basically, noise reduction on variable density film is secured by making the average transmission of the print sound track proportional to the amplitude of the sound being recorded at any given instant. In variable area sound track, to reduce noise, the average width of the clear portion of the track is made proportional to the amplitude of the sound being recorded at any given instant.

At approximately the same period during which noise reduction was being adopted, the technique of recording had become sufficiently standardized so that some thought could be given to the improvement of frequency characteristics and to microphones, amplifiers, and theater speaker equipment. The first of the Western Electric moving coil microphones and of the RCA velocity microphones were made available to the industry in 1930. Whereas, it had been necessary to mount the microphone amplifier employed with the condenser microphone as close to the microphone as practical, the moving coil and ribbon type microphones

permitted a considerable length of cable between the microphone and the microphone amplifier. Microphone boom construction was correspondingly simplified and considerably greater ease of following action on the set with the microphone resulted. In addition, both of the new microphones exhibited very much better frequency-response characteristics than did the condenser microphone.

The first of the so-called wide-range recordings was released in 1932. These served to indicate not only the added naturalness which could be achieved by extending the frequency range, but, and what was probably more important, it brought to the attention of the equipment manufacturers and recording engineers the high degree of distortion which existed in the various components of the recording and reproducing channels. Whereas, the earlier standard recordings in many cases exhibited quality which was somewhat telephonic in character, the extended range recordings exhibited an unpleasant boominess and excessive sibilance which was extremely annoying. Investigations which followed indicated the necessity for equalizing the recording channel in such a manner as to decrease the low-frequency response on dialogue recordings. A portion of this equalization has been found necessary to compensate for the difference between the dialogue level existing at the position of the microphone during recording and the higher reproduction level existing in the theater. Another portion of this equalization, somewhat variable in amount, appears necessary to eliminate boominess, or low-frequency reverberation, of studio sets. Within the past few years, some thought and study has been directed to the determination of the character and amount of recording channel equalization necessary to compensate for variations in speech effort and corresponding changes in spectral energy distribution of the actors' voices during their performances.

Changes in degree of channel equalization and the insertion of low and high-pass filters of various sorts did little more, however, than reduce the degree of objectionable distortion existing during projection. It, therefore, became necessary

to investigate in detail the distortion characteristics of each component of the recording system as completely as possible. It was soon found that few, if any, of the amplifiers employed in the recording channel were nearly as free of distortion as had been assumed and a long program of amplifier redesign was undertaken. New distortion testing equipment made it possible to analyze accurately the amount of distortion caused by the recorder modulator units and by film processing, while further studies indicated the need for higher-powered, lower distortion theater amplifier and speaker equipment.

Amplifier distortion was reduced to an acceptable value by the use of transformers having improved frequency-response and impedance characteristics, by the use of larger vacuum tubes, by judicious use of negative feed-back and in cases where considerable power output was required, by the use of carefully balanced push-pull stages. The development of heater type vacuum tubes had progressed to a stage which permitted the design of completely a-c operated amplifier equipment for the entire recording channel. As a result of these improvements in design, the amplifiers employed today have extremely low signal distortion at full recording levels and have excellent frequency-response characteristics. The bridging amplifier employed by Warner Bros., for example, has a gain of 11 db at 1000 cps, with a maximum deviation from this value of but 0.3 db between 30 and 12,000 cps, and will deliver a power output level of +22 db referred to six milliwatts with a distortion of less than 0.5 per cent at all frequencies between 60 and 8,000 cps. The combined hum and noise level of either of these amplifiers is approximately −85 db with respect to six milliwatts.

The distortion introduced by the recording machine modulator unit has been brought to a satisfactory low value by redesign of the light valves and galvanometers and by decreasing the effective width of the recording slit image on the film. Further reduction of distortion in original recording has been made possible by the use of pushpull sound track. It is interesting to note that one of the first patents on push-pull recording was issued in 1911,

but no practical application was made of this method in motion picture production until 1935.

In Class A push-pull recording two sound records are photographed side by side along one edge of the film, one being 180 degrees out of phase with the other. Each of the tracks is in itself similar to a standard sound track and by combining the signal resulting from the two sound tracks out of phase, the even order distortion components introduced by undesirable film and processing characteristics are practically eliminated.

Class B push-pull recording differs from Class A in that each of the individual tracks recorded contains only one-half of the sound wave form. That is to say, all of the positive half-cycles of the sound wave are recorded on one of the tracks and all of the negative half-cycles of the sound waves are recorded on the other track. During reproduction of Class B sound track the original wave form is obtained by proper re-combination of the wave forms appearing on the two sound tracks.

The equipment used in the production of sound motion pictures will be discussed in Part II, to appear in an early issue of ELECTRONICS.

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ELECTRON MICROSCOPE

Dr. Gordon Scott of Washington University Medical School (St. Louis) examines the image on the fluorescent screen of an electron microscope. The specimen is inserted into the microscope at the point indicated by the arrow

THE ELECTRON ART

Secret use of inventions, cathodoluminescence in television, a new thermal resistance unit, principles of nomography, technique of single flash photography, and vacuum tube reconditioning are reviewed this month

Secret Use of Inventions and Patent Law

CONTINUING ITS EXCELLENT SERIES of articles on various phases of patent law the Allis-Chalmers *Electrical Review* presents an article entitled "Can You Keep A Secret" by D. Journeaux in the December 1940 issue. The inventor of a new process or machine must decide between keeping it a secret and take his chances on its remaining undiscovered or unused by others, or expose it to competition by getting a patent. There are several important aspects to this problem and Mr. Journeaux discusses them, making free use of court opinions.

The advantages of patenting an invention are obvious. If the inventor chooses secrecy, however, not only is he entirely powerless to stop a competitor who has later invented the same invention, but he may even conceivably see this competitor obtain a valid patent thereon. Also, it should be borne in mind by anyone tempted to keep secret his invention that in the present stage of industrial activity the same improvement is often invented independently by several people. That this is so is shown by numerous instances of patents for the same invention being applied for by several inventors. The protection afforded by secrecy which may have been dependable when those acquainted with manufacturing problems were few and far between, therefore, seems destined to become more and more illusory as industry continues to expand.

Cathodoluminescence in Television

A DISCUSSION OF LUMINESCENCE and luminescent materials by H. W. Leverenz appeared in the October, 1940 issue of the *RCA Review*. In the introduction Mr. Leverenz says: "This article on the subject of cathodoluminescence is offered so that those in the radio and television art may have an outline of the historical, theoretical and practical features of the last act in television's complicated task of seeing at a distance. The last act comprises converting modulated electrical impulses and electron currents into visible images which give the sense of uninterrupted continuity and motion." Synthetic luminescent materials have been known for 337 years, but they did not receive concentrated attention in the research laboratories until about ten years ago when cathode-ray television started to come into prominence. The constitutions and syntheses of the better phosphors are briefly outlined and a simplified theoretical discussion of phosphor luminescence is given. There are eight important qualities of a good phosphor, each of which must be possessed in a superior degree by phosphors intended for television picture tube use. They are: (1) ease of applying to form a picture tube screen, (2) ease of outgassing, (3) secondary emission, (4) stability, (5) heat and infrared effect, (6) emission spectra, (7) brilliancy and efficiency and (8) phosphorescense. Unjustified restriction or over-emphasis of any one of these qualities would automatically eliminate most of the phosphors which are excellent in all eight.

Thermistors, Their Characteristics and Uses

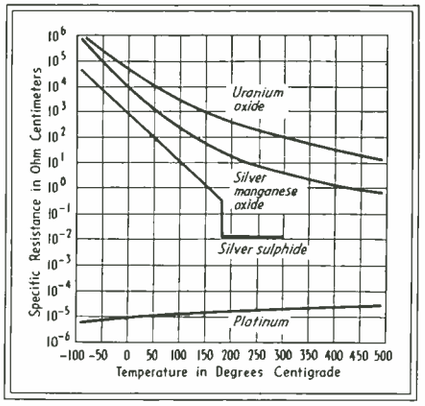
A NEW CIRCUIT ELEMENT whose electrical resistance varies rapidly with change in temperature is described in an article by G. L. Pearson in the December 1940 issue of the *Bell Laboratories Record*. It is called the thermistor, which is a contraction of the words "thermal resistor." These new units are made from a class of materials known as semi-conductors which have relatively large negative coefficients in contrast with metals which have small positive temperature coefficients of resistance. The accompanying diagram shows the resistance vs temperature characteristics for uranium oxide, nickel manganese oxide, silver sulphide and, as a comparison, the curve of platinum which has a small positive temperature coefficient and whose specific resistance is low. The curve for silver sulphide is linear and shows a linear relationship between the logarithm of the specific resistance and the temperature below 179 degrees C. At this temperature a change in crystal structure occurs which decreases its specific resistance by a factor of about 70. At higher temperatures the coefficient is slightly positive.

There are three common ways of using thermistors in electric circuits. In the first or externally heated method the resistance of the thermistor is controlled by the ambient temperature. The second or directly heated method

WAR DEPARTMENT'S AMATEUR CONTROL STATION

The War Department radio station WAR is available for direct communication with amateurs on Tuesday, Wednesday, Thursday and Friday evenings between 7 and 8 PM EST. It operates on a frequency of 4.025 kc. The army amateur radio system will be available for use during an emergency. Private Norton C. Richardson is sending a message and Major David Talley checks it

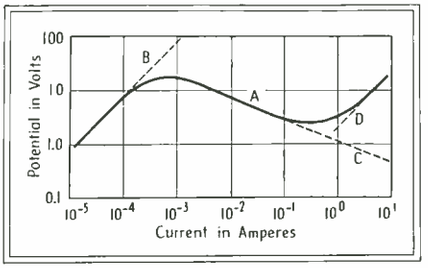
allows the electric current in the circuit to pass directly through the thermistor, thus heating it and changing the impedance in the circuit. The third or indirectly heated method uses a thermistor having a separate heating coil placed in a controlling circuit; the heat generated in it regulates the thermistor resistance. It should be



Resistance vs temperature characteristics of three thermistor materials and a metal

pointed out that silver sulphide or uranium oxide thermistors are usable only in alternating current circuits because the continued passage of direct current produces a polarization with an accompanying large increase in electrical resistance. Nickel manganese oxide does not polarize and is therefore equally stable in either a-c or d-c circuits.

A number of uses are suggested for this new circuit element. One of them is that of a resistance thermometer. In such an instrument the measuring current is kept so low that it produces no appreciable heating and the thermistor resistance is dependent only on the ambient temperature. Thermistors



Voltage vs current characteristic of a directly heated thermistor

may also be used to compensate for changes in resistance due to ambient temperature change in circuits having a positive temperature coefficient of resistance. This is accomplished by associating the thermistor with the circuit elements so that the change in resistance with temperature of the combination is equal and opposite to that of the remainder of the circuit.

Because of the resistance vs power

characteristics of thermistors, they are very useful as sensitive current and power-measuring devices. The extremely small capacitance contributes to their suitability for use in ultra-high frequency circuits. When placed in suitable bridge circuits thermistors may be used as flow meters, vacuum gages, or to measure other physical quantities dependent on the flow of thermal energy from a hot body. High sensitivity bolometers for the measurement of radiant energy have been built using directly heated thermistors for the temperature-sensitive element.

A standard relay may be made into a slow-acting device by putting a directly heated thermistor in series with its winding. The extent of delay depends on the thermistor characteristics, the relay constants and the circuit conditions. False operations of relays resulting from high voltage surges may be prevented in this manner. Indirectly heated thermistors may be used as variable resistance devices which are operated by an electric current through the heating coil rather than by a sliding contact as in a standard rheostat. These devices have the advantage that their resistance change is continuously variable and that they may be operated electrically from a distant point.

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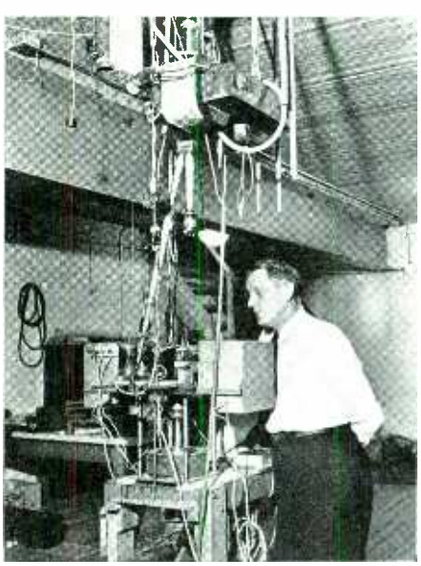
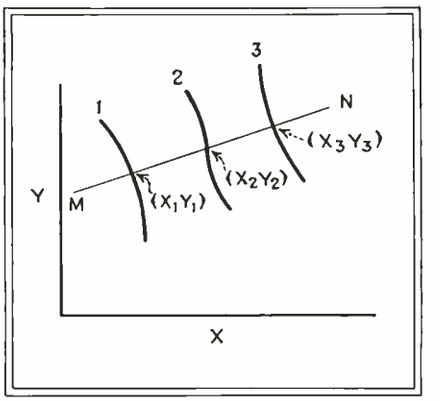
TRANSMUTATION OF ELEMENTS



Dr. C. C. Lauritsen, of the California Institute of Technology at Pasadena, conducting experiments with an "atom smasher." Every 20 seconds an automatic camera records the action of the elements under investigation. The device shown is one of several units used at California Institute of Technology, most of which follow original designs of Cal Tech physicists

Principles of Nomography

FROM TIME TO TIME THE ELECTRONICS Reference Sheet appears in the form of a nomographic chart. Such a chart is a representation of an equation or formula in such a way that a simple solution is provided by simple mechanical means. An outline of the principles underlying nomographic charts, together with several examples, is contained in an article entitled "Nomography for the Electrical Engineer," by Guido E. Ferrara in the December 1940 issue of *Electrical Engineering*. The convenience of nomographic charts is obvious from the following brief summary of their principal advantages: (1) The number and variety of problems to which they can be applied is quite large. (2) There is no difficulty when the number of variables is large, or when the variables are raised to fractional powers. (3) Once the chart for any particular problem has been prepared, chances for errors are minimized. (4) The charts are simple and certain in use, so that calculations can be left to the care of unskilled subordinates.



The equations of these curves are simply solved by the use of nomogramic methods

The mathematics of nomography is contained in the elementary theory of third-order determinants. In the study of analytic geometry, a geometrical meaning was given to a third-order determinant. In the accompanying diagram, the line MN intersects the three curves 1, 2, 3 at points whose coordinates are X_1Y_1, X_2Y_2, X_3Y_3. By similar triangles,

$$\frac{Y_2-Y_1}{X_2-X_1} = \frac{Y_3-Y_1}{X_3-X_1} \qquad (1)$$

Or

$$Y_1X_2 + Y_2X_3 + Y_3X_1 - Y_2X_1 - Y_3X_2 - Y_1X_3 = 0 \qquad (2)$$

From algebra, it can be shown that Eq. 2 is the expansion of the third-order determinant.

$$\begin{vmatrix} Y_1 & Y_1 & 1 \\ X_2 & Y_2 & 1 \\ X_3 & Y_3 & 1 \end{vmatrix} = 0$$

We then have the following theorem. If a third-order determinant has the value of zero, then the points X_1Y_1, X_2Y_2, X_3Y_3 are collinear. Therefore,

any equation which can be transformed into a form identical with Eq. 3 can be represented and solved by a nomographic chart.

To apply the foregoing theory to the practical construction of nomographs, the following requirements must be satisfied: (1) The equation of a number of variables must be reduced into one of only three variables. (2) The equation must be expressed as a third-order determinant. (3) By proper manipulation the determinant must be arranged into another of nomographic form. (4) The determinant must be represented by means of abscissas and ordinates properly scaled.

Any engineer who has the occasion to apply repeatedly a particular formula will do well to take the time to study this article, especially if the number of variables in the calculation is wide, or if the variables are raised to fractional powers.

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A Decade of Progress in the Use of Electronic Tubes

A REVIEW OF THE PROGRESS of the last ten years in the use of electronic tubes is reviewed in the December 1940 issue of *Electrical Engineering*. The review is divided into two parts, Part I covers the field of communication and Part II covers fields other than communication. They were written by Messrs. S. B. Ingram and W. C. White, respectively. No attempt has been made to make this review comprehensive in the sense that it includes all items of individual interest. Rather than this the object has been to trace the most significant trends of develop-

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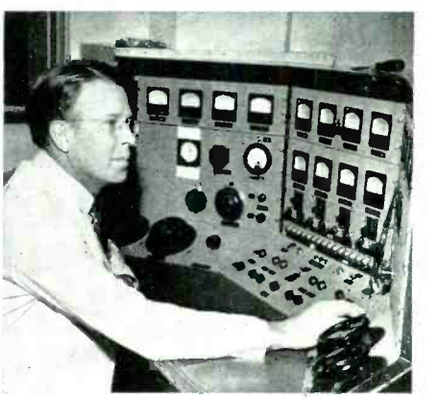
NATIONAL DEFENSE RESEARCH COUNCIL APPOINTEE



Dr. E. O. Lawrence, inventor of the cyclotron and Nobel Prize winner, who has been appointed by the National Defense Research Council to work on problems of national importance

ment in the various fields and to emphasize those lines of advance which appear to be most closely related to the general direction of progress in the several fields.

The trend in radio has been to the greater uses of ultra-high frequencies because of the continual expansion of present services and the introduction of new services.

In the field of television, the great trend has been to electronic methods. The field of telephony has been covered in a description of the broad-band carrier system which has been developed in the past decade. Progress in electronic devices has been divided into several groups. They are thermionic devices, devices based on secondary emission, photoelectric effects, electron optics and gas-discharge devices. In the field of circuit developments, in the opinion of the authors, the important developments were stabilized-feedback amplifier in wide-band carrier telephone systems and frequency modulation.

In Mr. White's portion of the review he describes the various electronic devices such as high vacuum diodes, vacuum tubes with one or more grids, thyratrons, cold-cathode glow-discharge tubes, photo tubes, ignitrons and cathode ray tubes. A considerable portion of the discussion is devoted to the applications of these devices.

A valuable portion of the review is contained in the excellant bibliography in which there are 88 references pertaining to communications and 144 references pertaining to industrial uses of electron tubes.

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NEWS IN UNDERGROUND SHELTERS

With air raids becoming a regular part of British life, the portable radio receiver finds considerable popularity when one is confined to the otherwise dull underground shelter or dug-out. A receiver, such as shown is battery operated and sells for about $25

Single-Flash Photography

SINGLE-FLASH PHOTOGRAPHY is discussed in an article by John M. Clayton in the November 1940 issue of the *General Radio Experimenter*. The Strobotac and Strobolux can be used quite successfully for taking single-flash pictures when the area to be illuminated is relatively small. The Strobolux furnishes about ten times as much light on a single flash than when it is flashed continuously from the Strobotac. The duration of a single flash is about 1/30,000th of a second.

The principal problem is the synchronization of the flash with the opening and closing of the camera shutter. The Strobotac and the Strobolux are supplied with appropriate terminals and connecting cords so they may be operated on single flashes. The two instruments are connected by these cords and the plug is inserted in the contactor jack of the Strobotac. When the wires attached to the plug are short circuited, a single flash is produced. The exact method of synchronizing the camera shutter with the flash of the Strobolux will depend upon the individual problem and the ingenuity of the user. In many cases where the motion of the subject is cyclic and the exact phasing of the motion is not important, the Strobotac can be set off by hand. It is necessary with photographs taken in this manner that they be made in subdued light because the shutter of the camera will be open for a considerable time before and after the flash.

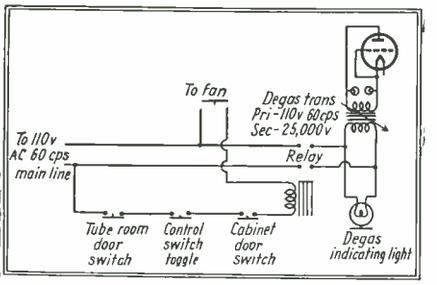
Exact synchronization between a sequence in a mechanical operation and exposure is required in certain applications. It is frequently possible to fit a simple make-and-break contact on a rotating shaft or moving part.

If the phenomenon to be photographed is accompanied by sound, it is possible to set off the light flash by means of a microphone and amplifier. Phasing is accomplished by changing the position of the microphone so that it is nearer or further away from the sound source. The Strobolux can also be made to respond only to sounds of a particular frequency by using a sound analyzer in conjunction with the microphone. By this method it is possible to obtain single-flash photographs of certain types of machine operations which produce a complex sound wave. The photoelectric cell can also be used to set off the flash light at the proper time. It is only necessary that the moving body interrupt the beam of light between the light source and a phototube or photoelectric cell. Synchronization is obtained by varying the distance between the subject and its position when the beam is interrupted.

It is generally advisable to develop films of this type of photography in a developer of the maximum contrast type. An increase of 50 per cent to 100 per cent in development time is also recommended for increasing the contrast.

Vacuum Tube Reconditioning

A SIMPLE and inexpensive reconditioner for transmitting tubes which considerably increases their life is described by Charles W. Singer in the November 1940 issue of *Pick-Ups* (Western Electric Co.) In practically all types of broadcast transmitters, the tubes, whether they are high- or low-powered, air- or water-cooled, will in



Circuit of a simple reconditioning outfit for de-gassing transmitting tubes to give them additional life

time become gaseous and therefore useless. This usually happens when a tube has been operated beyond the guaranteed period and there is no recourse except to discard it. However, this gaseous condition can be remedied and many additional hours of life realized by the use of the device outlined by Mr. Singer. To illustrate the usefulness of the device, the author describes the case of a W.E. 342A water-cooled tube which had been used in the WOR 50-kw transmitter. After being in operation for 5,000 hours this tube developed a series of flash arcs which would ordinarily cause it to be removed after sign-off and discarded as too risky to use. This tube was placed in the conditioning unit for degassing, the entire treatment taking only twelve minutes, and then reinstalled in the transmitter. By this short treatment more than 4,000 hours have been added to its useful life.

The construction and operation of this conditioner is quite simple. The entire unit costs less than $100 and at WOR this investment was returned by the savings in the cost of tubes in less than six months. The circuit of the tube conditioner is shown in the accompanying diagram. The principle of operation of the circuit is to apply a high alternating voltage of the order of about 25,000 volts between the plate and the filament and grid of the tube. The application of this high voltage cleans up any gaseous condition in the tube.

The second part of the treatment consists of filament aging at normal operating voltage for several hours. The tube is placed in the transmitter socket with standard water-cooling conditions and the filament lighted at normal operating voltage as measured at the tube terminals. Lighting the filament at normal operating temperature tends to clean up residual gases

and also to clean off both the filament and grid surfaces. The tube is then in shape to be tested in the transmitter under normal starting and running conditions. If the high voltage treatment is omitted the filament aging procedure is still of some value. It has been found that these treatments are effective in cutting down initial flashing during operation, even though the tube is returned to the spare shelf for a week or so prior to being installed for regular service.

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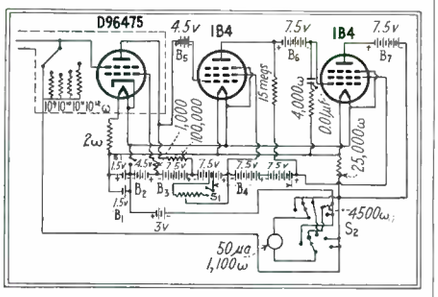
Degenerative Electrometer Tube Amplifier

DIRECT CURRENTS IN the range of 10^{-10} to 10^{-05} ampere are successfully measured with an instrument described by G. P. Harnwell and L. N. Ridenour in the October 1940 issue of *The Review of Scientific Instruments*. The principle involved is an extension of the use of a degenerative amplifier with ordinary receiving tubes as a meter for measuring small direct currents. A low grid-current input tube, such as the Western Electric D96475 or the General Electric FP-54



Circuit for measuring extremely minute currents with high accuracy

is used in the instrument whose circuit diagram is shown in the accompanying diagram. The amplifier described is quite stable and relatively free from drift.

The values of the battery potentials and resistances are determined by the static characteristics of the tubes used. The control grid potential of the D96475 should be −3 volts and the space charge grid and plate should be at +4 volts. The potentials applied to the two other tubes are of the same order of magnitude; much lower than the standard ratings. The filaments are also run under voltage. The effective amplification constants are low because of the low load resistance. However, the overall amplification factor is large enough so that fluctuations in batteries or tube parameters have a negligible effect on the fidelity of the instrument.

FM Demonstration System

(*Continued from page* 23)

have been grouped together and placed in each studio near the microphone, so that they are readily available when a demonstration is to be made. A typical collection includes a triangle, an elephant bell, a Chinese gong, chimes, a pitcher of water and a box of matches. Those familiar with high fidelity f-m broadcasts have undoubtedly heard the sounds of such "instruments" from some of the experimental stations during the past year. After some experimentation the correct distance from the microphone for each instrument has been determined and the demonstrator endeavors to keep the peak audio voltage, as indicated on the screen of the cathode ray oscillograph, below the level which will produce a ± 75 kc deviation. Satisfactory operation of the overall system is indicated by the grid current meters of the oscillator and the output tube.

No great precautions in studio technique are required to obtain satisfactory results. However, one important consideration is that of minimizing peaks of high frequency response due to reflections from the walls of live studios. Although most instruments have their maximum energy output in the low or middle audio range, sufficient energy may reach the microphone due to wall reflections to cause serious distortion in the modulator at the high audio frequencies where preemphasis is effective. This effect can be minimized by proper acoustic treatment of the studio, or by use of a directional microphone. By observing such simple precautions, the performance of the system can be made quite comparable with that provided by similar material broadcast by standard f-m transmitters and the results seem worthy of the time and effort expended to produce the system.

In conclusion the author wishes to acknowledge the frequency response data for the microphone and speaker systems as furnished by the Brush Development Co. and the Jensen Radio Manufacturing Co., respectively.

THE INDUSTRY IN REVIEW

News

✦ Hugh S. Knowles, vice-president and chief engineer for the Jensen Radio Mfg. Co. Chicago, announces the construction of a new sound room which will permit a more accurate determination of the response and directional characteristics of loudspeakers at low frequencies, and will greatly facilitate precision acoustical measurements. Rigging is being provided for outdoor measurements as well . . . Leach Relay Co., Los Angeles, Cal., manufacturers of electrical equipment for the aircraft, radio and other industries, recently started construction on a new building at 5915 Avalon Blvd. Most of the added space will be used for assembly purposes . . . Also expanding is the Cinema Engineering Co. with enlarged quarters at 1508 S. Verdugo Ave., Burbank, Cal. . . . Ground breaking ceremonies for the National Broadcasting Company's new million dollar studio building were held recently in San Francisco . . . The American Export Airlines, Inc., has signed a fifty-two week contract with the NBC International Division for a series of three fifteen-minute programs a week over international stations WRCA and WNBI. The program, known as "American Aviation", will be heard in Spanish, Portuguese and English throughout Latin America.

✦ Color television, using a standard type receiver with no additional equipment other than a revolving disk, was demonstrated at Schenectady recently to members of the National Television System Committee by Dr. E. F. W. Alexanderson, consulting engineer of the General Electric Company. George Henry Payne, member of the Federal Communications Commission, was also present. For the demonstration, Dr. Alexanderson installed a two-color 24-inch revolving disk about a foot in front of the picture end of the cathode ray tube of a standard type receiver. A similar colored disk revolved before the iconoscope pick-up tube of the transmitter at the studio . . . Six executives of R.C.A. Communications, Inc., were elected vice presidents recently at a meeting of the R.C.A. Board of Directors. John B. Rostron is now Vice President and Traffic Manager, C. W. Latimer is Vice President and Chief Operations Engineer; H. H. Beverage, Vice President in charge of Research and Development; F. W. Wozencraft, Vice President and General Counsel; L. G. Hills, Vice President and Controller; and A. B. Tuttle, Vice President and Treasurer . . . Airadio Company, of Stamford, Conn., who are licensed under AT&T and Hazeltine Service Corporation patents are now manufacturing a new type of ATR mount as per Aeronautical Radio Specifications and the Civil Aeronautic's Authority Type Certificate. R. T. Bozak is chief engineer and M. B. Andrews, formerly a supervisor of radio equipment at American Airlines, is general manager . . . The International Telephone and Telegraph Corp. has recently completed the installation of new radiotelephone and radiotelegraph circuits at La Paz, Bolivia, 15,000 feet above sea level. E. J. Smith, who supervised the new installation at La Paz, was formerly associated with Bell Telephone Laboratories of New York and also with Standard Telephones and Cables Ltd., of London. He is now Managing Director of Cia. Internacional de Radio Boliviana . . . Dr. D. E. Noble, former professor at the University of Connecticut recently presented a paper to the members of the Institute of Radio Engineers in New York in which he described the successful use of frequency modulation equipment as used by the State Police of Connecticut. An important aspect of the new system is that it can be adapted to the radio channels now assigned to police service . . . Major Edwin H. Armstrong, Professor of Electrical Engineering at Columbia University, has been awarded the Holley Medal of the American Society of Mechanical Engineers, for his work on frequency modulation. The Holley Medal is presented periodically by the ASME for distinguished service in engineering and science.

Literature

Electrically Operated Switches. Circular 500, available from Automatic Switch Co., 41 East 11th St., New York City, contains illustrations and brief descriptions of each of their standard switches. Included are automatic transfer switches, remote control switches, contactors, relays, etc.

Radio Products. Catalog No. 400 contains twenty pages of descriptive matter on radio products available from National Co., 61 Sherman St., Malden, Mass. The products listed include dials and knobs, condensers, couplings, coils and chokes, plate and grid grips, shields, cabinets, sockets, insulators, amplifiers and modulators, oscilloscopes, transmitters and receivers.

Screw Catalog. A fully indexed book which contains 112 pages of information on screws, bolts, nuts and rivets is available from Central Screw Co., 3501 Shields Ave., Chicago, Ill. This book is known as Catalog "K".

Radio Service Encylopedia. *Fundamentals of Television Engineering* is the title of Supplement 12 to the Mallory-Yaxley Radio Service Encyclopedia available from P. R. Mallory & Co., Indianapolis, Ind. Supplement 12 contains many diagrams, illustrations, patterns, etc., and is a reprint of F. Alton Everest's article which appeared in the Television Engineering Section of *Communications*. This will be the last of the current series of technical bulletins, for the present. This Supplementary Service was published to help service engineers, experimenters and amateurs. The editors of the Encyclopedia would like comments from its readers as to whether this service ought to be continued.

Parts and Accessories. A general catalog (Section VII of Catalog K) which contains descriptive matter on parts and accessories for audio transformers, switches, dials and knobs, plugs and jacks, coil forms, r-f chokes and relay racks is now available from General Radio Co., Cambridge, Mass.

Impulse-Generator and X-Ray Capacitors. Catalog No. 180X avaliable from Cornell-Dubilier Electric Corp., South Plainfield, N. J., contains circuits, illustrations and a description of high voltage impulse-generator and X-ray capacitors available from that company.

Voltage Regulators. American Transformer Co., 178 Emmet St., Newark, N. J., have available Bulletin No. 51–2 which describes their complete line of type "TH" Transtat voltage regulators. The bulletin also contains a nine page technical article with twenty-six circuit diagrams explaining methods of connecting voltage regulators for various applications.

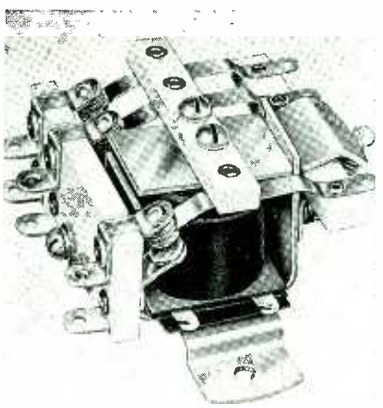
Transmitters. An eight page bulletin available from Federal Telegraph Co., 200 Mt. Pleasant Ave., Newark, N. J. describes two new transmitters designed to cover a wide variety of applications including aeronautical, point-to-point, marine land stations, police and commercial or military fixed frequency, single or multi-channel radio telegraph or telephone services. Specifications are included for both of the Models FT-300 (a 3 kw unit) and FT-500 (a 5 kw transmitter).

Phototube Applications. Form PT-20R1 gives complete information in simplified form, on phototubes and their applications, in a sixteen page booklet prepared by RCA Mfg. Co., Camden, N. J. The phototube's usefulness in light-operated relays, color discriminating devices, automatic counters, for light measuring, and for film sound reproduction, is explained in detail.

New Products

Relays

A NEW SERIES OF RELAYS designed to meet requirements for a small, rugged unit of high current capacity and low coil wattage operation is announced by Allied Control Co., 227 Fulton St., New York. Applications are in mobile marine and aircraft fields as well as for industrial uses where compactness is a factor. Insulation is alsimag, bakelite or high-frequency bakelite. Contacts are ¼-inch silver with wide spacing sufficient to handle 15 amps at 110 volts ac and 7 amps dc at 110 volts. Contacts are available in 2-pole double-throw. Coil operation can be had from 6 volts to 250 volts ac, and from 2 volts to 115 volts dc. These new relays are known as type HR and type HX relays.



Dictating Machine

THE SOUNDSCRIBER CORPORATION, of New Haven, Connecticut, has announced the production of a new type of dictating recorder using wafer-thin alloy discs. The set consists of a recorder with a microphone, and a transcriber.

The disc is of a metal alloy, 0.006 inch thick, 7 inches in diameter, and is practically indestructible. It can be dropped, bent, and written on without destroying the sound tracks. Fifteen minutes recording is attained on each side by the use of low turntable speed and close groove spacing. The disc can be filed like a letter, mailed without special packing and weighs one-third of an ounce.

The microphone has a selector lever on its base to accommodate a wide range of levels. It can record a whisper or all the voices at a conference up to a distance of 20 feet. For normal dictation, it is set on the desk about 3 feet from the speaker, who may move his head or shift about without paying any attention to the instrument.

The dictating recorder has a 7-inch turntable, and the recording head is equipped with a permanent diamond-tipped needle embossing the sound groove in the disc without chips or shavings. This unit also includes a built-in loud speaker and play-back head with a permanent sapphire-tipped needle. Dictation may be instantly played back on the same instrument by simply turning a control which automatically lifts and locks the cutting head while the disc is being played back.

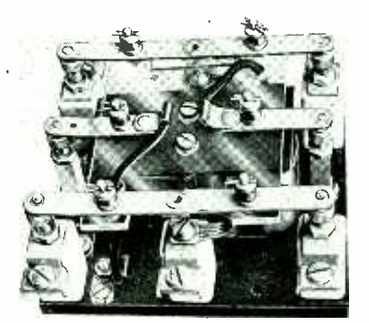
The transcriber contains the play-back features of the recorder, but is also provided with a gooseneck "soft-speaker," audible only at the secretary's ear. A jack is provided for those who prefer the old method. Remote controls for hand or foot are provided so that the disc may be instantaneously stopped and started, and the needle may be stepped back for repetition several grooves at the convenience of the transcribing operator.

Voltage Control

POWERSTAT VARIABLE TRANSFORMERS for line voltage control and electrical testing are now manufactured by the Superior Electric Co., 65 Harrison St., Bristol, Conn. in single and three phase capacities up to 27.5 kva for operation on 115, 230 and 440 volt circuits. Types are available for controlling voltage from zero to above line value, and for line voltage correction to take care of ten to fifteen per cent variations from normal line values. Electrical and mechanical variations can be made to meet individual requirements.

Heavy Duty Break-In Relay

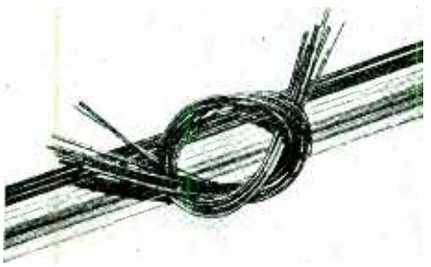
WARD LEONARD ELECTRIC CO., Mount Vernon, N. Y. announces a new break-in relay used in phone transmitters for push-to-talk operation. When the relay coil is energized the antenna is switched from the receiver to the transmitter position. The oscillator is turned "on" and the receiver plate circuit is opened. High test insulating materials used in the new heavy duty type consist of a Lucite cross arm carrying the contact fingers and Isolantite blocks mounted on a Bakelite base support the contact posts. All contacts are rated at 25 amps. These relays are described in a supplementary data sheet, Circular 507B, which will be sent on request.



Extruded Plastic Tubing

A NEW EXTRUDED PLASTIC tubing with high heat resistance is announced by the Irvington Varnish & Insulator Company, 24 Argyle Terrace, Irvington, N. J. The new tubing, known as Irv-o-lite XTE-100 is in many respects similar to Irv-o-lite XTE-30 tubing, described in the May issue of ELECTRONICS, but has better resistance to sustained high temperatures.

This tubing maintains all its characteristics at a continuous temperature of 176° F. It is suited for electrical insulation purposes, and has a dielectric strength, when dry, of 750 volts per mil and of 400 volts per mil after 24 hours soaking in water. The tubing is flexible, smooth inside and out and has a tensile strength of 2000 pounds per square inch, with high resistance to tearing and abrasion. XTE-100 is unaffected by petroleum solvents, is not attacked by a 10 per cent solution of sulphuric acid, and will resist most acids and alkalis in concentrations up to 30 per cent by weight. It does not support combustion, will not lose form up to 240° F. Immersion in transformer oil at 220° F for 48 hours produces only a slight swelling at the exposed ends of the tubing.



Irv-O-Volt, a varnished inside-and-out tubing, another product available from Irvington Varnish & Insulator Company

General Electric Products

SEVERAL NEW PRODUCTS are available from General Electric Co., Schenectady, N. Y.

A photoelectric gage which gives a continuous and accurate indication of variations in the width of moving steel strip without making contact with the metal has been announced. The width of the strip can be measured at any point or points in the mill and variations from the required width can be accurately transmitted to any number of desired stations such as the control pulpit, etc. While the strip is moving through the mill, adjustments to the edging rolls can be made by the operator to correct deviations from normal width. The gage was developed primarily for use on hot-strip mills, but is also applicable to other industrial jobs involving width control of moving strips of metal. In operation, both edges of the strip are followed simultaneously by narrow light beams and true indication of its width is given regardless of any sidewise movement

of the strip. The movements of the light beams are photoelectrically transmitted to indicating instruments.

Three types of general purpose photoelectric relays and several types of light sources and accessories are described in bulletin 1755-C. The relay models include CR7505-K2 for indoor use on 110 volt, a-c power supply. It works on five foot-candles at the phototube with approximately 5 watts power consumption. Model CR7505-L2 relay, for indoor use on 115 volts dc, has the same operating characteristics as the K2 model, except that the power consumption is approximately 7 watts. The third of these models is the CR7505-M2 which is an outdoor relay enclosed in a fabricated case. A large directional lens system and sun shield minimizes the effect of slanting rays from the sun. Some of the accessories, which are more thoroughly described in bulletin 1755-C, include various types of light sources, lenses and masks, phototube holder, and an infrared filter mask. Illumination data is also given.

General Electric Co., has extended the type CF line of inkless recorders to include d-c instruments (type CF2) available as voltmeters, ammeters, millivoltmeters, milliammeters, and microammeters in ratings down to 125 microamperes full scale. CF2 recorders are portable, may be wall or pole mounted, and are available for indoor or outdoor application. Providing continuous operation for 30 days without attention, they are suitable for installation where frequent servicing is impractical. Operating temperatures range from —10° F. to 120° F.

The 1000-watt f-m transmitter, Type GF-101-B, consists of two sections, the type GF-1B exciter (250 watts) which is the basic unit of the line, and a 1000 watt r-f power amplifier. Together, they are designated as type GF-101-B. Each section is completely self-contained and can be easily moved if necessary. If greater coverage is desired, the standard 10 k-w amplifier can be added to Type GF-101-B to make the complete 10,000-watt transmitter, Type GF-110-B. Three-thousand-watt and fifty-thousand-watt transmitters are also available.

A new portable sound level meter, lighter and more compact, has been built by Walter Mikelson and others of the G.E. engineering laboratory at Schenectady. The meter weighs 19 lbs and has a range of 24 to 120 db. The amplifier consists of five resistance-coupled stages. The instrument is designed to perform in accordance with A.S.A. standards for sound level meters.

Line Voltage Compensator

A NEW DEVICE to assist in correcting a fluctuating electric supply line is a voltage compensator, known as the Type LC Transtat available from American Transformer Co., 178 Emmet St., Newark, N. J. It is a manually operated unit especially designed to permit compensation for small volt-

age variations in a-c circuits. Since it functions with equal effectiveness, regardless of changes in power factor, frequency and amount of load, it is suited for use with all types of electrical equipment in maintaining input voltage constant so as to enable both efficient operation under all conditions and maximum operating life. The voltage may be adjusted smoothly

and without circuit interruption to within a fraction of a volt of the desired value. This new voltage compensator is a continuously adjustable, transformer-type voltage regulator designed to cover only a limited voltage range. It consists of a small, adjustable, autotransformer-type regulator which is connected across the line and an auxiliary buck-and-boost transformer with its secondary winding connected in series with the line. Voltage regulated either side of a center-tap in the winding of the regulator element is fed to the primary winding of the transformer, enabling either a bucking or boosting voltage to be set up in the secondary winding which is in series with the line. Standard types permit full correction over a range of ± 10 per cent and are available for service in 115, 230 and 460 volts, 50 to 60 cps, circuits. Equipment for single-phase and polyphase service is made in ratings from 2.5 kva to 85 kva output.

Cathode Ray Television Tube Lead Wire

A NEW CORONA-RESISTANT wire has just been announced by Belden Manufacturing Company, 4689 W. Van Buren Street, Chicago. The construction of the new 8868 makes it suitable for the high voltages carried in cathode ray tube television circuits. A special rubber compound, high heat resisting Pyro-Glaze seal and braid of Belden fiberglas protect this wire against corona and heat. The wire is white and has an outer diameter of 0.200 in.

Phonograph Pickup

THE ELECTROVOX CO., 424 Madison Ave., New York City, manufacturers of Walco Sapphire needles, have announced a light-weight phonograph pickup with a permanent sapphire needle for installation on any manually operated phonograph. The manufacturers state that the point is good for 15,000 records, and that dropping the arm will not injure the needle or the record. Improved grinding and polishing technique permits quantity production to a tolerance of ± 1/10,000 inch.

Plug-In Electrolytics

SOLAR MFG. CORP., Bayonne, N. J., announces a new series of dry electrolytic capacitors, Type DO, in metal cans of the plug-in type to fit standard octal tube base sockets. These capacitors have been designed for use where quick servicing is necessary. Straps are available for mounting under condition of vibration, such as for air or marine service. These capacitors are available in usual ratings as well as multiple units.

Timers

A TIMER KNOWN AS "TANDEM" is available from Industrial Timer Corp., 101 Edison Place, Newark, N. J. The "Tandem" is rated by the manufacturers as having a one hundred per cent timing cycle and/or delay cycle which can be selected in variable time controls from one second to fifty-five minutes in either or both operations.

The timer is arranged with both push-button control for single performance on both timing and delay operations, or a toggle switch and automatic reset for continuous recycling of both operations. The instrument also permits choice of either timing or delay cps at will, in single cycles or continuous recycling. The timer is equipped with heavy duty self-lubricating synchronous motors.

Fluorescent Lamps

NEW 100-WATT MAZDA fluorescent lamps with twice the power of any Mazda F lamps are now available from Westinghouse Lamp Division, Bloomfield, N. J. Each lamp is five feet long and 2⅛ inches in diameter, and is available in 3500° K white color. These lamps have a rated initial output of 4400 lumens, rated life of 2000 hours.

FORM G-126

INTER-OFFICE CORRESPONDENCE

McGRAW-HILL PUBLISHING COMPANY·INC

TO H. W. Mateer
LOCATION Manager, ELECTRONICS
SUBJECT PROGRESS REPORT - 1940

FROM Wallace B. Blood
LOCATION Sales Manager
DATE January 2, 1941

Dear Mat-

You know what a successful year ELECTRONICS has had in 1940, but here is a summation. Ordinarily one speaks of statistics as "cold facts," but we consider the following pretty "hot."

In 1940, the tenth-anniversary year of ELECTRONICS, all records were again topped...total advertising space and revenue, number of editorial pages, circulation.

Manufacturers supplying the electronic and allied industries used 585.07 pages in ELECTRONICS for their sales messages, an increase of 156.70 pages or 30.6% over the previous banner year of 1939.

During the year forty new advertisers started using ELECTRONICS as a medium for their sales work. They, alone, purchased a total of fifty pages during the year, and 90% of them continued to use this magazine after their initial appearance.

Circulation continued its steady rise, reaching approximately 15,000 net paid with the December issue. Our circulation in industrial plants increased more than 9% in the first six months, and we estimate that the year's increase in this important group will be about 20%.

ELECTRONICS has become one of the most important publications for sales approach to the defense industries. Manufacturers, recognizing our valuable coverage and penetration into the design headquarters of plants manufacturing defense equipment, increased their schedules and directed their copy to the attention of the engineers in these industries.

The editors of ELECTRONICS continued to offer more and more editorial service to our increasing number of readers. A total of 573.87 pages of editorial matter was presented during the year.

But, impressive as is this 1940 record, every indication is toward a 1941 even more successful. ELECTRONICS is proving to be the most economical means of penetrating to all important engineering organizations which are planning and putting into production the new devices in wire and wireless communication and industrial control.

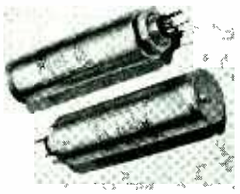
WBB/HE

Wally—
A swell report.
Let's give it to the industry.
Mat

Wally

Dry Electrolytics

MICAMOLD RADIO CORP., Flushing and Porter Avenues, Brooklyn, N. Y., announce the addition of a complete line of Type MP dry electrolytics. They are available in sufficient capacity and voltage ranges to accommodate practically all replacement requirements.



Standard lug mountings with both three and four terminals are available in both 1 inch and 1⅛ inch diameters. Descriptive literature is available from the manufacturers.

Voltmeter-Ohmmeter

RCA MANUFACTURING CO., Camden, N. J., have incorporated in their new Junior Volt-Ohmyst model, the Rider circuit which provides a convenient push-pull electronic d-c voltmeter-ohmmeter with a resistance range ratio wide enough for engineering and servicing requirements. The features of Junior Volt-Ohmyst are similar to the laboratory type RCA 163 Volt-Ohmyst. The instrument is applicable to servicing radio and television receivers, transmitters, aircraft radio, sound

amplification and reinforcement systems, facsimile and other types of equipment. The input resistance for measuring d-c voltages is constant at 11,000,000 ohms, allowing voltages to be read in high resistance circuits. A signal-tracing probe lead is provided with the instrument. The d-c voltmeter circuit has six ranges—0 to 3, 10, 30, 100, 300, and 1000 volts. The Junior Volt-Ohmyst is equipped to make isolated a-c voltage measurements, which are read on five scales of from 0 to 10, 30, 100, 300 and 1000, with a sensitivity of 1000 ohms per volt.

Standardized Mounting Strips

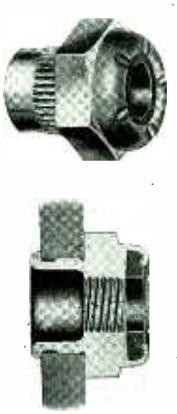
TO FACILITATE THE USE in multiple of signal-lights, toggle-switches, and push-buttons, the H. R. Kirkland Company of Morristown, N. J., announce the development of a line of standardized mounting strips, which have wide application in the signal, control, and general annunciator fields. The strips are made of stainless steel, and are available in three lengths to contain two units, three units, or five units per strip. There is a designation strip to match each length. The strips are flexible. One strip may contain any combination of devices, or the strips may be banked together. All of the devices are for service on voltages up to 220 volts.

Recorder and Reproducer

MILES REPRODUCER CO., Inc., 812 Broadway, New York City, manufacturers of Filmgraph devices for recording and reproducing sound on film electromechanically, have available a new model, ADB Filmgraph, which works automatically. This new model accommodates five hundred feet of film. The reels are seven inches in diameter and one inch thick, and since they are of the safety type can be mailed or stored. The film requires no treatment or processing of any kind and recordings can be played over many times without loss of quality.

Clinch Type Nuts

ELASTIC STOP NUT CORP., 2332 Vauxhall Rd., Union, N. J., are offering a clinch type of self-locking nut with a knurled shank for fastening sheet-metal assemblies in which the parts must be readily removed and returned to position. To install the nut, a hole



is drilled in the structure and the shank is pressed into the hole. The mouth of the shank is then spread against the back of the structure to effect a clinching hold. The knurling engages the drilled surface and thus assists in eliminating any turning of the nut. These nuts are available in a complete range of sizes, thread systems, shank length, and materials.

Mobile Amplifier

LAFAYETTE RADIO CORP., 100 Sixth Ave., New York City, designed their 30-watt mobile amplifier (model 462-T) especially for sound men who specialize in indoor rentals. Instead of being mounted in a carrying case it is

mounted in a housing provided with decorative handles. The amplifier is rated at 6 to 110 volts ac. Output is 30 watts, with 40 watts on peak. The equipment can also be used for mobile work.

Integrating-Sphere Densitometer

THE INTEGRATING-SPHERE Densitometer is a new instrument for measuring the density or pattern of light and shade which comprises the image on a motion picture film. It was developed by Dr. J. G. Frayne and G. R. Crane of Electrical Research Products, Inc., Laboratories in Hollywood. In taking measurements, the densitometer traps that portion of a beam of light which succeeds in penetrating a test sample of motion picture film. The trap consists of a hollow ball or sphere, the inner surface of which is finished in white, and fitted with a photoelectric cell. Light entering the globular chamber is reflected many times and finally falls on the photoelectric cell as a thoroughly mixed or integrated product. Its value or brightness is then translated into electrical current and registers, in terms of density, on a meter. This information enables technicians to regulate with great accuracy the chemical processes involved in developing or finishing the film. The densitometer operates in the same manner that a photographic exposure meter does except that it is more accurate, and can be used for controlling the development of both positive and negative film.

Code Practice Equipment

A COMPLETE NEW LINE of code practice oscillators and accessories are available from Bud Radio Inc., 5205 Cedar Ave., Cleveland, Ohio.

CPO-122 is an earphone model code practice oscillator capable of handling up to twenty pairs of earphones or up to five small magnetic speakers. It has a variable volume control and a variable pitch control so that both the

volume and tone may be adjusted to suit individual needs. The oscillator is housed in a streamlined metal case and is provided with red nameplates to identify the various controls. CPO-124 is similar to CPO-122 except that it is provided with a built-in loud speaker. Provision is also made to operate up to twenty pairs of earphones or up to five small magnetic speakers. Both the tone and volume are variable. CPS-123 is a three-inch magnetic speaker housed in a grey crackle enamel case. This speaker is intended for use with the CPO-122 and the CPO-124. CPO-127 is a key and phones outlet box and is designed to provide a convenient means for terminating key and phones connections in classroom or group practice. Two appropriately marked jacks are housed in a bakelite box which can be fastened to the bench at each student's position. Each outlet box is then wired to the master oscillator.

Recording Equipment

WILCOX-GAY CORP., Charlotte, Mich., have available their model "Recordio Junior" which is a radio, phonograph and home recorder combined in one instrument. Recording speed is 78

rpm for both radio and microphone recordings. The weight of the unit is twenty pounds. It measures 12¼x12½ x9⅜ inches.

Power Line Filter

A NEW POWER LINE FILTER, for eliminating line interference, is announced by Belden Manufacturing Company, 4689 W. Van Buren Street, Chicago. The new unit, type 8100, containing two dual condenser sections and two dual high "Q" choke coils, effectively prevents power line interference and eliminates man-made static on both broadcast and shortwave bands. It is highly efficient with all types of receivers. Ground is provided by a three-wire Belden power supply cord, eliminating possibility of shock from case. The unit has a rating of 3 amps at 115 volts.

A standard power line filter, 8105, is also available. It has a dual special high capacity low inductance condenser section and is otherwise similar to 8100. It effectively eliminates "back door" interference in practically all installations. Rating is the same as 8100.

Radio Direction Finder

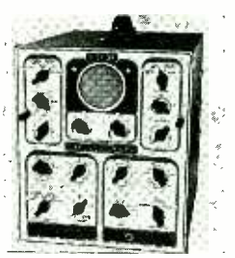
THE ANSLEY RADIO CORP., 4377 Bronx Boulevard, New York City, has developed a new self-contained marine radio direction finder for small boats to be used for establishing off-shore position. Model DF-1 has five tubes and seven tuned circuits which provide a range from 275 to 325 kc covering all marine radio beacon stations. A shielded loop antenna provides directivity within one degree accuracy. The instrument carries a seven inch compass card (of non-magnetic construction) for easy reading. Model DF-1 was designed primarily for salt water use.

F-M Conversion Attachment

STEWART-WARNER CORP., Chicago, announces a conversion attachment which may be plugged into any present style radio equipped with a phonograph jack to adapt the set to f-m reception without further changes, rewiring, or other alterations. This new unit, known as the "Interpreter" consists of a small, compact cabinet, which may be placed upon the top of a standard set and attached to the latter with a simple plug-in connection. It provides automatic push-button tuning for six stations. Other stations may be tuned in with a single knob, operating an indicator pointer over the face of an illuminated, calibrated dial. An on-off switch is also included. The "Interpreter" circuit employs nine tubes, operating on a 110-volt 60-cps current supply. An extra jack is provided for phonograph pick-up for use with existing record players.

Oscillograph

HICKOK ELECTRICAL INSTRUMENT CO. (10307 Dupont Ave., Cleveland, Ohio) has available model RFO-5 oscillograph for complete visual analysis for f-m, a-m and television servicing. It offers single or consecutive stage-by-stage trouble shooting from antenna post to speaker. It has a self-contained wide band f-m oscillator for f-m and television receivers, and a



narrow band f-m oscillator for a-m receivers, as well as a demodulator, video amplifiers, signal tracer and visual a-c vacuum tube voltmeter rated at from 0.2 to 1000 volts. The wide band f-m oscillator can be modulated from external sources such as a phonograph pickup, microphone or a-f oscillator, to provide an f-m transmitter for laboratory checks.

Tube Tester

SERIES 914 COUNTER TYPE tube tester and set analyzer features a seven-inch swivel mounted, easily read meter, that can be fully rotated in a complete circle, as well as back and forth.

Precision Apparatus Co. (647 Kent Ave., Brooklyn, N. Y.), designed it to provide a full view from all positions of test results. Precision's catalog for 1941 contains details about this instrument.

Safety Grounding Connector

AMERICAN PHENOLIC CORPORATION, 1250 Van Buren St., Chicago, Ill., announced in an issue of *Amphenol News* that automatic safety grounding connectors for aircraft magneto applications were available. Army-Navy Specification 9534 has designated the size 18 "AN" connector with element No. 2S as an automatic grounding connector, and Amphenol engineers, working in conjunction with the aircraft manufacturers, have developed a versatile design. One of the important features of this connector is that the grounding element may be installed in any of the four standard size 18 plug or receptacle shells, so that the grounding action can take place either at the end of a flexible cable or at the connector unit fastened to a bulkhead, firewall or directly on the magneto, etc.

Application for this connector is for automatically grounding the magneto to the engine frame when the plug is disconnected from the receptacle. This eliminates the danger of injuries which might be caused by the accidental starting of an engine should the propeller be moved during inspection, or while minor repairs are being made.

AN-3108 angle connector is for use where compact wiring in cramped quarters is necessary. It permits cable or flexible conduit to be brought out of the connector at a 90° angle.

This same issue of *Amphenol News*, Vol. 1, No. 9, contains articles on "High Tension 'AN' Connector" "Special Application Connectors," "Connector Sealing Compound" and "New Bell Airacobra P-39 Mystery Pursuit Plane."

CONTACTS

FOR THE FIELD OF ELECTRONICS

Transmission Equipment

THE IDEAL COMMUTATOR Dresser Co., 1631 Park Avenue, Sycamore, Ill., announces a new series of "Select-O-Speed" transmissions equipped with electric motorized control. These new models supplement the standard line from fractional to 7½ hp capacity that are equipped with lever type and hand wheel control. The electric control is intended where the drive must be mounted on the ceiling, back of, or inside the equipment. A two button switch controls the speed. Changes in speed adjustments are easily made by pushing and holding either the fast or slow button until the desired speed is obtained. Electric motorized control is also available on some type of Ideal's S.O.S. variable speed transmissions.

Louver Plastic Sheeting

A NEW TYPE OF SHEETING has been developed in "Plastocele," a cellulose acetate plastic, made by the E. I. du Pont de Nemours & Co., Wilmington, Del. The new sheeting "Louverglas" was conceived by L. C. Doane, of Doane Products Corp., and was developed in collaboration with the research staff of du Pont for the purpose of combining diffusion obtainable with an opal material with the directional efficiency obtainable with a clear material.

Poly-Directional Microphone

A NEW CARDAK (model 725) available from Electro-Voice Mfg. Co., 1239 South Bend Ave., South Bend, Indiana, has a constantly variable sound pick-up pattern which enables the operator to select the correct directivity for each particular installation. It is especially suitable for orchestras who travel with their own sound systems and who encounter a variety of acoustic problems. The response is substantially flat from 30 to 10,000 cps. The

average level is 1 volt/bar. Decibel rating is —52. A control on the instrument allows the microphone to function as a true cardiod for elimination of sound striking it from the rear, or as a bi-directional for elimination of sidewall reflected sound. It is adjustable for any combination of reflected sound direction.

Midget Signal Generator

THE "PEN-OSCIL-LITE" is a self-contained, self-powered, fully shielded signal generator (multi-vibrator type) available from General Test Equipment Co., 922 Avenue O, Brooklyn, N. Y. This instrument, which is scarcely larger

than a fountain pen, generates audio, i-f, broadcast, and short wave frequencies for complete receiver trouble shooting, for alignment, and for a number of other tests. A single battery generates a broadly tuned signal.

Interval Timer

THE R. W. CRAMER CO., Inc., Centerbrook, Conn., announce Model D2 interval timer which was designed primarily for the control of industrial equipment which can be automatically timed. It is a standard self-starting synchronous motor driven timer enclosed in a dust tight and splash proof cast aluminum housing. The housing is arranged for conduit connection and provided with a full vision non-clouding type window and external setting knob.

SEARCHLIGHT SECTION

(Classified Advertising)

EMPLOYMENT : BUSINESS : **"OPPORTUNITIES"** : EQUIPMENT : USED OR RESALE

UNDISPLAYED ——RATES—— DISPLAYED

10 CENTS A WORD. MINIMUM CHARGE $2.00
Positions Wanted (full or part time salaried employment only) ½ the above rates payable in advance.
Box Numbers—Care of publication New York, Chicago or San Francisco offices count as 10 words.
Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Individual Spaces with border rules for prominent display of advertisements.
The advertising rate is $6.00 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.
An advertising inch is measured ⅞" vertically on a column — 3 columns — 30 inches to a page.

POSITIONS WANTED

BROADCAST ENGINEER, 20, first class telephone, second class telegraph, two years experience in broadcast field, transmitter, studio control, announcing, regional network. Prefers middle west, but not necessary. Salary reasonable. Immediately available. Details on request. PW-258, Electronics, 520 N. Michigan Ave., Chicago, Ill.

ELECTRICAL ENGINEER. Mathematician, Physicist, 6½ years developmental engineering experience, industrial control equipment, X-ray equipment, relay electronic and radio circuit equipment. Desires industrial research position in modern field. Age 31, married. PW-261, Electronics, 520 N. Michigan Ave., Chicago, Ill.

OPPORTUNITY OFFERED

WANTED NEW LINES FOR EXPORT. Exporters with well established record in Electronics and precision instrument field seeks new lines for Export World-wide connections. SA-260, Electronics, 330 W. 42nd Street, N. Y.

OPPORTUNITY WANTED

For best informed sales representative in Government contract work write Riddell, 300 B-st., S.E., Washington, D.C.

FOR SALE

FOR SALE Super sonic oscillator. 500 watts, with two magnetostriction vibrators, other experimental parts. White Sound Service, 151 West 63rd St., New York, N. Y.

(POSITION VACANT)

An excellent opportunity

Open for one experienced in knowledge of manufacturing and pumping of hot cathode fluorescent tubes.
Explain experience in detail. All correspondence confidential.

P-260, Electronics
520 No. Michigan Ave., Chicago, Ill.

HIGH GRADE USED

ELECTRON TUBE MACHINERY

Huge Stock of Every Type and Variety

KAHLE ENGINEERING CORPORATION
Specialists in Equipment for the manufacture of Neon Tubes, Radio Tubes, Incandescent Lamps, Photo Cells, X-ray Tubes, etc.
900 DeMott St., North Bergen, N. J.

DEPENDABLE
Used
ELECTRONIC TUBE EQUIPMENT
Complete line of used equipment for the manufacture of Radio Tubes, Neon Tubes, Incandescent Lamps, etc. Write for Bulletin showing 25 to 75% savings.
CALLITE TUNGSTEN CORPORATION
formerly Eisler Electric Corp.
534 39th Street, Union City, N. J.

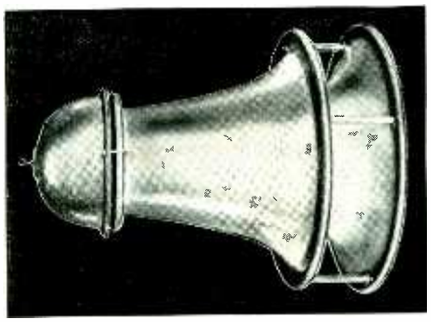
INDEX TO ADVERTISERS

Acoustical Device

A NEW TREATMENT of the acoustical problem presented by record surface and mechanical noises present in phonographs was revealed to the Acoustical Society of America recently by Dr. Harry F. Olson of the RCA Research Laboratories at Camden, N. J. The name of the new device is "Tone Guard." It is a tuned acoustical filter which captures extraneous sounds and destroys them. It employs a simple system of grooved wells around the inside edge of the phonograph compartment directly beneath the lid. "Tone Guard" is also applicable to soundproofing doors or windows.

Cone Speaker Projector

"LIGHTHOUSE" MODEL RLP cone speaker projector is a newly designed product available from University Laboratories, 195 Christie St., New York City. It includes all the features of University's cone speaker reproducers except that double the usual acoustic

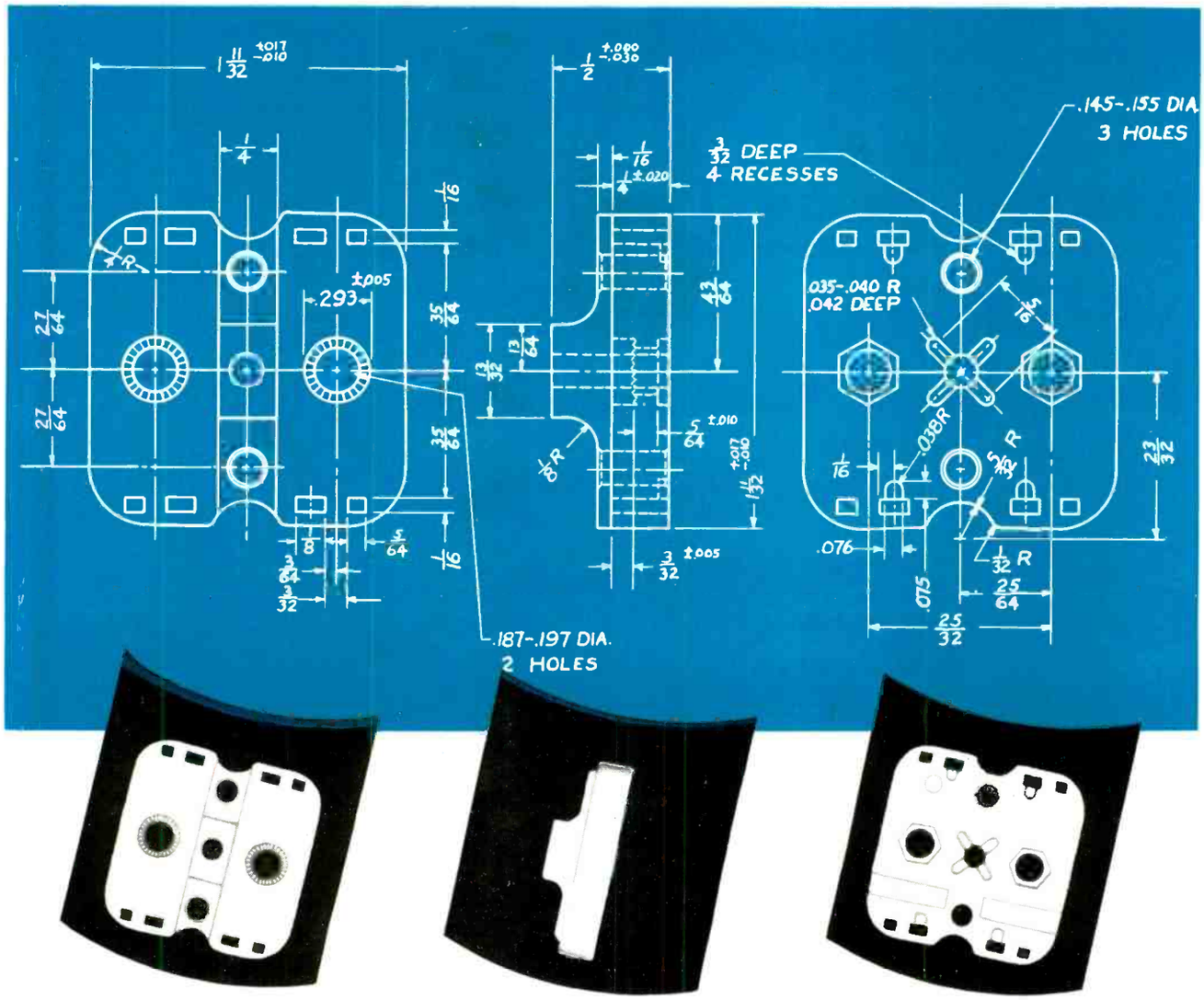


length is used in the projector. Due to the design of the bells, uniform 360 degree sound projection is possible. The bell diameter is twenty-four inches and overall height is twenty-eight inches. Model RLP was designed for all models of twelve-inch cone speakers.

Communications Receiver

DESIGNED TO SERVE EVERY purpose of a commercial, amateur or short-wave listener, Hallicrafters, Inc. (Chicago), have introduced their SX-28 model communications receiver known as

"Super Skyrider." The instrument has fifteen tubes. The tuning range is from 550 kc to 42 Mc in six bands to provide good L/C ratios. The main dial has an auxiliary micrometer scale. The band-spread scale is calibrated for amateur bands from 80 to 10 meters inclusive.



INSULATION FROM BLUE PRINTS

38 years of pioneering and developing steatite ceramic insulation convinces us that there are few applications where "standard" insulation will give best results. For that reason, neither time nor expense has been spared in developing materials and custom-manufacturing methods ahead of the times.

Our organization has unusual experience and skill in making insulating parts from blue prints. In many instances it is our privilege to help in making the blue prints and in selecting the "body" with the correct physical characteristics.

Why shackle your design to "standard" parts? Why not send us a blue print of your ideal design and let us show you what you can get from custom-built AlSiMag?

AlSiMag

Trade Mark Reg. U. S. Pat. Off.

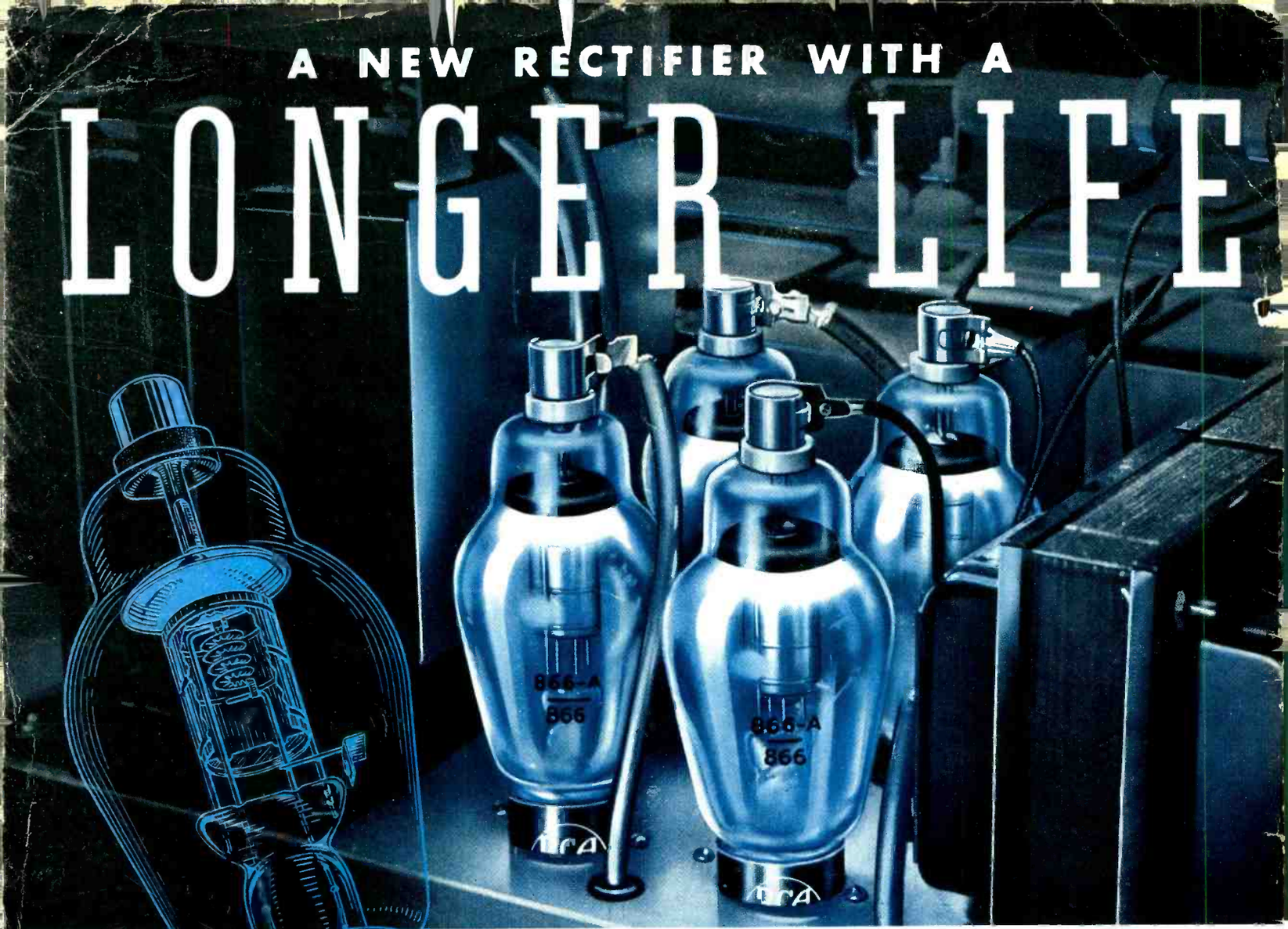
FROM CERAMIC HEADQUARTERS

AMERICAN LAVA CORPORATION • CHATTANOOGA • TENNESSEE

CHICAGO • CLEVELAND • NEW YORK • ST. LOUIS • LOS ANGELES • SAN FRANCISCO • BOSTON • PHILADELPHIA • WASHINGTON, D. C.

A NEW RECTIFIER WITH A

LONGER LIFE



56-
loading coil whip antenna
low HF

RCA-866-A/866 Half-Wave Mercury-Vapor Rectifier

SENSATIONAL PERFORMANCE
. . . at a New Low Price!

LONGER LIFE—Assured by radically improved new filament, dome bulb and insulated plate cap.

HIGH RATING—10,000 volts, peak inverse voltage. 1000 ma., peak plate current.

ENORMOUS EMISSION RESERVE—Provides ability to withstand high peak loads.

Secret of 866-A/866 superiority is another top-notch RCA engineering achievement — the edgewise-wound ribbon filament utilizing a new alloy material which not only has tremendous electron-emitting capabilities but which holds the key to longer life.

RCA-866-A/866 Half-Wave Mercury-Vapor Rectifier Tube represents a big forward step in providing higher voltage at lower initial cost. Equally important is the amazingly long life achieved by virtue of the new edgewise-wound coated ribbon filament and other features of design and construction. Judged from any angle, it is far and away the finest rectifier tube value RCA has ever offered—both a money-saver and a truly de luxe performer.

This new tube supersedes the 866 and the 866-A and may be used in equipment designed for these types. It combines the high conductivity of the 866 at low plate voltages with the ability of the 866-A to withstand a high peak inverse voltage—and, in addition, gives *plus* performance all along the line.

RCA-866-A/866's new edgewise-wound filament has great mechanical strength and provides more cathode area for the same filament-power rating.

Important among other features of the tube is the special filament shield which makes practical the use of a very low starting voltage. A ceramic cap insulator and new dome-top bulb minimize danger from bulb cracks caused by corona discharge and resultant electrolysis.

Install 866-A/866's and forget rectifier tube problems for a long, long time to come!

RATINGS:

Filament Voltage (A-C)	2.5 volts
Filament Current	5.0 amperes
Peak Inverse Voltage:	
Up to 150 cycles per second	10,000 max. volts
Up to 1,000 cycles per second	5,000 max. volts
Peak Plate Current	1.0 max. ampere
Average Plate Current	0.25 max. ampere
Tube Voltage Drop (approx.)	15 volts

$1.50 NET

RCA BROADCAST EQUIPMENT
From microphone to antenna

RCA

Transmitting Tubes

PROVED IN COMMUNICATION'S MOST EXACTING SERVICES

RCA MANUFACTURING CO., INC., CAMDEN, N. J. • A Service of The Radio Corporation of America

In Canada: **RCA VICTOR COMPANY LIMITED, MONTREAL**