# COMMUNICATIONS

**WARTIME DESIGN PRACTICE**

**SQUARE WAVE ANALYSIS**

**REVIEW OF 5th ANNUAL BROADCAST ENGINEERS CONFERENCE**

**MARCH**

**1942**

More than 100 types of tubes for use in Commercial Broadcasting, Point to Point Communication, Ultra High Frequency Transmission, Electro Medical Apparatus, High Voltage Rectification and many Industrial Applications.


# Now, this is a WAR!

"A TOTAL WAR! A war in which the fighting man DEPENDS upon radio for his information, his orders and his very life.

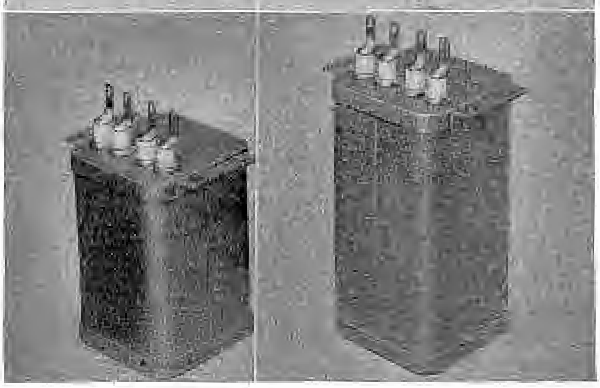
"And that odd-shaped bottle is an ultra-high frequency, high-power, air-cooled transmitting tube. Thousands of these, as well as other AMPEREX types, are in 'front line' service.

"Folks back home subordinate their civilian requirements to such military needs. It's an 'all-out' war calling for sacrifices from all of the people."

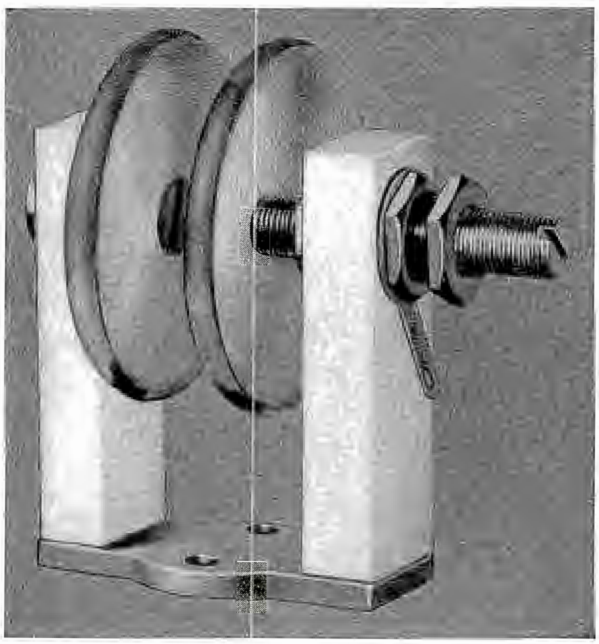
**AMPEREX ELECTRONIC PRODUCTS**

**79 WASHINGTON STREET** — **BROOKLYN, NEW YORK**

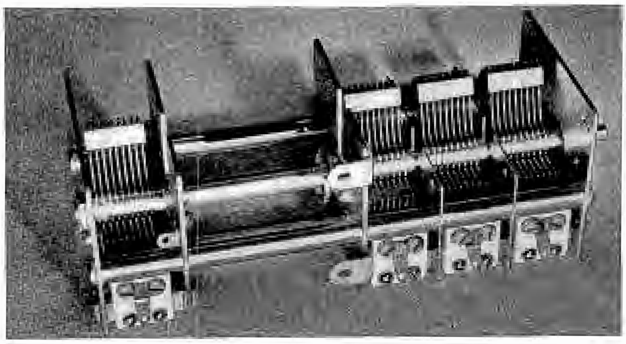
(*Below*) MINIATURE TERMINAL BUSHINGS offer a convenient, economical means of terminating low-potential leads in condensers, transformers, and similar equipment. In addition, they may be used as small stand-off insulators for anchoring condensers and resistors in radio equipment. Bushings are supplied complete with hard tinned copper terminals and nickel-plated copper flanges. Insulator bodies are of glazed Isolantite*. Bushings are supplied in two terminal lengths and two insulator lengths, making a total of four combinations, as shown in upper photograph. Lower photo shows a typical application of the bushings on transformers. Detailed information on these bushings is contained in Bulletin 104-A, which is available on request.



(*Below*) ACCURACY IN MANUFACTURE is an important advantage in many applications of Isolantite. In this high-voltage neutralizing condenser, for example, the eight faces of the upright supports are specially fabricated after firing to obtain accurate relationship of plane surfaces. This provides correct alignment of metal parts, and aids in producing desired electrical characteristics in the condenser.



# INSULATION HIGHLIGHTS



(*Above*) IN HIGH-FREQUENCY SERVICE of every type, Isolantite is the choice of leading manufacturers, because of its unique combination of high dimensional precision, low power factor, and high strength. These are among the reasons why Isolantite insulation was selected for use in this new condenser design.

(*Below*) NEW AUTOMATIC PRESS is unloaded as Isolantite's expansion program is rapidly pushed toward completion. The new press will facilitate production by permitting the automatic molding of shapes which formerly required special machining operations or partial molding on hydraulic equipment.

# ISOLANTITE

## CERAMIC INSULATORS

ISOLANTITE INC., 233 BROADWAY, NEW YORK, N. Y.

**Registered trade-name for the products of Isolantite Inc.*

**LEWIS WINNER, Editor**
**F. WALEN, Associate Editor**

# COMMUNICATIONS

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

**MARCH, 1942**

**VOLUME 22 NUMBER 3**

# *We See...*

ONE OF THE MOST INTERESTING directories ever to be compiled will soon make its appearance. In it we will have for the first time the name of the operator of every auto "graveyard" in the country, and the number of old or damaged cars in each yard. What an invaluable guide this will be for sources of scrap material, as well as parts that may have renovation possibilities. And what an invaluable guide would a similar type of "graveyard-directory" be to those in the communications industry, where the percentage of useable equipment in "graveyards" reaches high levels. With the millions of pieces of equipment that are traded in and stored away, a tremendous source of supply exists. There is no denying that the ratio of bad to good may be high, but the renovation and scrap material possibilities are too substantial to be cast aside.

Individuals who have conducted "graveyard" investigations in their own backyard have been surprised at what the search revealed. Engineers at the recent broadcast engineer's conference told of many such clean-ups that netted, in some instances, hundreds of dollars of old material that was entirely useable. Discarded heaps and "junk" drawers ofttimes have a habit of containing just the component you need, if you'll only look there, or better yet, organize that "junk" drawer!

THE NUMBER OF CONSERVATION CAMPAIGNS in the communications industry has increased by leaps and bounds during the past few weeks, with outstanding results. One of the most impressive contributions to this effort was that of E. K. Cohan, CBS director of engineering, who sent out a dramatic "Make It Last" memo to CBS technicians from coast to coast. He said: . . . whatever we have on hand now . . . we must make it last. We must save and use any part that has some utility left in it."—L. W.

**COVER ILLUSTRATION**

At the radio controls of a Navy plane.
*(Official U. S. Navy Photograph)*



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# THESE FEATURES MEAN MUCH TO TODAY'S RESISTOR BUYERS

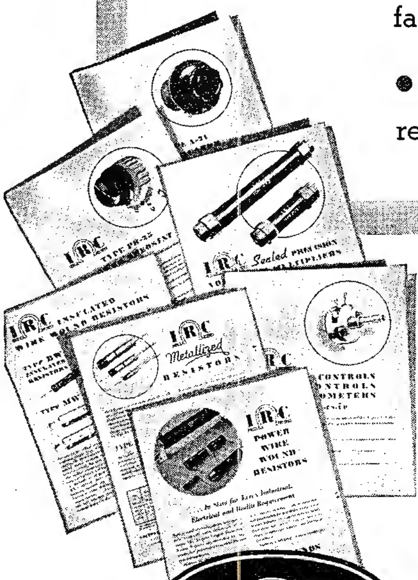
- ***THE CONVENIENCE*** of dealing with a single, primary source of supply for practically every fixed or variable resistor type.

- ***THE ADDED CONVENIENCE*** of being able to obtain many standard IRC resistor types for emergency requirements from almost 500 radio parts jobbers.

- ***THE ASSURANCE*** of full approval for exacting defense needs.

- ***THE COOPERATION*** of skilled resistor engineers, familiar with all resistance problems, backed by an organization which, for 18 years, has concentrated all of its efforts on the design, manufacture and application of quality resistors exclusively.

- ***UNSURPASSED PRODUCTION FACILITIES***—recently expanded for the third time in five years.



## THESE RESISTOR DATA BULLETINS WILL HELP YOU!

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**2** Metallized-type Resistors: Insulated ½, 1 and 2 watts; high frequency; high range; high frequency power; high voltage power.

**3** Insulated Wire Wound Resistors: Type BW from ½ to 1 and 2 watts; Type MW, 5 to 20 watts.

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**6** Power Rheostats: Quick heat-dissipating all-metal types up to 100 watts.

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# Volume Controls by Mallory Help Keep the Sea Lanes Open

Not long ago, a big war contractor needed some volume controls to build models of a naval communications device. The contractor's purchasing agent called the Mallory Distributor nearby. Within a few hours, standard Mallory Volume Controls were being tested in these "rush" models.

The rest of the story is equally pleasing . . . both to the war contractor and to Mallory. The test controls obtained through the Mallory Distributor proved so satisfactory . . . for performance, ease of installation and service life . . . that a large order for additional Mallory Volume Controls was placed. By this and other services, Mallory is helping to keep the sea lanes open!

Whether you need essential electronic parts for war devices or for plant replacements, test or experimental work, or to improve the performance of a product you plan to manufacture . . . you'll be wise to call on your Mallory Distributor. Want a rectifier? Condenser? Resistor? Switch? Noise filter? Jacks and plugs? Electronic hardware? Your Mallory Distributor can help you choose the best design for each job.

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# COMMUNICATIONS

LEWIS WINNER, Editor


# WARTIME DESIGN PRACTICE

by ELLIOTT MARSHALL

The vision and skill of American engineering are today pitted against the toughest assignment in the history of mankind. Never have the demands been so acute, so paralyzing in their severity, in view of the unprecedented conditions that are to be met in the field. This does not mean that in the past, design and construction has been lax, or that field conditions have been simple to solve. In the communications world, tremendous strides have been made and reams of balky obstacles overcome, but in wartime, these obstacles become truly mountainous. And in the present grave wartime era, situations that are well nigh unbelievable run riot.

Lightning arrestors seem to be simple devices. Yet their design and operation is involved; so much so, that Westinghouse engineers developed the arrangement shown above to make a photographic record of an electric arc in 1/10,000 of a second of its flight.

### *Equipment Strains*

It is impossible for anyone to imagine the strain experienced by equipment in a screaming dive bomber, or a speeding submarine or a racing smashing 60-ton tank. Conditions can be aptly classified as just "impossible" but nevertheless the apparatus just must work. Alibis don't help the pilot, or the sub commander or the others in the thick of the bullets. Thus design today is an exceedingly complicated matter, involving a physical-material knowledge as well as an extensive application of electrical and radio engineering advancements. For instance, in the recent design of an apparently simple antenna mast for one of our fighting air machines, endless hours of research and study were essential. It was necessary to apply a material that would resist the terrific stresses set up by wind pressure that existed up and above speeds of 400 miles per hour. In addition the shape of the design had to be such that the aerodynamic drag was exceedingly low, for the power required to draw such a protuberance through the air can mount to considerable magnitude. Weight was another factor in this latter problem. Thus it was essential to select a material that was unusually lightweight, strong, and with of course good electrical properties. In this instance, macerated fabric filled phenol-formaldehyde molding powder was used for the cap of the mast. The base, serving as the bottom closure and attaching mount, used this material plus five laminations of canvas integrally molded around the flange. The thin walled tapered mast was constructed as a molded laminated tube.

The simple antenna mast that required an intricate design to achieve the necessary results for bomber application.

(Modern Plastics Competition Photo)

### *Other Examples of Design*

Another recent design that exhibits wartime design practice is a voltage regulator for use in planes. Here is another apparently simple device, that

Tanks on the assembly line into which go a wide variety of communication equipment that must pass rigid tests never before imagined. Tanks shown are of the 30-ton type. The 60-ton type are now coming off the line and, perhaps soon, even heavier types will be made and thus even more durable types of communication equipment will be necessary.

(OEM Photo)

nevertheless required tremendous research to afford operation under strained conditions. In its completed state this improved regulator operates at temperatures ranging from 40 degrees below zero and from sea level to more than 35,000 feet up, affording suitable current supply to communication and other associated equipment on planes. This unit weighs but two pounds, yet handles three times more current than its predecessors. The smallest regulator for industrial use weighs 13 pounds, and is almost four times the size of this newer unit.

Many laboratories have constructed "actual-condition" tests that run the projected component through every possible "in-use" application. One plant, for instance, tests its relays at temperatures from —70° to 200° F. In addition it places these components in a three and four-pound vacuum to simulate ionization, runs them through dirt blasts to see of the contacts will be acceptable to dirt, gives them a salt-spray test, water-immersion test, a rigid vibration test (¼" amplitude for an artifical simulated gravity up to 209), and a series of electrical tests to 50 mc. In some of these electrical tests elevations up to 40,000 feet are simulated. One switch recently developed is said to be rated at 25 amperes at 28 volts direct current at this elevation.

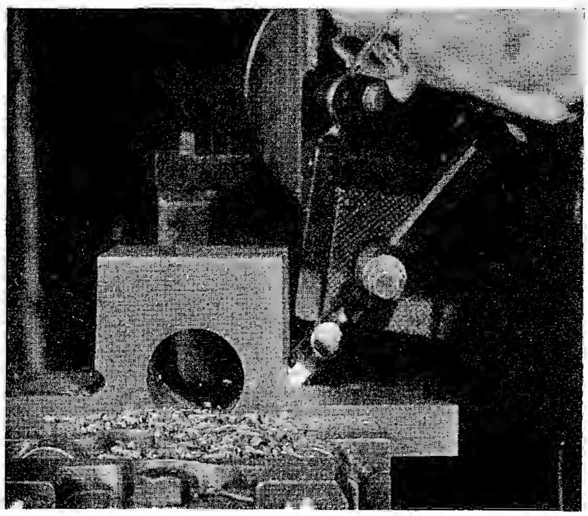
### ALTERNATE METALS

In view of the trend towards the use of alternate metals, many of which are radically new to communications, microscopic tests have become of increasing importance. The electron microscope has been of invaluable help in this work, having supplied exact data on alloys heretofore never available. At a recent demonstration, for instance, results of the structure of martensite were shown. This material is made by chilling heated carbon steel very rapidly, and is used in lathes and other machine tools for cutting metal at high speed. The tests showed that actually the martensite consists of alternate plates of iron and iron carbide, a finding that will afford many other applications in our wartime effort.

Since the curtailment of many metals common to communication work, such as copper, tungsten, we have been hearing quite a bit about sterling silver. There is no doubt that this material is much more expensive as a bulk replacement, but it can be used in small quantities in many instances to afford very effective results. One of the best examples of this application is in the high speed tool. There is no need to have such a tool made entirely of high speed steel. Only a small tip need have the tungsten bearing alloy. Practically all of the rest can be of carbon steel, because of the silver brazing alloys that help to make a secure joint between the two other metals. A joint less than ,003" thick turns the trick. It is also interesting to note that silver alloys respond very well to heat treatment. Sterling silver, which actually contains 925 parts of fine silver and 75 parts of copper or 7½% of the total weight, can be hardened by heat treatment as well as by cold working. Sterling silver which is heated to 700° F. and quenched has a scleroscope hardness of 23 and a Rockwell hardness of 47.

The importance of the proper design of another simple unit was effectively demonstrated recently when a freighter that had been machine gunned in the Mediterranean, docked in New York, and displayed its radio equipment. Because of the unusual design of a magnetic contactor, the communication equipment was kept "on the air," even though a bullet had made a jagged hole in the contactor cover, shattered the asbestos and plastic bases and even cut the resistor wires deeply. Here was a component with an effective design that truly "saved the day."

(Left) GE engineers inspecting new components designed specifically for wartime practice. (Right) Placing a high polish on a machine part to eliminate cracking under the high speeds and terrific vibration experienced in wartime.



## *A Report on the 5th Annual Conference of*

# BROADCAST ENGINEERS

**by LEWIS WINNER**
**Editor**

A SERIES of meetings, without parallel in the history of broadcasting, occasioned the fifth annual broadcast engineering conference at Ohio State University, Columbus, Ohio, during the week of February 23. Gathering for the first time since the inception of broadcasting, under actual war conditions, engineers and executives listened with grave intent to the papers and the "on-the-floor" discussions. They listened to the staggering problems of a nation at war and its significant impact on such vital industries as communications. They listened to analyses of all sides of the maze of issues by one of the most representative groups of government and civilian specialists ever to convene at a conference.

The position of the government was effectively presented by E. K. Jett, chief engineer of the Federal Communications Commission and chairman of the coordinating committee of the Defense Communications Board. He stated that officialdom thoroughly understands the tremendous power of broadcasting and as such will continue to subscribe to its consistent operation. The new War Production Board and the Defense Communications Board have each adopted coordinating policies with the FCC acting as counsel and liaison to afford preparation of rules and regulations that will facilitate and expedite all operations, according to Mr. Jett.

The DCB, the board consisting of experts from both military and civilian communication organizations, has the wide responsibility of studying and determining all communication problems, said Mr. Jett. Thus within this committee a cross sectional viewpoint of the entire industry can be exacted from the various members, and essential decisions can be reached rapidly.

Since broadcasting stations also have the important function of serving as vital information centers, and are thus considered as important units in the national emergency system, they must be safeguarded, particularly against sabotage, continued Mr. Jett. Many stations have already installed protective systems and many others are making ar-

Figure 1

E. K. Jett, chief engineer of the FCC (left), and Lewis Winner, editor of COMMUNICATIONS, at the broadcast engineering conference.

rangements for such installations. Many new developments to provide effective safeguards are also under way. To assure the utmost of such effective protection, an extensive study of plans, methods, rules and regulations is now being made, said Mr. Jett. This is a problem that should not be slighted, according to Mr. Jett. It is of paramount importance and should be immediately recognized as such.

On the subject of new transmitter construction, Mr. Jett emphasized the fact that requests for unnecessary embellishments be stopped. Only if there is a really primary area to be served and if major changes are essential, should any applications be made. However, this does not mean that development or research or improvements cannot continue, said Mr. Jett. It must, and American ingenuity will see to it that there is an ever constant flow of advancements. The papers that were delivered at the meeting more than attested to this fact.

Speaking of station improvements, it was pointed out that priority forms have been greatly simplified. These simplified forms can also be used for parts required for replacements. This new application comes under the P-100 ruling. If an A-10 ruling is not sufficient to obtain the required duplicate parts, then the PD-1-A form should be used.

Probably one of the most important phases of broadcast operation today, according to Mr. Jett, is effective maintenance. A station properly maintained will serve not only to increase the life of the various components, but provide an operating efficiency of an unusual scope. One of the best examples of such proficiency is exemplified in the system at WOR, and fortunately enough described at the convention by Charles W. Singer, technical supervisor of the WOR transmitter.

### *THE WOR MAINTENANCE SYSTEM*

AT WOR, the word reliability has taken on added significance, said Mr. Singer. It is no longer an idea, but rather a duty. The pointers

Figure 2

The transmitter maintenance round table at the conference consisting of (left to right) Frank V. Becker, chief engineer of WTBO; Floyd Lantzer, chief transmitter engineer of WLW; G. Porter Houston, chief engineer of WCBM, and Charles W. Singer, technical supervisor of WOR, who was chairman.

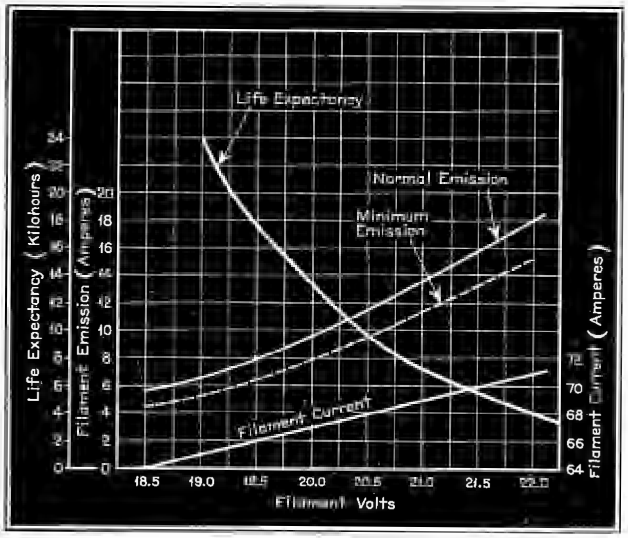



Figure 3 (left)
The filament and life expectancy characteristics of a 10 kw triode. From these curves we can see how an increase or decrease in the filament affects tube life.

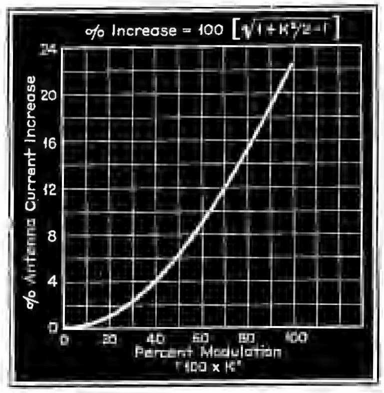



Figure 5
Carrier shift and db loss with antenna current increases are represented by the curves above. Note the comparatively slight db loss to the listener with the varied antenna current.

on reliability in broadcasting operations that were learned during the past score of years, can now be of real help in this period of national emergency. In addition, said Mr. Singer, where special precautions to safeguard the long life of parts and the continuance of service may not have been too rigid because of the ease with which new parts were available, it is now essential to enforce such precautions.

Continuing, Mr. Singer said that the business office is naturally concerned with results, and the engineer certainly knows how to keep a station on the air, for all he needs is equipment and operators. But, that was yesterday. The war has turned this simple solution to a severe handicap. Materials are becoming increasingly difficult to get, and experienced operators are being lost to the Army, Navy and other defense assignments. Thus, the broadcast industry is faced with two great problems.

Younger and untrained technical men out of schools and colleges are finding their way into the transmitting scene, and thus it is still more important to emphasize strict maintenance rules and regulations to achieve efficiency plus, said Mr. Singer.

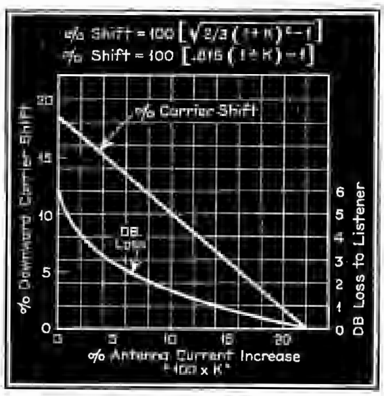
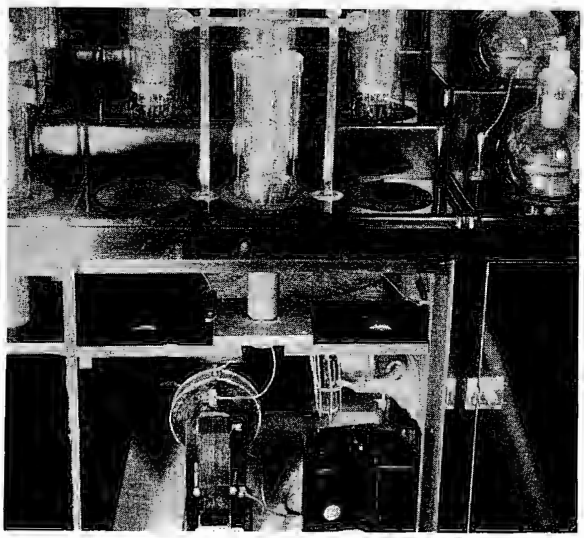
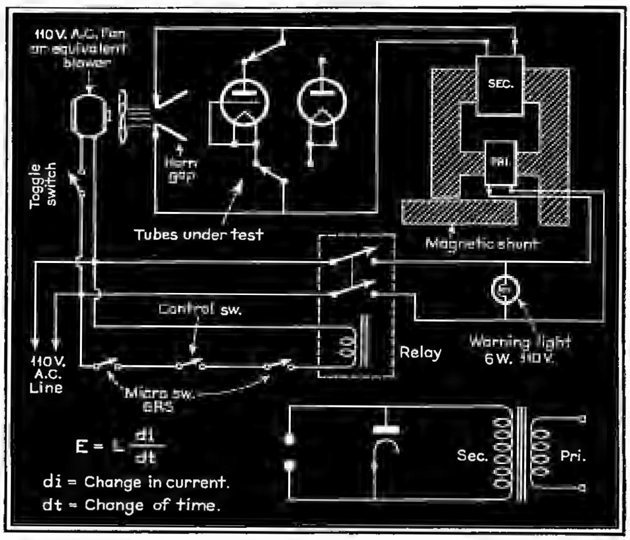



Figure 4
The antenna current increase with modulation is shown in this curve.

Experience at WOR has shown that there are four vital and vulnerable points of transmitter maintenance. These are tubes, condensers, relays and resistors, and in exactly that order, said Mr. Singer. These points should be checked regularly and a permanent record, capacity and resistance measurements kept. Since tubes occupy such a prominent niche in every transmitter, the word precaution looms high and mighty here. This is particularly true because of the poorer quality of some tube elements and parts that may of necessity find their way into some tubes now coming into use. Thus, said Mr. Singer, the effect on the performance and life of a tube will demand careful watching.

Filament control constitutes the major step of control in every maintenance






Figures 6 and 7
The vacuum tube reconditioner for high power thermionic and thermionic mercury vapor tubes.

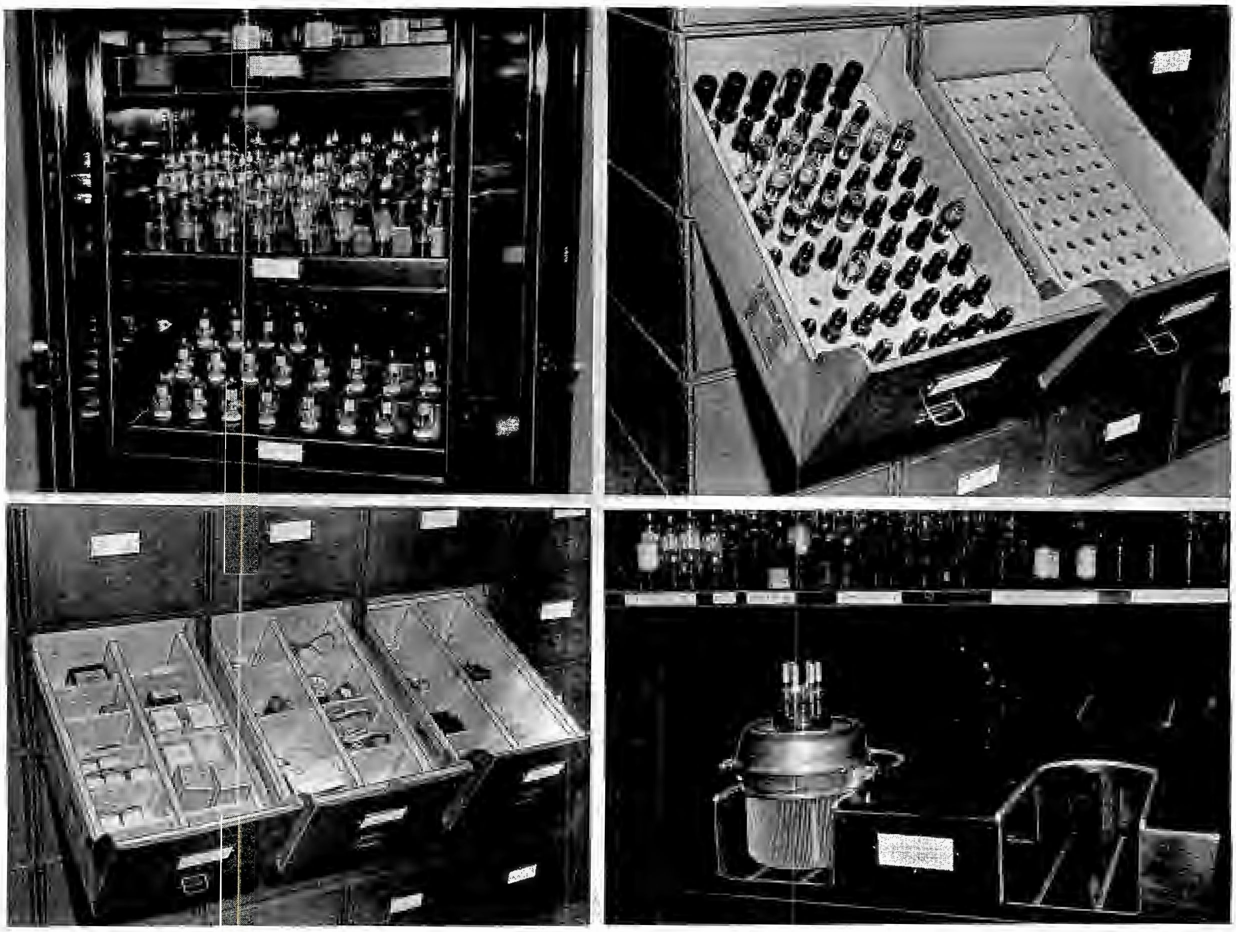


Figure 8
At WOR, reserve tubes and parts are classified and stored in ordinary office lockers with the necessary slight alterations. Spare parts are stored in ordinary cardboard transfiles. In both instances complete indexing, classification and inventory affords an instantaneous guide to the components or tubes required at any time.

program, and today, it takes on added importance. It is a well known fact that the dropping of as little as ½ volt, for instance, can extend tube life tremendously, and vice versa. Life expectancy of a tube thus also forms a vital link in maintenance control. The point can be appreciated from the graphical representation of a life expectancy test of a 10 kw triode in a class B linear transmitter shown in Figure 3. A study of this curve reveals a 5% reduction of the filament voltage doubled the life of the tube, while an increase of 5% in filament voltage decreased life one half. The rated filament voltage for this tube is 20 volts, and its life expectancy is 13,500 hours. By reducing the filament voltage to 19½ the life expectancy was increased some 4,100 hours. This curve illustrates the increase in tube life by operating the filament voltage below normal in the second linear stage. Of course, there is no denial that such reduced filament voltage will have some ill effects, said Mr. Singer. Modern broadcast transmitters when operated normally, provide a 22½% increase in antenna current, with full modulation, single frequency. Decreasing the filament voltage will naturally diminish the antenna current rise. Thus there arises the important question as to whether it is wise to sacrifice idealistic operation for longer tube life, provided it does not seriously impair the listener' reception. A variety of opinions were given at the convention in response to this problem. In Figures 4 and 5, we have a graphical explanation and an apparent answer to this question. In Figure 4, for instance, we see the percent modulation with various values of antenna current increase. Let us assume, said Mr. Singer, that we drop our filament voltage from 20 to 19. For purpose of illustrating the effect of this lower filament

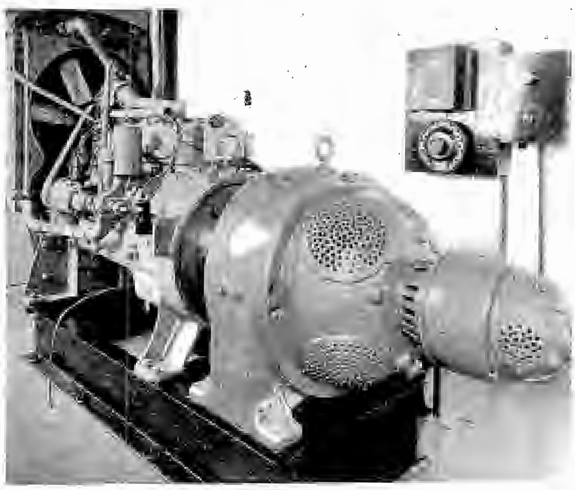
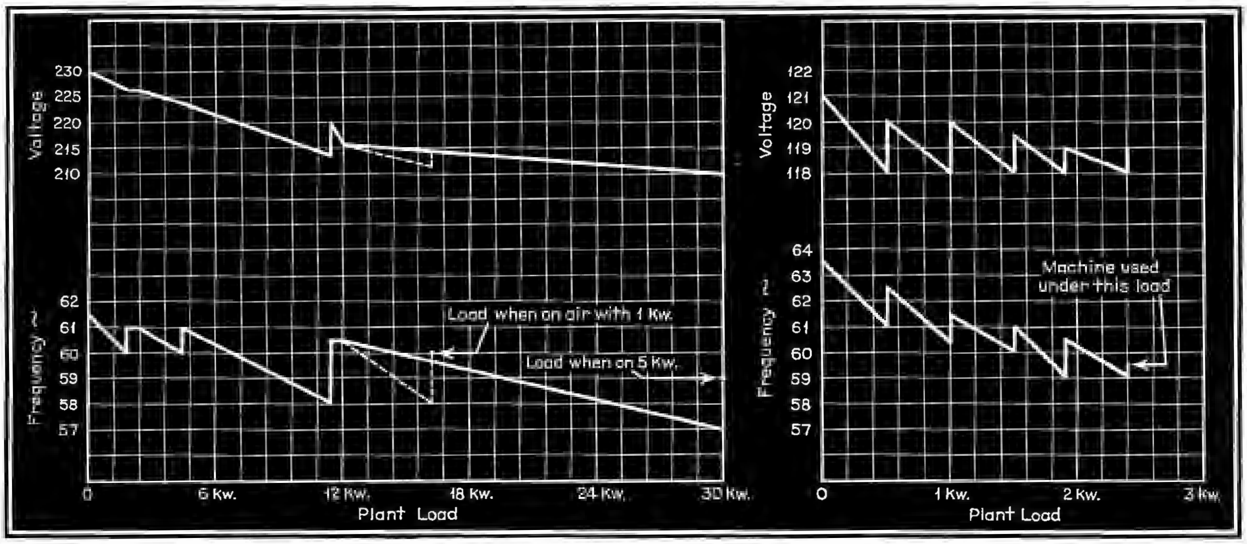


Figure 9
The gasoline engine, alternator and exciter that was selected by chief engineer Karl Troeglen as an emergency power unit for station WIBW.




**Figures 10 and 11**
**Performance characteristics of gasoline engines used for emergency power service.**

voltage, the percentage of antenna current rise is said to increase only 10% instead of the ideal 22½%. Now, as we see in Figure 5, the positive peaks of modulation then become limited to 65%, the percent carrier shift has increased 10%, but the loss to the listener is only 1.68 db. This is comparatively insignificant, and poses the question this time: isn't it better to depart from ideals in this moment of emergency to conserve tube life? A variety of opinions were offered. Although many intimated that such a reduction in listener service was small, it might serve as a wedge to continue such reduction in efficiency. However, the consensus was that if reduction were maintained at suitable levels, there was no reason why this important filament reduction practice could not become a standard of control.

Another important phase of tube maintenance discussed by Mr. Singer concerned the gaseous content control of high and low powered air and water cooled vacuum tubes. Unfortunately, this gaseous condition usually happens when a tube has already operated beyond the guaranteed period, and there is no recourse except to discard it, said Mr. Singer. To operate the tube in a condition which will cause many flash-arcs is extremely risky to both transmitter and program operation. However, this gaseous condition can be remedied with many thousands of hours of additional life realized, said Mr. Singer, by the use of a tube reconditioner. This conditioner, in use at WOR, has "saved" many a tube that would otherwise be in the junk heap. For instance, a Western Electric 342A water cooled, one of eight used in the 50 kw transmitter, was submitted to this treatment, and its life extended another 4,000 hours, after it had already spent 5,000 hours in the final amplifier stage. A series of flash-arcs warned the operator that the tube was dying of old age, but twelve minutes in the reconditioner completely rejuvenated the bottle. This has effected a saving of at least $5,000 in one year. The conditioner used is illustrated and diagrammed in Figures 6 and 7.


**Figure 12**
**F-M receiver mounted atop a mountain and in continuous operation that serves as a reliable receiving station for the New Hampshire state police.**

Initial operation of power tubes which have been kept on the shelf for extended periods may also be improved upon by this conditioner, before they are placed into service, according to Mr. Singer. Tubes that have just been purchased require no treatment before being placed into service. However, according to Mr. Singer, some tubes may deteriorate on the shelf before being used. Now, of course, stations are required to maintain a complement of spares, if they are available. Before a tube that has stood on the shelf for several months is put into operation, said Mr. Singer, it is recommend that it be given a conditioning treatment.

In explaining the reconditioning characteristics of the unit, Mr. Singer said that if during the reconditioning period the tube shows a hazy type of discharge on the first application of voltage, the tube may be gassy as a result of a small leak. A ten minute treatment should clean up this haze condition unless the tube has developed a leak sufficiently large to cause trouble when put into service.

In the second part of the treatment, filament aging at the normal operating voltage for several hours has been tried, said Mr. Singer. During this process, the tube is placed in the transmitter socket with standard cooling conditions and the filament lighted at the correct operating voltage as measured at the tube terminals. Lighting the filament at normal operating temperature tends to clean up residual gases and also tends to clean off both the filament and grid surfaces, continued Mr. Singer. After this operation, the tube is then in shape to be tested in the transmitter under normal starting and operating conditions. In case the first high voltage treatment is necessarily omitted, said Mr. Singer, the filament aging procedure is still of some value. It has also been found that these treatments are very effective in reducing initial flashing during operation, even though the tube is returned to the spare shelf for a week or so prior to its installation in the transmitter.

Continuing on this very important issue of extending tube life, Mr. Singer pointed out that tubes held as spares be conditioned monthly to insure continuity of service when they are inserted for use. Unless a spare socket is available for treating tubes, the conditioning process can be done during off hours when more than one tube can be treated simultaneously so that more than one spare is always conditioned for use. This conditioning process also applies to high vacuum rectifier tubes. A little different process is followed when conditioning new mercury rectifiers. These should be preheated and tested under standard operating conditions to determine that there is no vacuum leak and that all of the mercury splashed on the tube elements during shipment and handling has been evaporated to the lower part of the envelope. After the initial acceptance test, according to Mr. Singer, the tubes should always be handled and stored vertically to insure that the excess mercury does not splash on the electrodes. This treatment is imperative and if the tube is allowed to remain on the shelf for a period greater than three months before its use again, it may become completely inoperative, said Mr. Singer. This is due to the action of the mercury, eating its way into the pores of the cathode and carbon anode.

The problem of a tube failing to rectify without arc-backs, even after preheating, was also discussed. The correction treatment suggested by Mr. Singer includes the insertion of a resistance bank of approximately 1 megohm, such as 20-20 watt, 50,000 ohm resistance units, in series with the anode of the tube which has shown arc-backs. Using the maximum available voltage in the transmitter, the inserted resistance prevents excess currents from flowing through the tube which tends to arc-back. According to Mr. Singer, the voltage should be left on for at least one hour, or until all visible mercury is removed from the anode. Room temperature air should be blown on the lower end of the envelope during this treatment, said Mr. Singer. Then the tube may be operated under standard conditions without the resistance and placed back into the spare tube cabinet for future use.

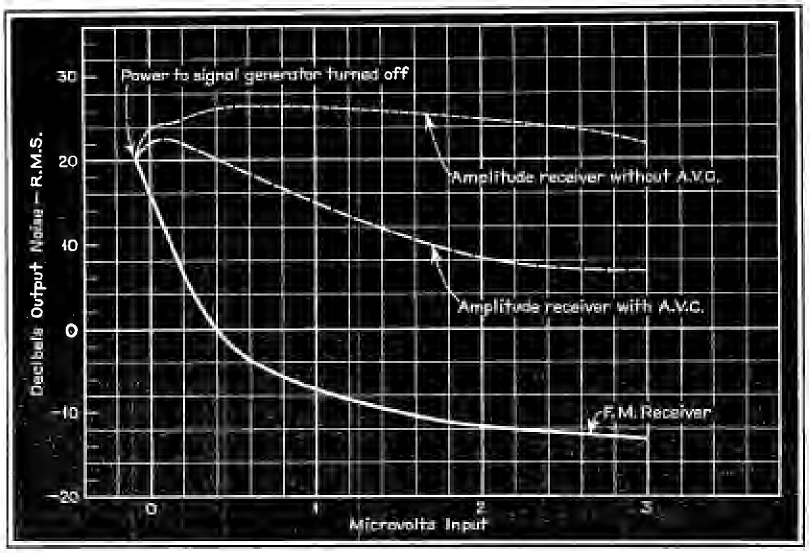



Figure 13
**Output tube noise plotted against carrier input level at 33 mc of an f-m receiver and an a-m receiver.**

To affect maximum efficiency from spare tubes, Mr. Singer also suggested that a definite rotation schedule of spare tubes will insure a longer operating life. He also pointed out that tubes should not be run half voltage simply because they get poisoned.

Other sources of trouble discussed by Mr. Singer concerned warm and hot spots in condensers. This condition may take from months to years to become evident. As soon as the trouble is found, the condenser should be removed and placed in a circuit where the requirements are not so severe. In explaining this problem, Mr. Singer pointed out that, although manufacturers rate and test their capacitors as accurately as possible, it is not a simple matter to test each piece of mica that constitutes a condenser. It is the gradual breakdown of some small piece of mica in the condenser that causes it to carbonize and get warm in one spot and eventually lead to the loss of a program.

Relays are another prominent source of trouble, said Mr. Singer. They should be cleaned monthly. The tools for relay maintenance are burnishing tools, crocus cloth, carbon tetachloride, gram gauge, etc.

Resistors are the most difficult in which to anticipate trouble. Experience has shown, said Mr. Singer, that, aside from overload, the first indication is discoloration, and second, faulty connections. Resistances should be measured at least three times a year to maintain efficiency.

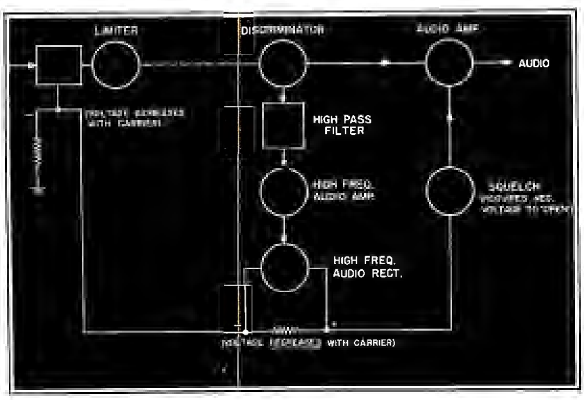



Figure 14
**Block diagram of the squelch system. This system is extremely effective in controlling the sensitivity and noise-limiting characteristics in an f-m receiver.**

### *TROEGLEN'S DATA ON EMERGENCY POWER PLANTS*

A CONSISTENT source of power supply is another major problem which faces all stations in these moments of emergency. This problem formerly only concerned those stations in remote points where emergency power line links could not be easily be made because of physical as well as electrical obstacles. Today, however, emergency power systems are necessary everywhere. Aware of such exigencies, chief engineer Karl Troeglen recently

(*Continued on page* 26)

# 5 plus FEATURES

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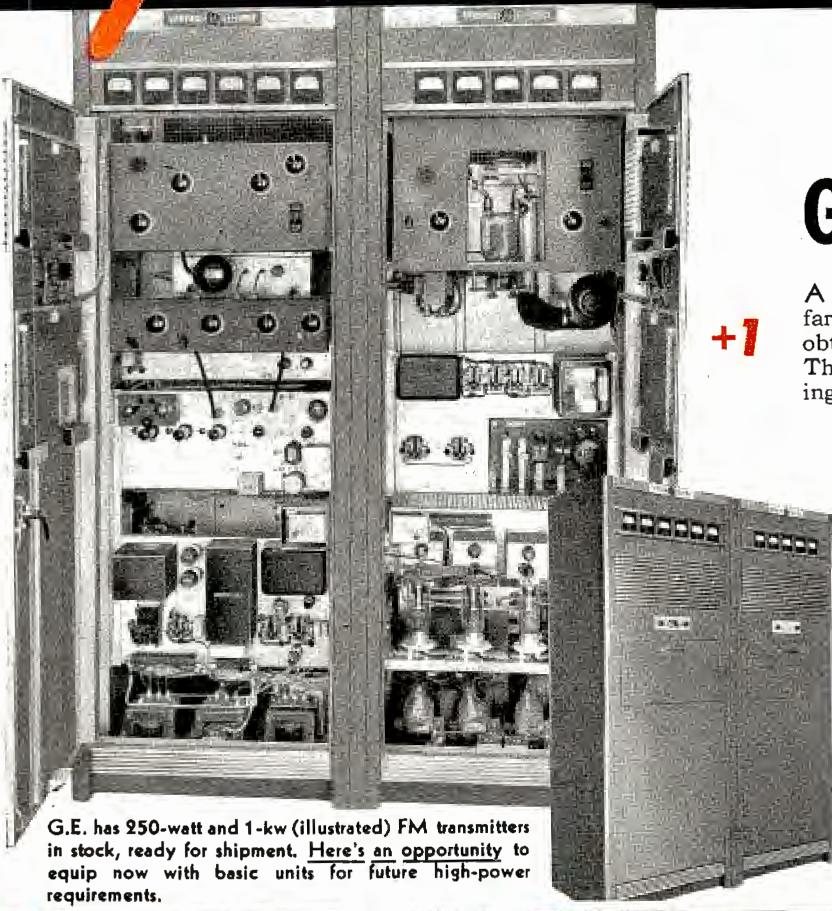


G.E. has 250-watt and 1-kw (illustrated) FM transmitters in stock, ready for shipment. Here's an opportunity to equip now with basic units for future high-power requirements.

**+1** **A new method of controlling crystal temperature,** which far surpasses older methods in the frequency stability obtained, is utilized in the hermetically sealed G-31 Thermocell crystal unit. Provision is made for switching to a spare during operation.

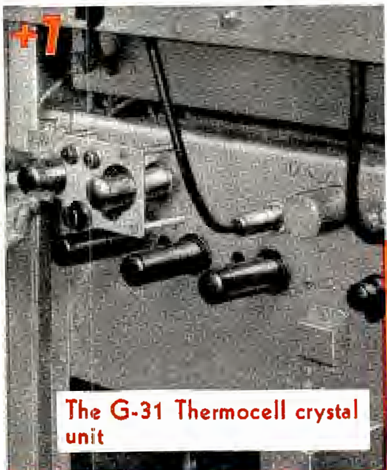
**+2** **An automatic recloser circuit** makes the interruption of service caused by momentary overloads (removed by overcurrent relays) almost imperceptible to the listener.

**+3** **Telechron motor time-delay relays** protect the rectifier tubes against premature application of plate voltage.

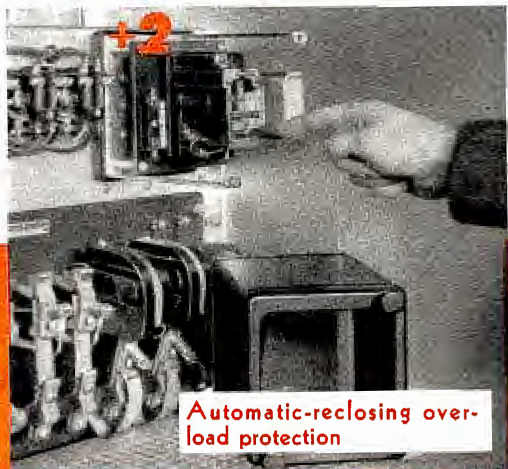
**+4** **Vertical-chassis construction** makes every tube and soldered joint completely accessible. There is no need of removing entire units from the transmitter for detailed inspection.

**+5** **Safety to operating personnel** is assured by interlocks and high-voltage grounding switches on the main-access doors.

**Details, yes, but important. Extras like these, standard for all G-E *FM* transmitters, contribute substantially in assuring you unusually excellent performance. For long dependable operation at low cost make your FM installation completely General Electric.**



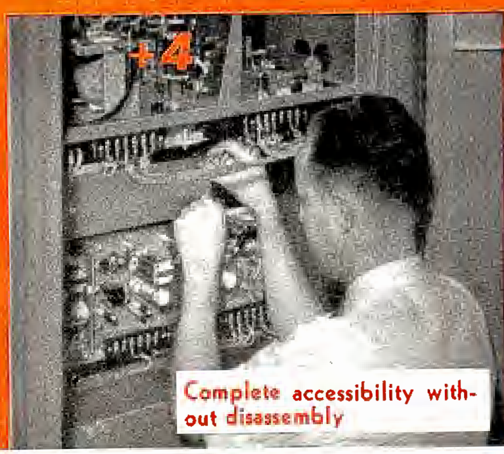

The G-31 Thermocell crystal unit



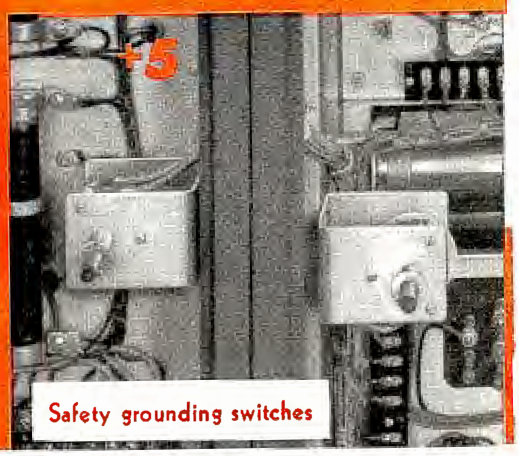

Automatic-reclosing overload protection

*General Electric and its employees are proud of the Navy award of Excellence made to its Erie Works for the manufacture of naval ordnance.*


Telechron motor time-delay relays




Complete accessibility without disassembly

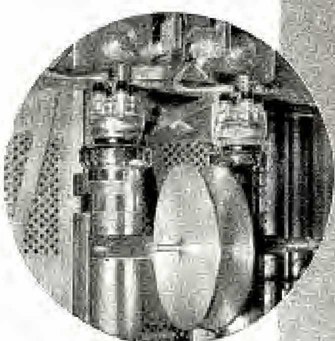



Safety grounding switches

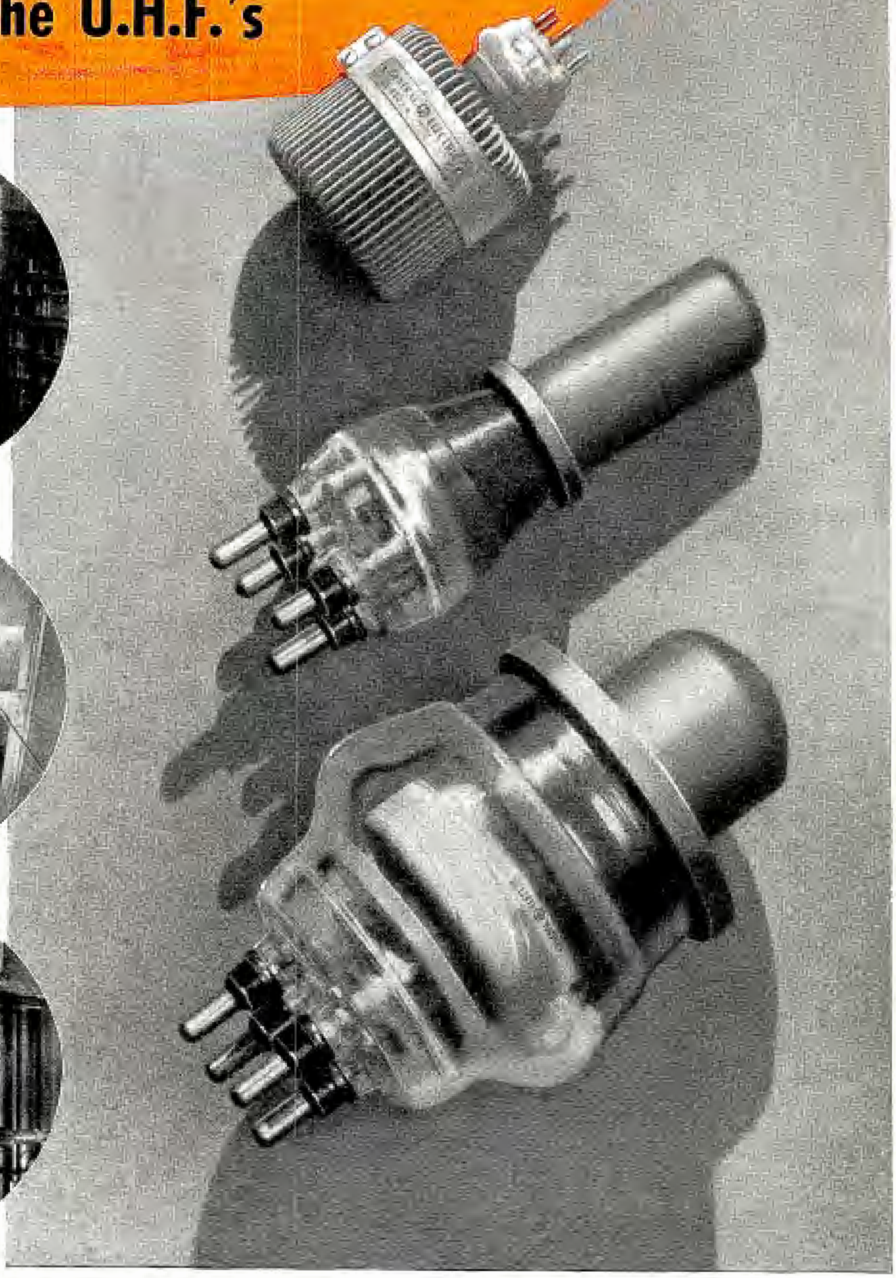
# ...and here are THREE TUBES FOR HIGH EFFICIENCY at the U.H.F.'s

Hardly a handful, but the GL-8002R's output is 1800 watts up to 100 mc

Zenith's FM station W51C packs a 50-kw wallop with a pair of GL-880's



Twenty kilowatts of FM from these GL-889's at W47NV*



"EXCELLENT stability," "Easy to drive," "Easy to neutralize," "No cooling problems," —that's what users are saying about these three tubes. Although built by General Electric primarily to speed the conquest of the ultra-highs, the GL-8002R, GL-889 (also available with radiator for forced-air cooling) and GL-880 provide superior performance for all present-day broadcasting.

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# *Low Frequency*

# SQUARE WAVE ANALYSIS

**by ALBERT PREISMAN**

**Assistant Chief Instructor, RCA Institutes, Inc.**

THE square wave has been used as a means of testing the performance of video, and even audio amplifiers, both at the high and at the low frequency ends of the spectrum. The interpretation of the results is, in general, by no means a simple matter, and it is the object of this article to suggest a relatively easy physical interpretation at the low frequency end of the spectrum.

By means of a Fourier analysis, it is found that the square wave may be expressed as an infinite series of the form

$$G(t) = \sum_{n=1}^{\infty} \frac{4H}{\pi n} \sin n\omega t \quad \ldots\ldots\ldots (1)$$

where H is the peak amplitude of the square wave, G(t), and n is any odd integer from one to infinity, expressing the order of the harmonic.

Suppose this wave is impressed upon an amplifier having a gain characteristic

$$\alpha = H(\omega)\varepsilon^{j\theta(\omega)} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

where $H(\omega)$ is the amplitude response, as a function of frequency, and $\theta(\omega)$ is the phase shift through the amplifier, as a function of frequency. The output wave will be made up of sinusoids of the same frequencies as those given by equation (1) but the relative amplitudes will be changed by the multiplying factor $H(\omega)$ and the phase of each one relative to the input will be changed by the addition of the phase angle $\theta(\omega)$. It is no simple matter ordinarily to plot nor to visualize the output wave when it is thus modified.

In the case of a low frequency square wave, say 60 cycles, a fairly easy interpretation is possible. A video amplifier is usually flat down to this frequency if it is to pass the wave with any semblance of its appearance at the input, and the phase shift is relatively small. Hence, at the third and fifth harmonics and above, that is, at 180 and 300 cycles respectively and higher, the amplitude response $H(\omega)$ is practically constant and $\theta(\omega)$ is practically zero, since both of these become the type of functions to be expected of a purely resistive circuit, in view of the fact that the parameters $C_g$ and $C_f$ (Figure 1) have negligible reactance at these higher frequencies. We may therefore expect that all the harmonics come through the amplifier with the same relative amplitudes and with zero phase shift. (The high frequency parameters such as a peaking coil and the tube interelectrode capacitances do not begin to impose their effects appreciably until frequencies of 1/10th megacycle and higher are reached, and such harmonic frequencies of a 60 cycle square wave are negligible in importance). The distortion of a 60 cycle square wave may therefore be explained as due almost entirely to the variation in amplitude and the shifting in phase of its fundamental 60 cycle component. We shall therefore study the effects of the shifting of the phase of the fundamental and the variation in its amplitude upon the appearance of the resultant output wave.

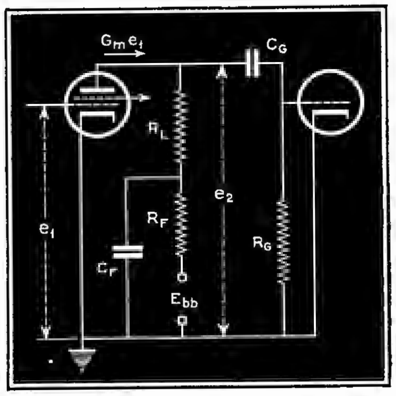


Figure 1

In Figure (2)a is diagrammed a square wave and its fundamental component. Suppose in passing through the amplifier this component is given a leading phase shift, but its relative amplitude is unchanged. By this is

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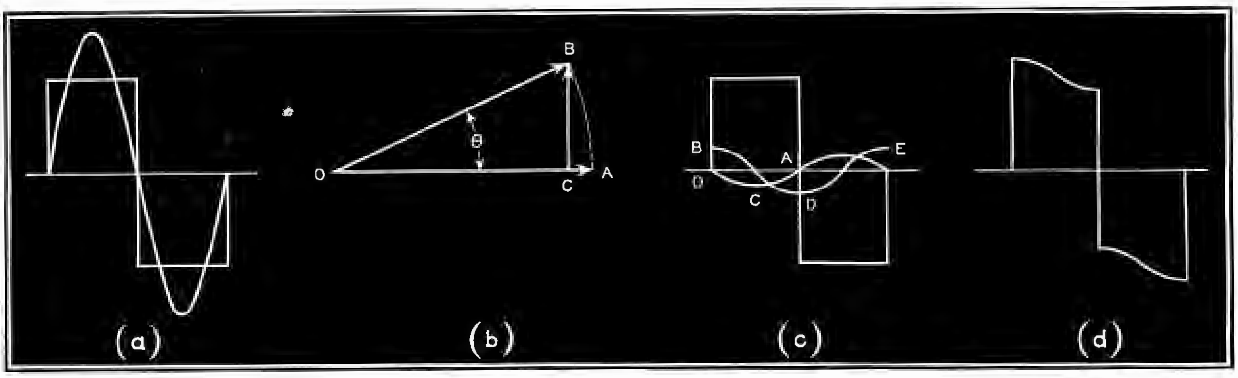



Figure 2

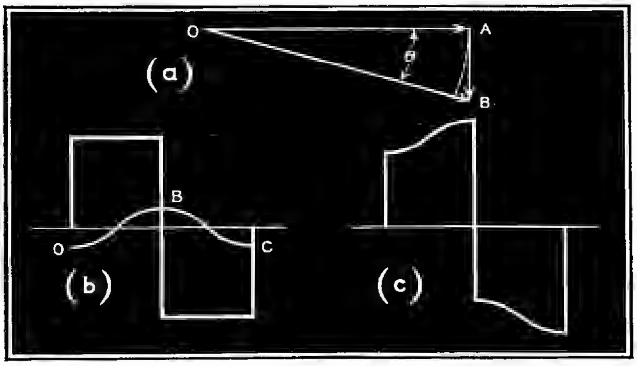



Figure 3

meant that it is amplified to the same extent as the harmonics, but shifted in phase, whereas, the harmonics are not thus shifted in passing through the amplifier. This is portrayed in Figure 2(b). OA is the output fundamental if it were merely amplified and OB is the same fundamental amplified and shifted in phase by the angle θ. As shown in the diagram, OB is equivalent to OA—CA (in phase with it) plus the quadrature component CB. We may therefore consider the shifting in phase by the amplifier as equivalent to a fundamental component OA, which together with the harmonics that pass through give rise to an undistorted square wave, from which is to be subtracted a component CA and then to which is to be added a quadrature component CB. The result of these three operations equivalent to the phase shift is shown in Figure 2(c). Here we have the square wave undistorted in appearance as would be the case if only OA had been the fundamental component. The vector CA is shown in this figure as the wave shape OCA. The obvious effect upon the square wave is to cause hollows in the wave as shown by the broken line. The leading quadrature component BC is shown in this figure as BDE. If this is now added to the hollowed wave a resultant wave, shown separately for clarity in Figure 2(d), is obtained. This wave will be immediately recognized as the type obtained when a square wave is passed through a video stage whose grid time constant ($R_gC_g$) is smaller than the plate decoupling time constant $R_LC_F$, (Figure 1). The coupling condenser $C_g$ causes the current in that branch of the circuit to lead the voltage across it. This leading current in flowing through $R_g$ sets up a leading voltage (with respect to that apparently generated in the plate circuit) so that a leading phase shift may be expected. This effect, however, as mentioned previously, is only of consequence at the fundamental frequency of the square wave and possibly to some slight extent at the third harmonic frequency. Hence, a wave as shown in Figure 2(d), sloping towards the axis in the direction of increasing time, suggests that the grid time constant is too low. The important things to note are . . . 1)—that the phase shift causes sloping of the output wave through the action of the quadrature component, whereas . . . 2)—an in-phase-component such as produced by amplitude discrimination alone would cause a hollowed wave whose two sides would be of equal height. It is thus possible by this method of analysis to picture in simple fashion the effect of phase and amplitude distortion upon the appearance of the output square wave.

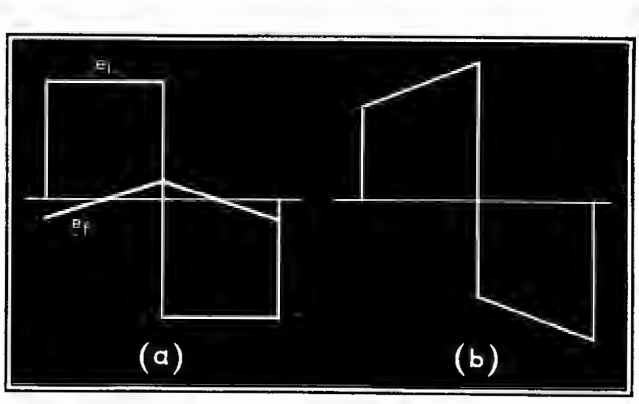
Referring to Figure 2(b) once more, it will be noted that a small phase shift produces an appreciable quadrature component BC but only a very small in-phase subtractive component CA. Indeed, if θ is very small then BC is practically equal to $OB \times \theta = OA \times \theta$, i.e., $\sin \theta = \theta$, and CA may be neglected. Now, in a properly designed video amplifier that is slightly out of adjustment, the reduction in amplitude gain is exceedingly small so that the reduction in fundamental component is practically negligible. The phase shift may also be small but the quadrature component due to it will not be negligible as can be noted from Figure 2(b), and so a sloping output wave may be expected. This indicates that distortion of the square wave in passing through an amplifier is due mainly to phase shift and not to the concommitant variation in amplitude response, a fact that has been noted by Von Ardenne in the case of a saw tooth wave.[1]

We can now study the case where the plate time constant $R_LC_F$ exceeds the grid time constant $R_gC_g$ (Figure 1). If we assume a pentode tube or constant current type of generator, and further that the grid circuit (composed of $C_g$ and $R_g$ in series) is a negligible shunt across the plate circuit, then the constant current output, of value $G_me_1$, may be regarded as flowing entirely through the plate load of $R_L$ and $C_F$ in series. (We shall thus assume, for the time being that $R_F$ is a negligibly high shunt across $C_F$ for the frequencies under consideration).

This current produces an in-phase voltage across $R_L$ and a quadrature (lagging) voltage across $C_F$; hence a total voltage, $e_2$, which partially lags the current. The fundamental component of $e_2$ lags the fundamental component of $G_me_1$ (assumed a square wave) by the greatest amount, since the reactance of $C_F$ is greatest at this lowest frequency. Hence, as a fair approximation, we may assume that all the components of $e_2$ are in phase with the corresponding current components, except the fundamental, which lags the current fundamental by some small angle θ. We now have the vector situation shown in Figure 3 (a). Here OA is the proper (zero) phase for the fundamental of $e_2$ for a perfect square wave voltage. OB represents the actual magnitude of the fundamental. Note that it leads OA by the angle θ, and is larger, because of the additive contribution of the voltage drop across $C_F$. In the diagram it has been shown just long enough so that OA may be regarded as the drop across $R_L$, and OB, that across $C_F$. We assume therefore that for the harmonics, the voltages are those developed across $R_L$ alone, and that the drops across $C_F$ are

[1]Von Ardenne. M., Distortion of Saw-tooth Waveforms, Electronics, November, 1937.

Figure 4



negligible at these higher frequencies.

The effect upon the square wave is shown in Figure 3 (b). Thus the fundamental, OA, of Figure 3 (a) becomes merged in the square wave of Figure 3 (b), and the quadrature component, AB, of the former figure is represented in the latter as OBC. The resultant wave is therefore as shown in Figure 3 (c). It has a tilt towards the trailing edge, which is in the opposite direction to that of the grid circuit, Figure 2 (d). Thus the plate circuit may be used to counteract the tilt of the grid circuit, and hence permit a square wave to be presented to the grid of the next stage.

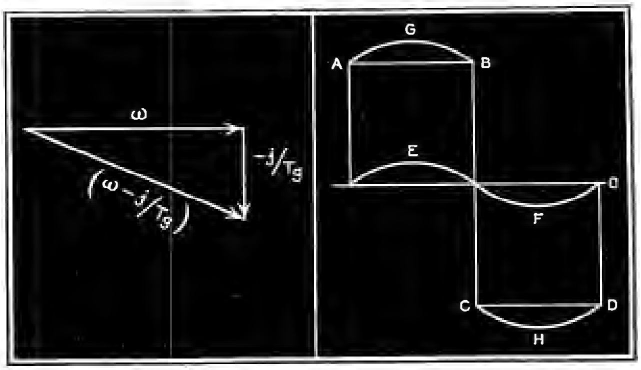
In the case of the plate load of $R_F$ and $C_F$ in series, an alternative simple explanation is possible which is even more correct than the approximate one given above. The input grid voltage, $e_1$, may be considered as having the constant value $E_1$ during the positive half cycle and $-E_1$ during the negative half cycle. The alternating component of the plate current is therefore $G_mE_1$ and $-G_mE_1$ during the corresponding half cycles. The voltage, $e_L$, across $R_L$ is therefore $G_mE_1E_L$ and $-G_mE_1R_L$, or a square wave, too.

The voltage across $C_F$ is given by

$$e_F = \frac{1}{C_F}\int_o^t i\,dt = \frac{1}{C_F}\int_o^t G_mE_1dt = \frac{G_mE_1}{C_F}\cdot t$$

for the positive half cycle, and $(-G_mE_1/C_F)t$ for the negative half cycle.

This is evidently a saw tooth wave, as shown in Figure 4 (a) as $e_F$, together with the square wave, $e_L$, across $R_L$. The resultant wave is shown in Figure 4 (b), and exhibits the tilt predicted in the discussion of vector considerations—plate time constant. The viewpoint here, namely, that $C_F$ acts as an integrating circuit, is more accurate in that it takes into account not only the action of $C_F$ upon the fundamental component of $e_2$, but upon its harmonics, as well. No such method of approach is possible for the grid circuit, however, and so the more approximate, but eminently satisfactory method given in the discussion of grid time constants must suffice. This steady state, or vector analysis of a square wave will be of value in a further study of the amplifier action.




Figures 5 (left) and 6 (right)

In a previous article[2] the author presented a fairly complete analysis of the low frequency response characteristic of an n-stage video amplifier. The gain could be written as

$\alpha_n$ is equal to $G(_{m1}\cdots G_{mn})\,(R_{L1}\cdots R_{Ln})$ times the quotient of $\omega^n\,(\omega - j/T_{LF1})\cdots(\omega - j/T_{LFn})$ divided by $(\omega - j/T_{F1})\,(\omega - j/T_{g1})\cdots(\omega - j/T_{Fn})(\omega - j/T_{gn})$ ..........(3)

In this formula, the subscripts refer to the individual stages, all assumed of the form given by Figure 1. The time constant $T_{LF}$ represents the product of $C_F$ and $R_L$ and $R_F$ in parallel, while $T_F = C_FR_F$, and $T_g = C_gR_g$. It is thus to be noted that $R_F$ is not considered a negligible high shunt across $C_F$. The grid circuit, however, is considered a negligibly high shunt across the plate load, which is generally the case in practice.

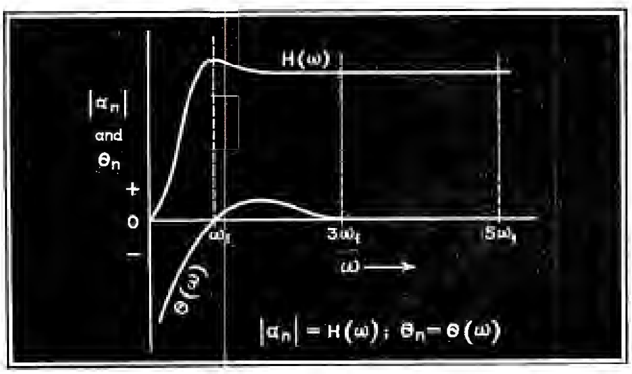
We can now study the behavior of the system to a square wave in terms of its steady-state response and in the light of the effect of the behavior of the fundamental component of the wave upon its shape. An examination of equation (3) shows that it is composed of the product of n scalar $G_m$'s, n scalar $R_L$'s, and a quotient of two sets of products involving time constants and ω. It is to be noted that both the numerator and the denominator involve powers of ω from the $2n^{th}$ to the first. Indeed, we may regard either as a polynominal in ω written in the factored form, i.e.—a product of terms, each of which represents ω minus a root of the polynominal.

Thus the first stage contributes two terms to the numerator: $(\omega - o)$ and $(\omega - j/T_{LF1})$. The two roots are zero and $j/T_{LF1}$, a pure imaginary. Similarly, the first stage contributes two terms to the denominator: $(\omega - j/T_{F1})$ and $(\omega - j/T_{g1})$, with roots $j/T_{F1}$ and $j/T_{g1}$. If the numerator and denominator could be arranged to have the same roots, they would be identical for all values of ω, and hence their quotient would be a real number, such as unity, and independent of ω. In this case the gain would be constant over the low frequency end of the spectrum where tube electrode capacitances and counteracting peaking coils are inactive.

Such a desirable condition can only be approximated, however. We note that the numerator has n roots equal to zero. Hence the denominator must have n such roots, or n infinite time constants. If we make n grid time constants $(T_g)$ infinite, then we must equate $T_F$'s in the denominator to $T_{LF}$'s in the numerator. But $T_F$ is always greater than the corresponding $T_{LF}$ arising from the same stage, because $T_F = C_F\,R_F$, and

$$T_{LF} = C\frac{R_L\,R_F}{R_L + R_F},\ \text{and}\ \frac{R_L\,R_F}{R_L + R_F} < R_F.$$

Hence we would make n $T_F$'s infinite,




Figuro 7

[2]"Some Notes on Video Amplifier Design" by A. Preisman, RCA Review, April, 1938.

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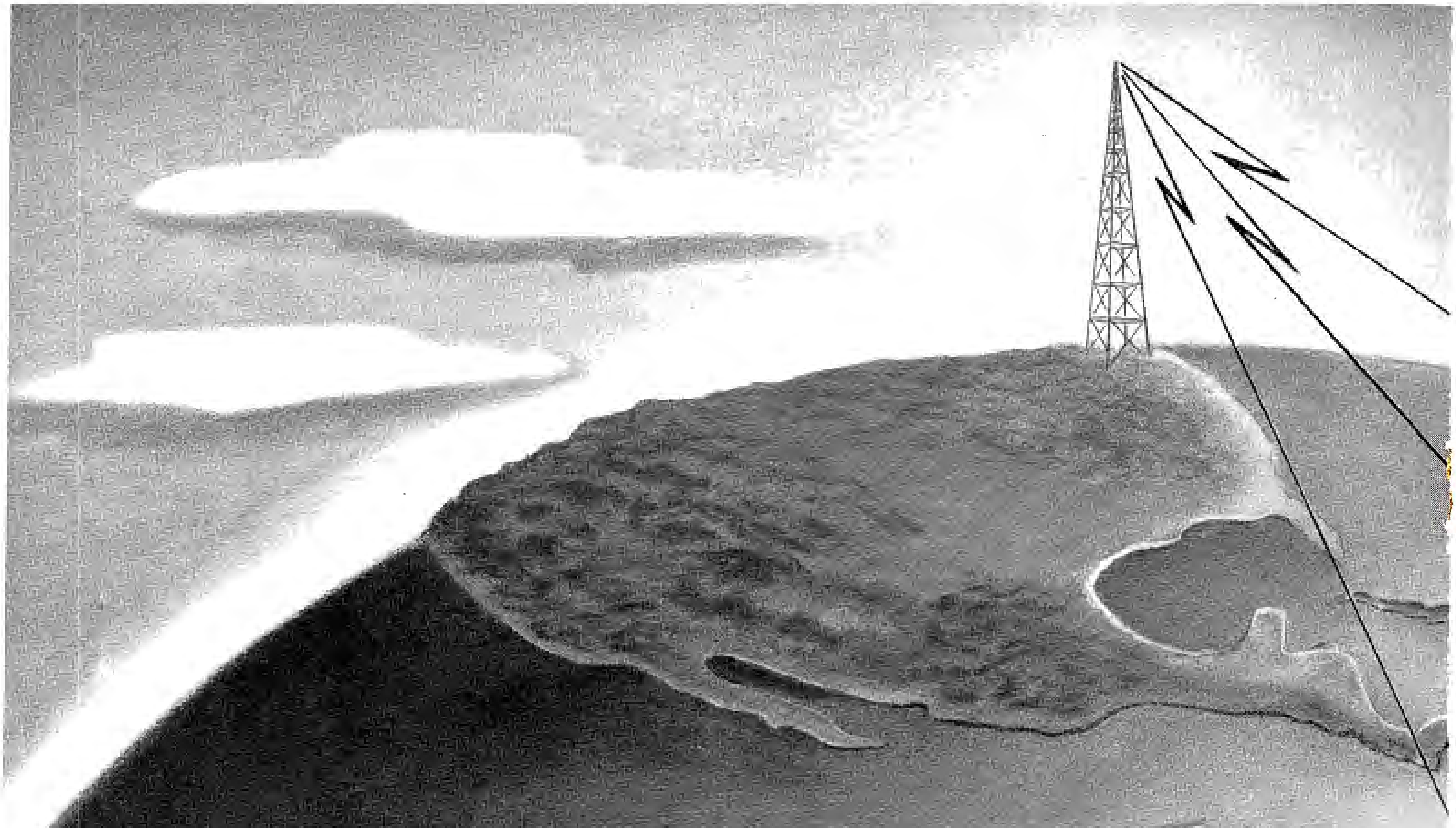

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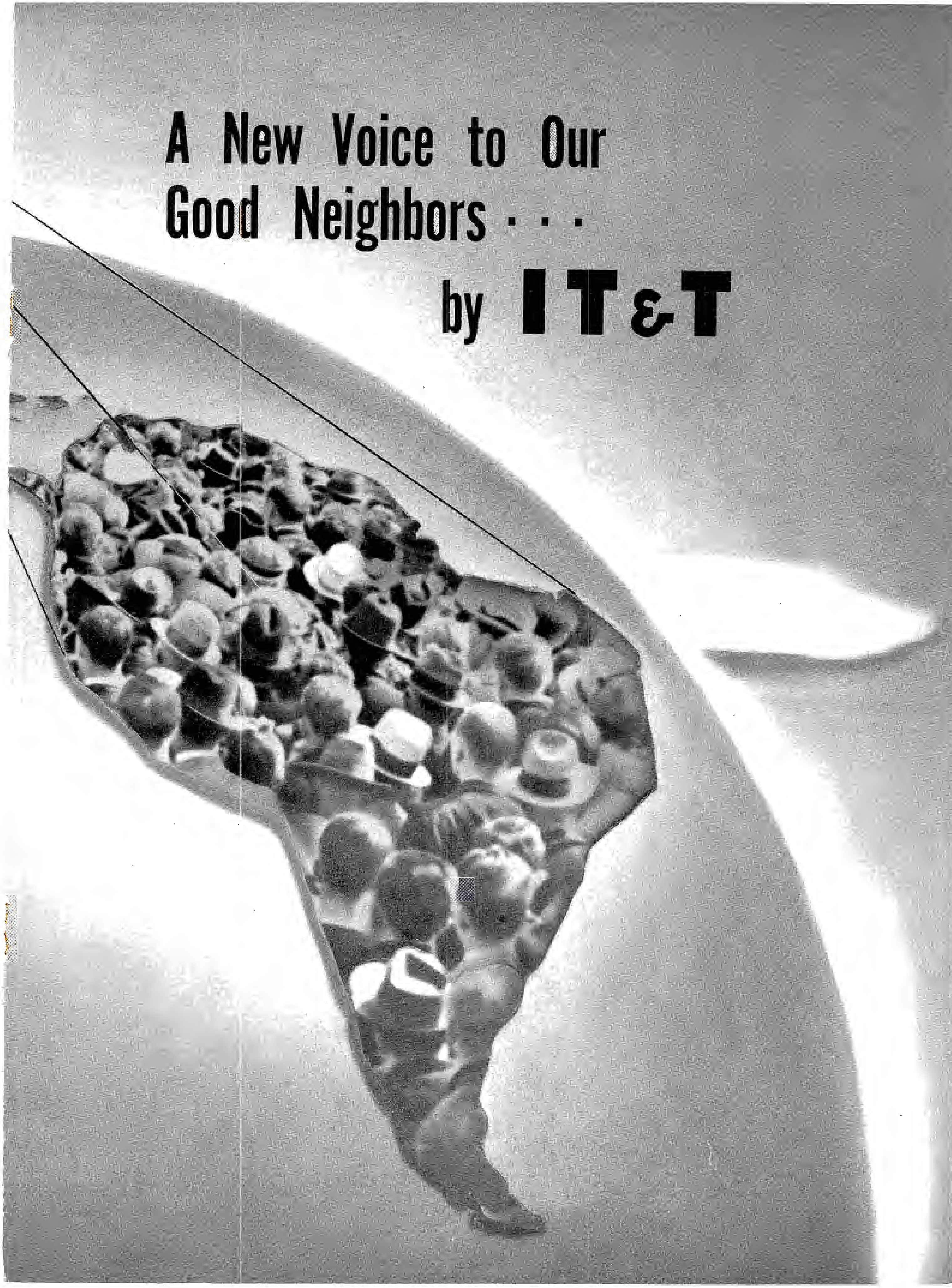
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*(Continued from page 17)*

and thus obtain n factors in the denominator of the form $(\omega - j/T_F) = \omega$. This would result in $\omega^n$ in the denominator cancelling $\omega^n$ in the numerator. We would then equate $T_{LF}$'s and $T_g$'s in pairs, and obtain the desired result.

This is what is normally approximated in practice. At the lowest value of $\omega$ in which we are interested, say — 30 cps, we arrange that $T_F = C_F R_F$ is so high compared to $\omega$ that

$$-j/C_F R_F << \omega$$

or

$$-j/\omega C_F << R_F \quad \ldots\ldots (4)$$

The inequality given by (4) usually results in a value of $R_F$ sufficiently high, so that $(R_L R_F / R_L + R_F) \cong R_L$; and $T_{LF} \cong C_F R_L$. In this case, for flat response down to the lowest frequency, we equate $C_F R_L$ of a stage to $C_g R_g$. The two time constants may be of different stages, but in actual practice it is simpler to equate the plate and grid time constants of the same stage.

Sometimes it is impossible to do this, and so the question arises; is it possible to compensate for several small time constants of one type with a large time constant of the other type? Another question that arises; can good results be obtained if $R_F$ is not sufficiently high, and hence j/T not negligible compared to the lowest value of $\omega$? Before these can be answered, equation (3) must be studied a little more carefully.

We note that each term involving $\omega$ is a complex number or time vector. A representative term is shown in Figure 5. Its magnitude and angle are respectively

$$\left.\begin{aligned} L &= \sqrt{\omega^2 + (1/T_g^2)} \\ \text{and} \quad \theta &= \tan^{-1}(-1/\omega T_g) \end{aligned}\right\} \ldots\ldots (5)$$

The product of such vectors is a vector whose magnitude is equal to the product of the magnitudes of the individual vectors, and whose angle equals the sum of the individual angles. Thus the numerator and denominator are two vectors whose magnitudes and angles are function of $\omega$. Their quotient is also a vector, of length equal to the quotient of the numerator by the denominator length, and angle equal to their difference in angles. Thus, finally, we have $\alpha_n$ expressed as a vector which is a function of frequency.

Now it is evident from equation (5) that L and $\theta$ follow different laws with respect to $\omega$. Thus, for very small values of $\omega$, $L \cong 1/T_g$, and $\theta \cong \pi/2$. As $\omega$ increases, L approaches $\omega$ in value, and $\theta$ approaches zero. Thus we can obtain among many other possibilities, the condition that at some frequency the angle of the numerator equals the angle of the denominator, but its magnitude exceeds that of the denominator. This can occur, for example, if all save one $T_F$ are negligibly high, and this one $T_F$ and a $T_g$, in the denominator, are to be balanced by a single $T_{LF}$ in the numerator while other $T_{LF}$'s and $T_g$'s are balanced in pairs. When we attempt to do this experimentally, we adjust a time constant (usually $T_g$ by means of $R_g$) so that the square wave has no tilt. From the preceding discussion, it is evident that what we do is essentially to eliminate any phase angle in $\alpha_n$. Thus $\theta_{LF}$ of the above $T_{LF}$ is adjusted equal to $(\theta_F + \theta_g)$ of the above $T_F$ and $T_g$, respectively. The angles involved are usually small, so that in view of equation (5)

$$1/T_g + 1/T_F \cong 1/T_{LF} \quad \ldots\ldots\ldots\ldots (6)$$

and $T_g$ and $T_F$ are therefore relatively small compared to $\omega$, so that the product of the lengths $(\omega - j/T_F)$ $(\omega - j/T_F)$ is approximately $\omega^2$ from equation (5), and $(\omega - j/T_{LF})$ is $\sqrt{\omega^2 + (1/T_{FL}^2)}$. Thus the numerator length tends to exceed the denominator length at that frequency where the overall angle is zero. We thus have the condition of an excess gain at a frequency where there is no phase shift. On the other hand, for large values of $\omega$, all terms individually approach $\omega$ in value, so that

$$\alpha_n \cong (G_{m1} G_{m2} \cdots G_{mn}) \; (R_{L1} R_{L2} \cdots R_{Ln}) \quad \ldots\ldots\ldots\ldots (7)$$

or the gain is constant at a lower value than at that critical frequency, but the phase shift is again zero. This situation is depicted in Figure 7. At some frequency, $\omega_1$, the gain $|\alpha_n|$ is excessive, but the overall phase angle $\theta_n$ is zero.

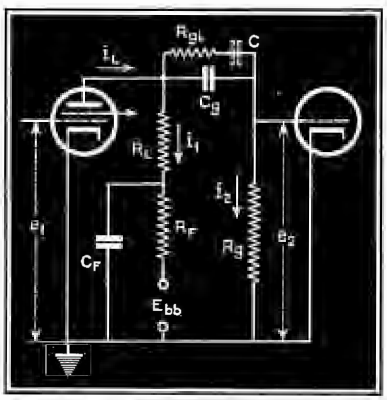



Figure 8

Note that the phase shift starts out leading with increase of $\omega$, crosses the latter's axis, reaches a small maximum, and then subsides to zero.

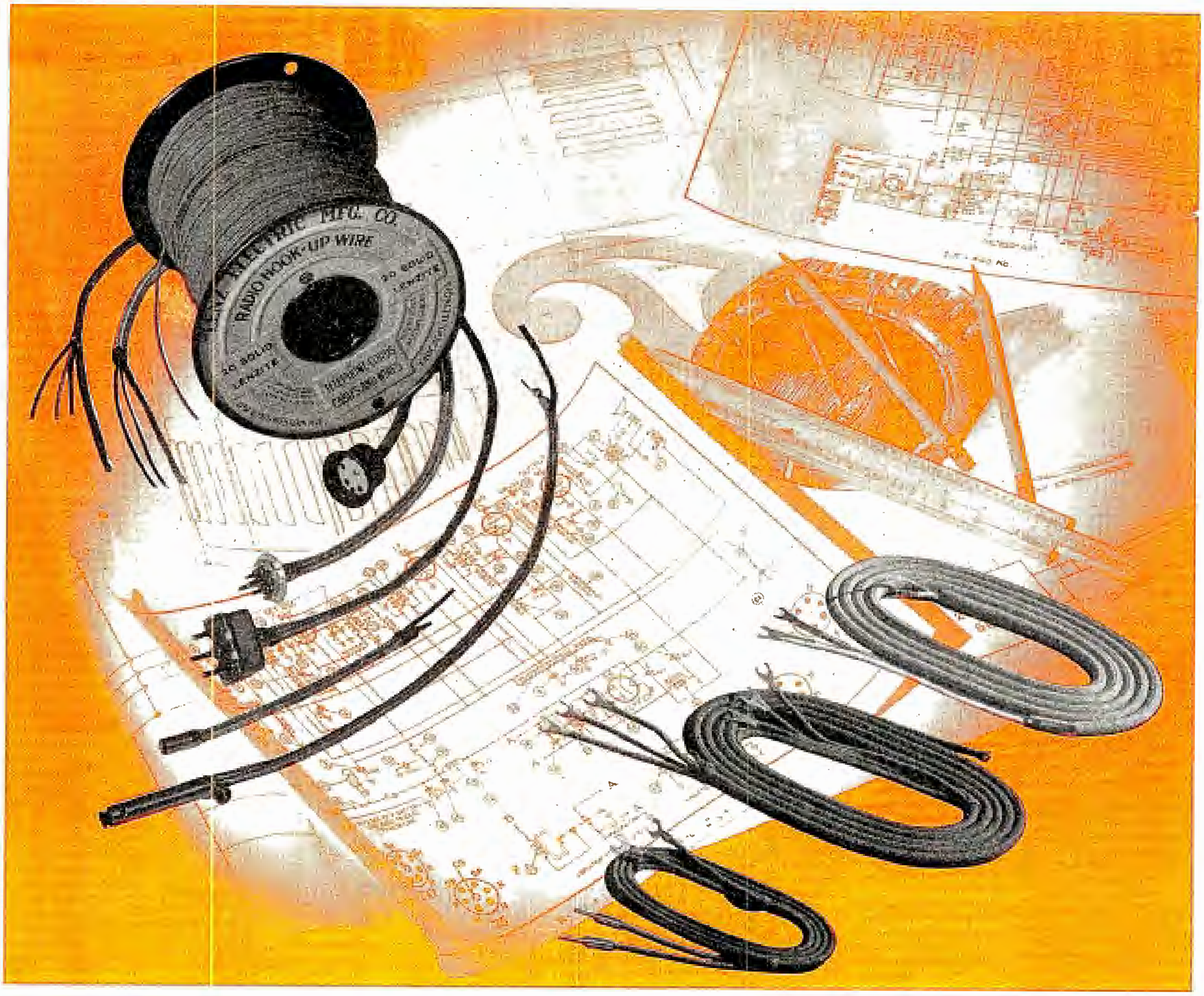
Suppose a square wave whose fundamental component of frequency is of frequency $\omega_1/2\pi$, is impressed upon this amplifier. The phase shifts for the third and higher harmonics are practically zero, as is also the case for the fundamental. The magnitudes of the harmonics at the output are relatively the same as at the input, but the fundamental is excessive. The result of this can be predicted by the grid and plate time constant methods and is shown in Fig. 6. The proper portion of the output fundamental may be combined with the output harmonics to give the square wave OABCD. The excess fundamental is shown as OEF. When combined with the fundamental, it gives rise to the bowed wave OAGBCHD. Any attempt to readjust the time constants in order to eliminate this bowing results in a tilt in the wave instead. It cannot be eliminated unless the time constants are readjusted. This in general means that $T_F$ must be increased until its effect is negligible. This can be done by increasing $C_F$ or $R_F$. However, if the "B" supply voltage is limited, $R_F$ cannot very well be increased, and if $C_F$ is increased instead, then, because it also enters into the time constant $T_{LF}$, it will be necessary to increase $C_g$, too (Since $R_g$ is limited by grid current). Increasing $C_g$, however, may increase the shunt capacity to ground and thus affect the high frequency response.

Nevertheless, amplifiers having values of $C_F$ equal to 100 mfds. and $C_g = 1$ mfd. are in successful operation. Careful arrangement of parts permits a satisfactory high frequency response. The use of such high capacities has two beneficial effects. The first is that no adjustment of time constants is required, as their reciprocals are negligibly small compared to the lowest $\omega$ under consideration, and equation (3) reduces to equation (7) over the desired spectrum. In addition, small variations in the time constants with age are inconsequential, and do not impair the operation of the amplifier. The second is that the amplifier is relatively insensitive to line voltage variations, and does not produce "bounces" in the picture or oscilloscope pattern.

Before proceeding to the next item, it

*(Continued on page 28)*

[3] E. C. White—British Pat. #456,450—"Improvements in and Relating to Coupling Means for Thermionic Valve Circuits."


MFG. CO.
RADIO HOOK-UP WIRE

# NEWS BRIEFS OF THE MONTH . . . —

### NAVY ASKING FOR MORE ENGINEERS

An activity of the United States Navy is in need of civil junior, assistant and associate radio engineers; assistant and associate physicists and physicists for laboratory research and development work in conjunction with the National Defense Program. Salaries range from $2,000 to $3,800 per annum. For further information and application for employment form write The Director, U. S. Navy Radio and Sound Laboratory, San Diego, California.

* * *

### FEDERAL AWARDED INSTRUMENT LANDING CONTRACT

The Civil Aeronautics Administration of the U. S. Department of Commerce has awarded the Federal Telegraph Company a contract to manufacture equipment for ten airplane instrument landing systems for installation at principal airports.

This instrument landing system, which permits flyers to land "blind" entirely by instrument, if forced to do so by weather, was developed for the CAA by IT&T engineers. The equipment was tested and adjusted for several years at the CAA experimental station at Municipal Airport, Indianapolis, and was then adopted for installation at the other airports. Many pilots have already been trained in its use at Indianapolis and the new installations being made throughout the country are intended to familiarize all commercial air line pilots with its operation as a vital additonal safeguard against sudden bad weather.

* * *

### W. H. GREEN IN NEW GE POST

W. H. Green recently joined the radio and television department of General Electric with the responsibility for planning and formulating, in conjunction with the publicity department, advertising and sales promotion for radio transmitting and carrier-current equipment, and transmitting, industrial, and special-purpose tubes.

Later in 1937 he entered the General Electric Company at Pittsfield, Mass., as a student engineer in the transformer test section. In October, 1937, he was transferred to Schenectady, where he worked on the WGY Farm and Science broadcasts for a year before joining the GE Publicity Department to handle radio and television advertising and sales promotion.

Mr. Green has been with GE since 1937, starting as a student engineer. Since 1941, he has been assigned to industrial control advertising and sales promotion.

* * *

### PRACTICAL DATA ON ELECTRONIC GADGETEERING

Recognizing the fact that radio amateur activities are being seriously curtailed for the duration of the war, Aerovox engineers are compiling and already releasing practical data on electronic gadgeteering as a promising outlet for the equipment, skill and ambition of the radio hobbyist. Articles on radio control circuits and the industrial applications of electronic devices are currently appearing in the monthly Aerovox Research Worker. Copies will be sent to anyone writing Aerovox Corporation, New Bedford, Mass. Also, a free subscription may be obtained by getting the endorsement of any Aerovox jobber.

### RCA WINS NAVY "E" PENNANT

Citing "outstanding results in the production of Navy material vital to our war effort," the United States Navy has awarded to RCA Manufacturing Company the coveted Navy "E" pennant.

Secretary of the Navy Frank Knox sent a congratulatory telegram to George K. Throckmorton, president of RCA Manufacturing Company, stating, "The splendid achievement of the Radio Corporation of America Manufacturing Company of Camden, New Jersey, its management and its employees, in producing an ever growing output of material for the United States Navy is characteristic of the vigor, intelligence and patriotism which have made America great and which have kept her free. On this occasion of public recognition of your accomplishment, please accept my congratulations."

* * *

### TURNER APPOINTS NEW REPS

E. J. Watkins, 580 Market St., San Francisco, California, has been appointed representative for the Turner Co., Cedar Rapids, Iowa, in northern California. Mr. Berk, of the S. W. Berk Sales Company, 530 William Penn Way, Pittsburgh, Pennsylvania, will cover for Turner Western Pennsylvania and West Virginia.

* * *

### RCA NAMES PLANT MANAGER

H. F. Randolph has been appointed plant manager of the new RCA tube manufacturing plant being erected at Lancaster, Penna.

* * *

### WILLIAM LODGE ASSIGNED TO RESEARCH DEFENSE WORK

William B. Lodge, engineer-in-charge of the radio frequency division of Columbia Broadcasting System, has been given a temporary leave of absence to engage in research work for the National Defense Research Council.

During his absence, Warren White, his assistant, assumes the responsibilities of the radio frequency division as acting engineer-in-charge.

* * *

### D. C. PATRICK NOW DENVER SYLVANIA REPRESENTATIVE

D. C. Patrick has been appointed Hygrade Sylvania representative in the Denver territory for all of the company's products, including Sylvania radio tubes, Hygrade fluorescent lamps, Miralume fluorescent fixtures, fluorescent accessories and Hygrade incandescent lamps. His address is 1100 Colorado Blvd., Denver.

* * *

### 1942 C-D CAPACITOR MANUAL

A contribution to the paper conservation program and to the service man's convenience, has been made by the arrangement adopted for the 1942 Cornell-Dubilier capacitor manual. Heretofore it has been the practice to include all the replacement information from previous editions, plus data on new receivers. This year, the new manual takes the form of a 50-page supplement with provision for attaching directly to the cover of the 1941 Manual.

Copies of this supplement are available without cost by addressing requests to Cornell-Dubilier Electric Corp., South Plainfield, New Jersey.

### RADIO INSPECTOR POSITIONS OPEN

The position of radio inspector in the Federal Communications Commission has been added to those jobs in the field of radio for which the U. S. Civil Service Commission is seeking qualified persons. Salaries range from $2,000 to $2,600 a year. The maximum age is 45 years. Applications for the written test on radio and electrical engineering must be filed with the Commission's Washington, D. C., office not later than April 21, 1942.

* * *

### BEAL PROMOTED AT W.E.

Henry C. Beal, now manager of the Western Electric plant at Kearny, New Jersey, has become engineer of manufacture with offices at headquarters, 195 Broadway, New York City. He will be succeeded as works manager by Reese F. Clifford, personnel director for the past year. Arthur B. Goetze, assistant personnel director, will assume Mr. Clifford's post.

* * *

### APCO CONVENTION IN JULY

The annual convention of APCO will be held in July from the 27th to 30th, at the Hotel Lennox, St. Louis, Mo.

* * *

### UNIVERSAL MICROPHONE BUILDS NEW PLANT

Universal Microphone Co., Inglewood, Cal., early in March broke ground for its second plant. It will be to the west of the original plant and will be an exact replica of the original three-story building.

* * *

### TECH LABS EXPAND

The Tech Laboratories of 7 Lincoln Street, Jersey City, New Jersey, have just completed an expansion of their plant which more than doubles the size of their factory space. They have also doubled their machinery and equipment. Erling Bjorndal is now production manager; William Richards, superintendent, and Henry Kovaric is engineer and purchasing agent.

The New England representative of Tech Laboratories, Henry P. Segal, is now located at 221 Columbus Avenue, Boston, Mass.

* * *

### LASURE NOW HEADS BOOSTER CLUB

Harry A. Lasure, manufacturers' agent of Los Angeles, has been elected president of the Radio Booster Club of Southern California. The Radio Booster Club is composed of radio manufacturers' agents and has been meeting once a month for over ten years.

The new vice-president is Don Wallace, and Herb Becker is secretary-treasurer.

* * *

### CLARKE DUNCO REP IN CHICAGO

John W. Clarke Company, 327 S. LaSalle Street, Chicago, Ill., have been appointed sales and engineering representatives of Struthers Dunn, Inc., Philadelphia, Pa. Territory includes the state of Wisconsin, the upper peninsula of Michigan; Northern Illinois; Chicago and the neighboring counties of Indiana and the Eastern border counties of Iowa.

* * *

### BELL'S NEW PLANT

Bell Sound Systems, Inc., 1183 Essex Ave-

*(Continued on page 29)*


Vital....
for Victory!
WINCO DYNAMOTORS
help to "Keep 'Em Flying"
Today when "Keep 'em Flying" is a mandate for liberty—we stand more than ready to pledge our all to the Herculean tasks that lie ahead.
As a matter of fact—we've already started working—tremendous manufacturing expansion on Winco Dynamotors gives us facilities not only to meet current delivery schedules—but also future orders.
Quality built in every detail, the sturdy, tough Winco Dynamotors supply efficient, dependable current for all types of communication systems. Special design, finest materials and skilled workmanship insure years of uninterrupted service in conditions ranging from —40° to +65° centigrade. More than 50 separate electrical and mechanical assembly tests guard the outstanding quality of Winco Dynamotors.
Winco Dynamotors are regularly available in standard outputs and sizes. . . . Special Winco Dynamotors can be quickly and easily designed to meet your exact needs. Why not take advantage of our complete free Advisory Engineering Service. Write or wire today!
ONLY WINCO GIVES YOU
ALTI-TEMP
The Dynamotor designed to insure maximum efficiency—at all operating altitudes and temperatures.
WINCO DYNAMOTORS
WINCHARGER CORPORATION
SIOUX CITY, IOWA

# VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

W. J. McGONIGLE, President — RCA BUILDING, 30 Rockefeller Plaza, New York, N. Y. — GEORGE H. CLARK, Secretary

### *MEDAL OF HONOR TO FRANKLIN D. ROOSEVELT*

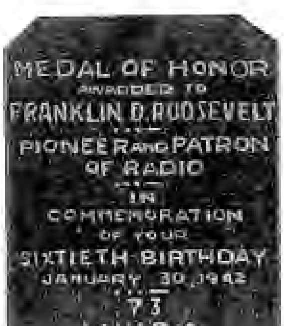
THE special Gold Medal of Honor awarded to the President of the United States by our Association as a "Pioneer and Patron of Radio"—in commemoration of his Sixtieth Birthday—was presented to the President, in his White House office at 4:00 p. m. on Thursday, February 12, 1942. A committee, composed of members of VWOA, with the Hon. James Lawrence Fly, of FCC-DCB, as chairman, and George W. Bailey, president of the American Radio Relay League and chairman of the radio section of the Office of Scientific Personnel of the National Research Council, as secretary, included Rear Admiral Leigh R. Noyes, former Director of Naval Communications; Neville Miller, president National Association of Broadcasters; Major General Dawson Olmstead, Chief Signal Officer of the Army; W. D. Terrell, field agent for FCC; F. P. Guthrie, chairman of the Washington chapter of VWOA; Cmdr. E. R. Webster, assistant chief engineer FCC—formerly chief of Coast Guard communications; and E. H. Rietzke, vice-chairman of our Washington chapter. The members of the committee were introduced to the President by Mr. Fly, after which the chairman made the presentation. The President graciously accepted the medal, commenting upon its beauty and appropriate inscription.

The committee spent over a quarter of an hour reminiscing with the President—recalling events of the past, especially his work in radio when he was Assistant Secretary of the Navy in World War I.

### *DINNER-CRUISE*

Our association celebrated its seventeenth anniversary with simultaneous dinner cruises in various cities throughout the country on Saturday, February 21, 1942. The New York cruise was held at the Hotel Astor, with many well-known radio personalities attending. At the speaker's table, from left to right (illustration above), were George H. Clark, secretary of our association and "Historian of Radio"; Ted McElroy, World's champion radio telegraphist at 77 words per minute—he received our Marconi Memorial Award for code proficiency; E. H. Rietzke, president of the Capitol Radio Engineering Institute who presented a Marconi Memorial Scholarship in the Home Study Division of the Capitol Institute to "Dick" Nebel, a paralysis victim since the age of three and recipient of our Marconi Memorial Scroll of Honor last year; Robert Thorp, heroic tropical radio telegraph operator aboard the United Fruit freighter San Gil when that ship was torpedoed on February 3, 1942, who was presented a Marconi Memorial Scroll of Honor for his outstanding devotion to duty; Captain Arnold, District Communications Officer of the United States Navy who represented the Director of Naval Communications, Captain Redman; (standing) Dr. Leo Stanton Rowe, Director General of the Pan American Union, who received our Marconi Memorial Service Award plaque for the Pan American Union and the twenty South and Central American Republics; William J. McGonigle, VWOA president, who presented the awards and was toastmaster for the evening; George W. Bailey, president of the American Radio Relay League and the International Amateur Radio Union, who received our Marconi Memorial Medal of Service as the elected representative of the majority of radio amateurs; Major General J. O. Mauborgne, U. S. A. (Ret.), former Chief Signal Officer of the Army and recipient of our Marconi Memorial Medal of Service last year; Arthur F. Van Dyck, life member of our association and president of the Institute of Radio Engineers; Jack Berenbaum, heroic radio officer of the ill-fated tanker "Malay," which was torpeoed in the Atlantic on Jan. 19, 1942, who received our Marconi Memorial Scroll of Honor for his splendid performance under fire (the ship was shelled for ninety minutes and finally managed to reach port under its own power); A. J. Costigan, vice-president, director of our association and traffic manager of the Radiomarine Corporation of America; Frank Butler, one of Doc de Forest's first assistants, and Abraham White, early wireless pioneer.

At the VWOA dinner-cruise in New York City.




The Presidential Medal.

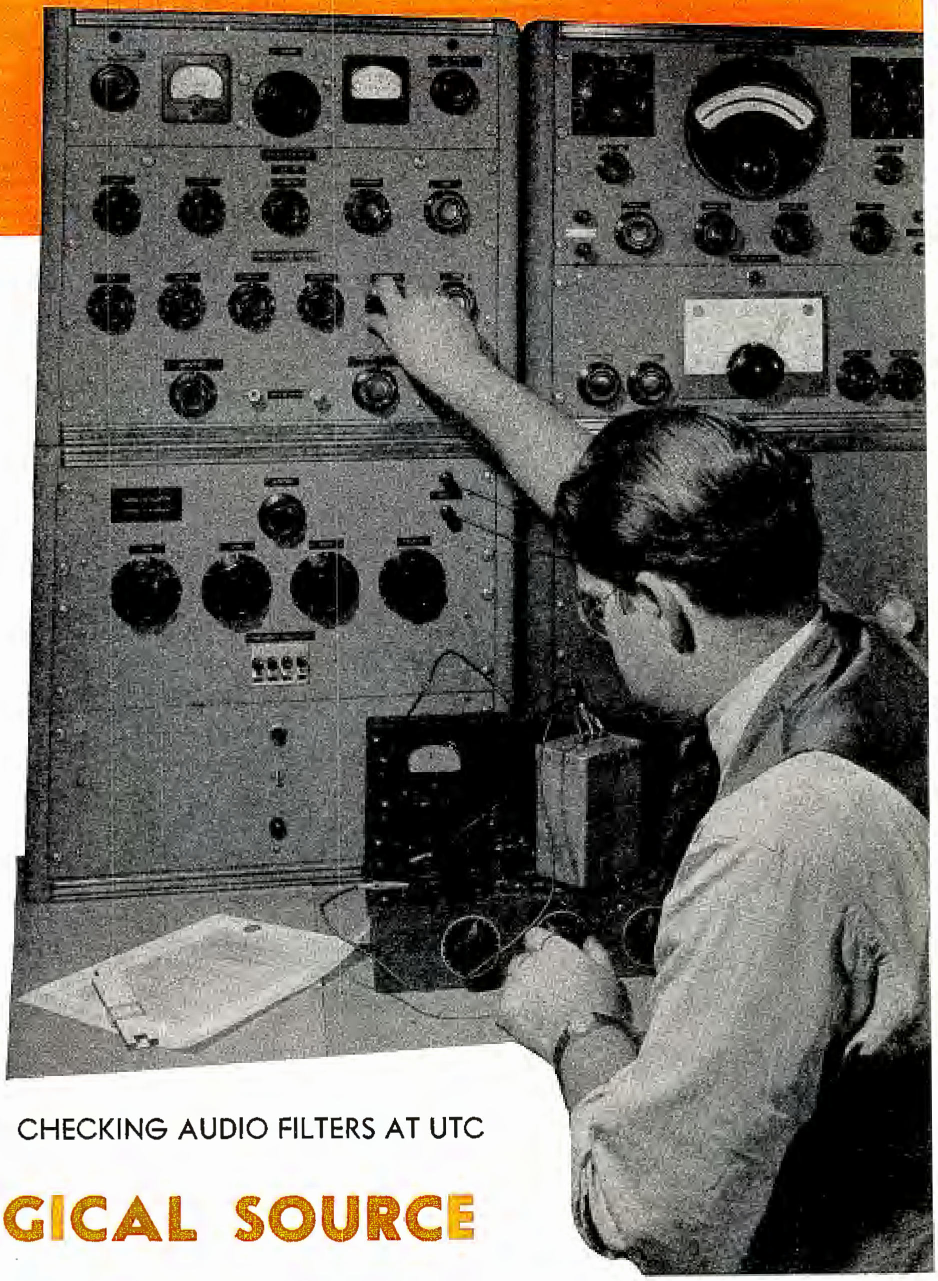
A portion of the proceedings was broadcast over the Red network of the National Broadcasting Company. The combined short-wave facilities of WRCA and WBOZ carried the program on February 26.

Among the others present at the New York Cruise were: Commander Fred Muller, U. S. N., former president VWOA; Jim Maresca, first secretary VWOA; E. N. Pickerell, pioneer wirelessman; Dick Cummings, radio department A. T. & T.; C. W. Horn, assistant vice-president NBC in Charge of Development and Research; Arthur Lynch; "Bill" Simon, VWOA treasurer and marine radio superintendent of Tropical Radio Telegraph Company; Captain MacCumber, marine superintendent of the United Fruit Company; Fred P. Guthrie, chairman of our Washington chapter; Wm. Aufenanger, assistant to the president Radiomarine Corporation of America; Robert H. Marriott, honorary member and prominent consulting radio engineer, until recently chief examiner for the British Civilian Technical Corps; John Cose, superintendent of RCA Institutes; C. D. Guthrie, VWOA director and supervisor of radio for the Maritime Commission; Paul K. Trautwein, chairman of our finance committee and president of the Mirror Record Corporation; Lewis Winner, Editor of *Communications*; John Varian, purchasing agent for Radiomarine; Henry Hayden of Ward Leonard; E. K. Cohan, director of engineering for CBS; Carl A. Nelson, publisher of "Telegraph and Telephone Age"; C. B. Cooper, long an officer of our association; Frank Orth; Arthur F. Rehbein; Frank Rigby, personnel director of RCA Communications; Charles Singer, chief transmitter engineer of WOR; George McEwen of RCA Communications; H. P. Kasner of RCA Manufacturing; K. B. Warner, secretary of the American Radio Relay League with Clinton B. De Soto of the ARRL staff, and many others.

*If any old transformer will do...*
*Any make will do!*

# *But*

If your problem is • weight (our smallest units weigh only one-third ounce) or • size (our sheet metal division can run off a case to accurately fit your particular requirements) or • precise adjustments or tougher than ordinary electrical characteristics or • mechanical requirements or • submersion type components, etc. . . . •



CHECKING AUDIO FILTERS AT UTC

## UTC IS THE LOGICAL SOURCE

MAY WE ASSIST YOU? A note to our Engineering Division will bring a quick response with details on units to your requirements.

# UNITED TRANSFORMER CO.

150 VARICK STREET ★ NEW YORK, N. Y.

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

## BROADCAST CONFERENCE

(*Continued from page* 11)

installed a very practical emergency system in station WIBW.

The system is unique in that solutions to many problems to be encountered now have been solved. For instance, up until recently, it has been relatively simple to obtain a commercial engine driven power unit of almost any size. But now, in view of conditions, this practice is impossible, and thus components must be secured. This is the step that was followed by Mr. Troeglen.

In choosing the parts made by different companies, it was necessary to make a thorough study of the characteristics to be possessed by the complete machine. For instance, it was determined that the machine should be able to furnish full output continuously, and the voltage and frequency stability should be sufficient under moderate load variations so as not to cause serious carrier shift in an operating transmitter. Then the machine had to be able to start and deliver full load in as short a time as possible, so as to cut carrier interruptions to a minimum. Other requirements concerned availability of parts, cost, economy of operation, etc.

Although there were various types of machines available, only two types of engine driven supplies seemed to have the characteristics necessary. These were the diesel driven units, and the gasoline or natural gas driven units, said Mr. Troeglen, in discussing his installation.

The diesel has the advantage of slower speed and lower fuel consumption in cost per kwh, but it weighs almost twice as much as an ordinary gasoline unit for the same power, and in addition has some serious starting problems, outlined Mr. Troeglen. The problem of maintenance and repair of a diesel is also more complex, and finally the original cost of a gas engine is quite a bit lower. In view of these features, the gasoline unit was chosen at WIBW. In connection with the gasoline unit, an alternator with an externally attached exciter was selected.

The engine selected was a six cylinder type, designed to deliver 82 brake horsepower at 1,200 rpm, said Mr. Troeglen. A regular centrifugal governor maintained speed under varying load. A regular starter motor operated automatically by a Bendix starter and a 12 volt starting and ignition system constituted the starting apparatus. In conjunction with this system, a Sisson electric automatic choke was used. The generator is rated at 37.5 kva and will deliver 30 kw at .80 pf. This output is 220 volts a-c, 60 cycles, three phase in a three wire circuit, said Mr. Troeglen.

Figure 15

Raymond Guy and J. D'Agostino of NBC and Lynne C. Smeby of NAB discussing some of the problems anent fire protection and fire fighting during wartime.

A floating core vibrator type of voltage regulator was selected to regulate output voltage under varying conditions, continued Mr. Troeglen. The emergency supply is placed into operation when any one of the phases of the regular supply drops to 70% of its normal value. Transfer is effected as soon as the voltage and frequency of the emergency supply reaches a predetermined value, this being controlled by a tuned relay circuit. After the voltage on all phases of regular supply has been restored to 90% or more of the normal, return to regular supply is delayed for predetermined period by a time delay relay, explained Mr. Troeglen. This was done to avoid outages due to regular supply coming on for a few seconds and dropping out again. According to Mr. Troeglen, the machine will start and connect itself to the load in from four to six seconds, while the transfer back to the regular supply is so rapid that no carrier interruption is apparent, said Mr. Troeglen.

Installation of this power plant requires exacting attention. The local Fire inspection bureau should be consulted, prior to the placement of the plant. In addition, it is important to mount the machine on some vibration deadener. Mr. Troeglen used a single layer of ⅜" thick Keldur. This material was also used for bushings and washers, to isolate the mounting bolts.

Several methods were suggested to adjust the engine speed and generator voltage to the desired operating condition. The output voltage can of course be checked with a voltmeter, while an oscilloscope can be used for frequency check, if a frequency meter isn't available. A synchronous phonograph motor with a stroboscopic disc, two synchronous clocks . . . one connected to normal supply and the other to the emergency supply, or a motor speed indicator, were some of other methods suggested.

In Figures 10 and 11, performance characteristics of the machine are given. In Figure 10 we have voltage and frequency curves made under actual operating conditions, with the lighting, heating and transmitter load applied in various stages. The graph shows to what values the voltage and frequency dropped as definite additional load was applied. It can be noticed that the voltage and frequency rose to a steady value. The gradual decrease of operating frequency is due to the slowing up of the gasoline engine. It can also be seen that the voltage regulator becomes very effective after the machine has carried approximately one-half its full load. And under full load the output voltage is practically constant. Although during the tests, it was noticed that a variation of a quarter cycle above and below existed, this variation was not noticeable while playing electrical transcriptions, while running the turntable from this power source, explained Mr. Troeglen.

The voltage and frequency changes were fairly rapid, when a large amount of load was "dumped" on the machine, Mr. Troeglen showed in explaining these graphs. The total time for complete recovery to the steady state was three seconds at the most, however, said Mr. Troeglen. In the graph has been represented a no load to full load condition with the engine speed varied from 1230 to 1140 rpm, then recovering and operating at 1180 rpm. Thus actually, the speed of the motor varies only 50 rpm from no load to full load at a steady state, a voltage regulation that is quite sufficient for ordinary uses, said Mr. Troeglen.

In Figure 11 appears the results of a 5 kw. universal machine in service. This unit was powered by a cylinder engine, at 120 volts, 60 cycles, with a flyball type of governor.

Incidentally, the fuel consumption of the gasoline generator system under full load was six gallons per hour.

### MOBILE F-M

There is little doubt that f-m has become the talk of the town. In civilian and military channels, it has become the accepted essential for successful mobile transmission. Of course, to police radio must go the well deserved thanks for acting so effectively a proving ground for mobile f-m. And when one speaks of police radio, one cannot help but speak too of that f-m pioneer, Daniel E. Noble, whose numerous contributions catapulted f-m mobile radio to fame.

The convention had the pleasure of listening to Mr. Noble, at present research engineer at the Galvin Manufacturing Company, Chicago, discussing characteristics of some of the police f-m systems.

The superior sensitivity of f-m is acknowledged, said Mr. Noble, but to make capital use of this feature, it is ofttimes necessary to select reception points of low noise level.

In the New Hampshire State Police system, developed by Basil Cutting, a low noise level remote pickup point has been installed at the top of a 1,000-ft. mountain for maximum efficiency. The receiver is mounted in a waterproof box attached to a telephone pole and the antenna mounted at top of the pole (Figure 12). The output from this receiver is carried over telephone wires to police headquarters six miles from the pickup point. A second low noise pickup point is provided by an automatic ultra-high frequency relay unit installed atop Mt. Kearsarge, he added. Transmission from the mobile units is received by a receiver which includes a relay in the squelch system. The received signal automatically turns on a 118 mc transmitter and the output of the receiver modulates the transmitter, so that the message is relayed to police headquarters at a point 22 miles away from the transmitter. With these two pickup points it is said that complete coverage of the state of New Hampshire has been achieved.

In Michigan the process of changing over from an a-m intermediate frequency system to a two-way f-m system is now under way as a result of tests conducted by Frank Walker, in charge of the installation. With four 250-watt transmitters and 24 mobile units now in operation, plans have been completed for the installation of a total of 44 fixed transmitters and more than 200 mobile units to provide 2-way service for Michigan, indicated Mr. Noble.

Inherent receiver noise at the front end of an f-m receiver may be minimized, and thus sensitivity improved, tests have showed, said Mr. Noble. To conduct such a test, Mr. Noble said it was first necessary to check on the magnitude of the leakage from the generator used in the f-m receiver measurements, since measurements are frequently questioned when the magnitude of the signal is less than 1 mc as was in this instance. A type 18C Ferris signal generator was used. It was connected to the antenna input terminals of the receiver with the squelch open. The audio output was adjusted so that a decibel meter across the audio output indicated 20 decibels. The attenuator of the signal generator was then varied and the output of the signal generator, as indicated by attenuator reading, was plotted as a function of the decibel meter reading across the audio output, continued Mr. Noble. One reading was taken beyond the zero setting of the attenuator by turning off the power supplied to the signal generator, and thus recording the output reading corresponding to absolute zero signal input. This reading indicated that the leakage of the generator used was the order of the magnitude of .1 of the microvolt. The quieting signal characteristics of the receiver taken in this manner showed that a 20 decibel noise reduction could be achieved with a signal input of .4 of a microvolt. The quieting signal taken by itself does not provide all of the necessary information regarding the receivers ability to suppress noise, said Mr. Noble, but it must be considered along with information on the total over-all gain product of the receiver and the performance of the limiters. In the past, the sensitivity of the emergency service radio systems has been limited by the absolute sensitivity of the audio squelch systems used, pointed out Mr. Noble. In other words, a signal could be received by opening the squelch system manually, but it could not be received when automatic squelch operation was required. In order to use the maximum sensitivity of a system, said Mr. Noble, the squelch must operate automatically at signal levels too low for useful communication purposes, but the squelch must remain closed when the receiver input is fed by ignition impulses and other electrical noises which do not have the characteristics of a carrier. The receiver under test, a Motorola unit, uses the reduction in noise made possible by the low quieting signal to operate the squelch. The use of noise for squelch operation provides an automatically compensating system for external noise. Where the noise level is low a very weak signal will suppress the inherent noise in the receiver sufficiently to operate the squelch system. At a higher level noise reception point a stronger carrier is necessary to operate the squelch system.

Figure 16
Stuart Seeley and Arthur Van Dyck with the alert receiving equipment analyzed during one of the sessions of the convention.

The sensitivity of the squelch system is especially important where car-to-car operation is required, explained Mr. Noble, since standing waves will produce the annoying effect of opening and closing the squelch abruptly during reception periods unless the squelch is properly compensated for noise variations, and unless it will operate at signal levels too low for communication purposes.

#### THE WHAS EMERGENCY

The application of broadcast facilities in dire moments of emergency were thrillingly portrayed by Orrin H. Towner, chief engineer of WHAS during one of the meetings. His discussion was based on the incidents encountered during the Ohio River Flood, which had engulfed a large portion of the city of Louisville, in which WHAS is located. The experiences during this tragic event closely paralleled those which may be met in war time, and as such served as an excellent example of necessary precautions to take.

#### TALKS BY DE WITT, CHINN, VAN DYCK

Others at the convention who spoke included J. H. DeWitt, chief engineer of WSM, covering studio transmitter links and high frequency antennas[1], Howard Chinn in charge of audio facilities at CBS on recording standards[2], and Arthur VanDyck, IRE president, on the alert receiver system[3].

#### WARTIME PANEL

A panel on broadcast station operation during war time, organized by Lynne C. Smeby, discussed subjects such as priorities and procurement; fire fighting and property protection; telephone lines, battery operated equipment for emergency use; radio broadcast silencing systems; temporary and auxiliary antennas, and emergency equipment. Members of the panel included Frank Cowan, AT&T; J. D'Agostino, NBC; Raymond F. Guy, NBC, Andrew D. Ring, consulting engineer. Frank Cowan of this group and transmission engineer for AT&T was instrumental in installing Intercepter Command Information Centers and special defense communication networks. Mr. Ring is secretary of the Domestic Broadcasting Committee of the DCB. Others either served on the DCB, or in a specialist capacity and thus provided invaluable statistics and corresponding data.

[1]Communications, August 1941, page 5.
[2]Communications, September 1941, page 10.
[3]Communications, August 1941, page 11.

# SQUARE WAVE ANALYSIS

(*Continued from page* 20)

may be well to mention that non-linear distortion in an amplifier will not distort a square wave, but can distort by "clipping" a tilted or bowed wave. Non-linear distortion, therefore, cannot produce bowing in an amplifier whose time constants are correctly adjusted; it can only distort further an already distorted square wave.

There are occasions when $R_F$ cannot be made very low, such as when the stage is fed from a voltage divider. In this case $R_F$ is essentially the two halves of the voltage divider resistance in parallel with each other. The by-pass condenser represents $C_F$. To avoid bowing of a square wave, the following circuit, due to E. C. White[3], may be used. This is shown in Figure 8. The proper value of the components are as follows. $R_L$ is determined by the high frequency response, while $R_g$ is determined by the grid current (gas and emission).

Let

$$R_g/R_L = m \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Then

$$C_F/C_g = R_{g1}/R_F = m \quad \ldots\ldots\ldots\ldots (9)$$

The operation of this circuit depends upon the following considerations. Let the plate load ($R_L$ in series with the parallel combination of $C_F$ and $R_F$) be denoted by Z. Equation (9) is really another way of stating that the grid impedance ($R_g$ in series with the parallel combination of $R_{g1}$ and $C_g$) is equal to mZ. The total impedance (grid and plate impedances) is therefore

$$Zt = (m/1 + m)\, Z \quad \ldots\ldots\ldots\ldots (10)$$

and if a pentode tube is assumed, the voltage at the plate terminal is

$$E_p = e_1G_m(m/1 + m)\, Z = e_1G_m(m/1 + m)\ (R_L + Z_F) \quad \ldots\ldots\ldots (11)$$

where $Z_F$ represents $R_F$ and $C_F$ in parallel.

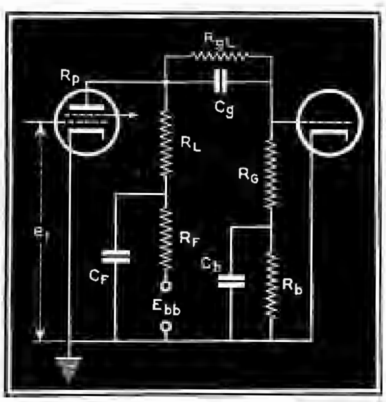



Figure 9

It is evident that the branch currents $i_1$ and $i_2$ are in phase with the line current, and of relative value such that $i_2 = i_1/m$, and the line current is $i_L = i_1(i + m/m)$. From this

$$i_2 = i_L(1/1 + m) \text{ and } i_1 = i_L(m/1+m) \quad \ldots\ldots\ldots (12)$$

The output voltage is evidently

$$e_2 = i_2R_g = i_L(1/1 + m)\, mR_L = i_LR_L\ (m/1 + m) \ldots (13)$$

The voltage across $R_L$ is

$$e_L = i_1R_L = i_L(m/1 + m)\, R_L = e_2 \quad \ldots\ldots\ldots\ldots (14)$$

Since $i_L = e_1G_m$, we have finally

$$e_L = e_2 = e_1G_m(m/1 + m)\, R_L$$

or the gain is

$$\alpha = e_2/e_1 = G_m(m/1 + m)R_L \quad \ldots (15)$$

and is independent of frequency, down to d-c. If d-c amplification is not desired, a blocking condenser, C, Figure 8, may be employed. A further refinement is to split $R_{ge}$ in half, and place C between these halves. In this way the stray capacity of C to ground will be in series with $R_{g1}/4$ to the "high" side of the circuit at the higher frequencies, and will have a negligible effect upon the high frequency response, even though C is relatively large and bulky (since its reactance at the lowest frequency considered must be low compared to $R_{g1}$).

This circuit has two advantages. One is that r-f can be as low as desired without bowing of a square wave occurring and the second is that the grid circuit does not have to be a high impedance compared to the plate circuit; it may even be lower than it, if necessary. While the above derivation was for a pentode tube, a pair of simple circuit transformations combine the appreciably low plate resistance of a triode tube with $R_L$, $R_F$ and $C_F$ into a new set of values $R'_L$, $R'_F$ and $C'_F$ in the same configuration as the unprimed parameters. Equations (8) and (9) are then applied to the primed values. This is discussed in the reference given.

Another circuit configuration, shown in Figure 9, achieves the same results as Figure 8, and also permits grid bias to be applied in a correlated manner to the rest of the circuit. The author obtained this circuit by starting with a triode tube, instead of as White did with a pentode tube[4].

Let the plate resistance of the tube be $R_p$, and $R_L$ the plate load resistance as determined by the high frequency response, and further let

$$R_L/R_p = k \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (16)$$

We now choose a value of grid resistor, $R_g$, such that

$$R_g = m\, R_L \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (17)$$

The value of m should be such that $(R_g + R_b)$ does not exceed the manufacturer's maximum permissible value of grid circuit resistance.

We can then show, by methods somewhat similar to that in the preceding section, that

$$C_g = \frac{m + 1 + m\,k}{m(m + 1)} C_F \quad \ldots\ldots\ldots (18)$$

$$C_b = \frac{m + 1 + m\,k}{m^2\,k} C_F \quad \ldots\ldots\ldots (19)$$

$$R_{g1} = \frac{m(m + 1)}{m + 1 + m\,k} R_F \quad \ldots\ldots\ldots (20)$$

and

$$R_b = \frac{m^2\,k}{m + 1 + m\,k} R_F \quad \ldots\ldots\ldots (21)$$

The gain of such a stage is

$$\alpha = \mu \frac{m\,k}{m + 1 + m\,k} \quad \ldots\ldots\ldots\ldots (22)$$

which gain is maintained up to the high frequency end of the spectrum by means of peaking coils or similar high frequency expedients.

An example will indicate the range of values that may be expected for the various paramenters. Thus, assume a typical triode value of 10,000 ohms for $R_p$, and 2,000 ohms for $R_L$. Then $k = 0.2$. Suppose the necessary values to prevent coupling through the common "B" supply for $C_F$ and $R_F$ are 8 mfd. and 10,000 ohms, respectively. Suppose m can be 100. Then from equations (18), (19), (20), (21), and

(*Continued on page* 35)

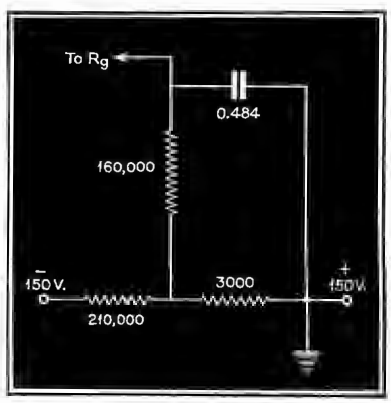



Figure 10

[4]A. Preisman, Pat. No. 2,243,121, Amplifying Systems.

# NEWS BRIEFS

(*Continued from page* 22)

nue, Columbus, Ohio, is now completing an addition to the present plant which will approximately double their previous production capacity.

* * *

### ALLIED'S 1942 CATALOG

Allied Radio Corporation has just released a new 1942 spring and summer catalog. A variety of receivers, parts and sound equipment are shown. This catalog may be had free of charge from Allied Radio Corporation, 833 West Jackson Boulevard, Chicago, Illinois.

* * *

### SYLVANIA SALES UP 43%

The best year in the company's history was reported by Hygrade Sylvania Corporation in its annual report for 1941. A 43 per cent increase in sales during the year, producing a total volume of $20,561,000 as compared to $14,358,808.88 for the previous year, was shown in the report.

* * *

### POST OPENS NEW FACTORY

The Frederick Post Company of Chicago has opened a new factory branch at 1215 Capitol, Houston, Texas.

* * *

### NAB CONVENTION IN MAY

The NAB Convention for 1942 will be held on May 11, 12, 13 and 14 at the Hotel Statler, Cleveland, Ohio.

* * *

### VICTOR ANDREW MOVES

Victor J. Andrew Company, formerly located at 6429 South Lavergne Avenue, Chicago, Illinois, has moved its offices and factory to 363 East 75th Street, Chicago, Illinois.

* * *

### MILTON AUSTER IN GOVERNMENT POST

Milton Auster, of the sales staff of The Dale Radio Company, Sylvania tube distributors in N. Y., was appointed recently as business specialist on radio parts in OPA in Washington.

* * *

### SHAKEPROOF'S NEW CATALOG

A 140-page data book on fastenings has just been published by Shakeproof Inc., 2501 North Keeler Ave., Chicago, Ill. Detailed explanations of the many different Shakeproof fastening devices such as lock washers, thread-cutting screws, SEMS fastener units, spring washers, locking and plain terminals, locking screws and intricate precision stampings are included. Besides thorough engineering data on types, sizes and dimensions, it shows many application suggestions for saving time and improving fastening performance. A special section is devoted to government specifications and approvals.

This book should prove to be a helpful guide to faster assembly operations for design engineers, production men and purchasing executives. Copies are available to officials of metal working companies by simply directing a request on company stationery to Shakeproof Inc.

* * *

### RCA ISSUES VICTORY DATA

An interesting illustrated 36-page brochure, entitled "Radio, All Out for Victory," has just been released by RCA. Various activities of RCA in peace and in their present victory program effort are effectively analyzed.

# THE INDUSTRY OFFERS

### INSULATION TUBING FOR LOW TEMPERATURES

A new transparent, flexible tubing with resistance to brittleness down to —50° C. has been developed by the Fibron Division of Irvington Varnish & Insulator Company. This transparent tubing, known as Transflex, was made especially for aircraft flying at high altitudes.

Transflex is tubing available from No. 14 to ⅝-inch inside diameter. Its tensile strength is approx. 3000 pounds per square inch. Its dielectric strength (conducted on a tubing with a wall thickness of approximately .020") is said to be 850 VPM when dry and 815 VPM when wet. Other characteristics of Transflux tubing are: water absorption, 0.4 per cent in weight after 24 hours immersion; Wemco Oil Test (48 hours at 100° C.), not attacked; allowable continuous operating temperature, 150° F. (66° C.).

* * *

### DUREZ 11863

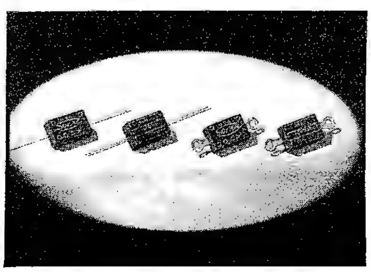
A new phenolic molding compound, said to have a very low power factor (0.07 at 1,000 kc) and high dielectric breakdown fatigue, has recently been introduced by Durez Plastics & Chemicals, Inc., of North Tonawanda, N. Y. This material was especially developed for radio parts such as condensers, crystal holders, etc. It has been designated as Durez 11863 and is said to have excellent moldability, being easy to handle in compression molds. It is available in one color, natural.

* * *

### MICA CAPACITOR DATA

The newest Solar Catalog 12, Section E, contains important design data on mica capacitors, moulded in bakelite, types MK and ML.

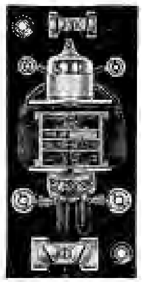
A copy of this catalog is available to engineers, executives.



### MERCURY PLUNGER RELAY

A mercury plunger relay with three major design changes has been developed by the H-B Electric Company, 2530 N. Broad St., Philadelphia, Pa. The changes include the elimination of the metal cap and support frame that held the mercury tube, thereby releasing strategic metals for the war. Then the mercury tube was made secure by a single metal band and the area for terminal fastening and connecting was tripled, thereby eliminating the danger of tube breakage and simplifying installation.

The relay is said to have been tested to 10 million operations without a failure. The relay has only one moving part, and is available for either a-c or d-c. Rated at 30 amperes, 110 volts, 1 h-p. Listed under reexamination service or the Underwriters' Laboratories, Inc.



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### ELECTRIC PREDETERMINED COUNTER

Electrically-operated predetermined counters for many applications have been developed by the Production Instrument Company, 706-12 W. Jackson Blvd., Chicago.

Any number from 1 to 9999 can be quickly set up on this instrument by simply turning knob pointers to the proper digits. When the count reaches the predetermined number thus set up, a control and signal circuit is closed (or opened). This circuit may be used to sound an alarm or operate a relay to perform any desired function. Counting ceases at the predetermined number until a reset lever is depressed (which requires less than half a second), making the instrument ready for a new count cycle.

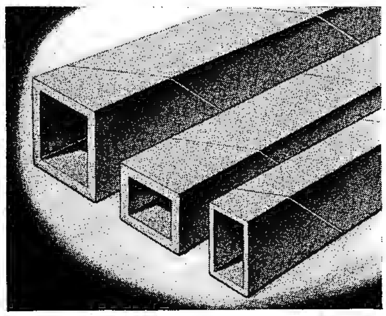
The monitor model PDC-E predetermined electric counter, as this new development is called, is actuated by any switch, relay or photoelectric unit with a closed period of .035 second or more and an open period of .040 second or more.

### DIELECTRIC PAPER TUBES

By the use of a specially adapted heat die machine, a new type of dielectric paper tube has been produced by the Precision Paper Tube Co., 2033 W. Charleston St., Chicago, Ill.

The improved tubes are preliminarily formed as heretofore, of dielectric kraft, or fish paper, or a combination of both. The paper is spirally wound on a steel die in an automatic machine. The tube is then pushed pneumatically through the new heated compression die which is said to effect an added compression of about 10%. Precision tubes made by this process can be supplied in round, oval, square or rectangular cross section and in continuous lengths of any wall thickness with any inside or outside diameter.

It is said that tubes made by this process can be held to a tolerance of .002 inch.



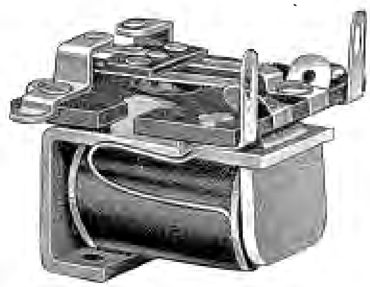
* * *

### MIDGET RELAY

A light-weight midget relay, designed to provide maximum control in minimum space, is now being made by Guardian Electric, 1623 West Walnut Street, Chicago, Ill.

Known as the series of 195 DC or midget relay, its maximum contact capacity is approximately 150 watts, measured at 110-volt, 60-cycle, non-inductive a-c. The manufacturer reports that in a number of present aircraft applications, the contacts on the new midget are making and breaking 3 non-inductive amperes at 28 volts d-c. Maximum contact combination available is double-pole, double-throw.

With a 2-watt coil, and single-pole, double-throw contacts in the de-energized position, the normally closed contacts of this relay are said to withstand vibrations of six times gravity (6 G's); the normally open contacts withstanding 10 G's. In the



energized position, the contacts are said to withstand 10 G's. The relay coil is available for any voltage up to 75 volts d-c, maximum resistance 3,000 ohms, average power requirements of the coil being 2.5 watts.

A light armature operates the contacts, which are mounted on and insulated (900 hi-pot. test) from the field piece, through a direct lever action. Coil and contact terminals are solder lug type. Contact blades are tinned phosphor bronze with silver contact points. Field piece and armature are annealed magnetic iron. Coil is varnish impregnated and baked. Weight with single-pole, double-throw contacts, is .85 oz.

* * *

### *AUDIOGRAPH 40-WATT BATTERY AMPLIFIER*

A heavy duty 40-watt amplifier (for operation from 6 volt battery or 110 volt a-c) is now offered by Audiograph division of John Meck Industries, 1313 W. Randolph St., Chicago.

A switch provides instant change-over from battery to a-c operation. Two microphones may be operated simultaneously, with separate volume control for each. Tone control, as well as volume control for phono input, is also included.

* * *

### *SELF-CONTAINED UHF TRANSCEIVER*

A completely self-contained ultra-high frequency transceiver built on the same order as the well known "Walkie-Talkies," is now available from Jefferson-Travis Radio Mfg. Corp., 380 2d Avenue, N. Y. City. Known as the UF-1, it is a ½ watt, 3 tube unit and is housed in a steel carrying case 11" high, 8" wide and 6" deep. The equipment, complete with carrying case, canvas covering, telescopic antenna whip, handset and batteries weighs approximately the same as does the average portable receiver, about 16 lbs. The unit may also be operated by a vibrapack working from a 12 volt external battery. Its frequency range is 60 to 75 mc.

* * *

### *START-STOP RELAY*

For remote-controlled starting and stopping of radio transmitters and receivers, drainage pumps, or other apparatus, a new "start-stop" relay has been developed by Automatic Electric Company, 1033 W. Van Buren St., Chicago. This new relay, known as "Type 19," operates and releases over two wires, with a common return. Typical operation is by means of a two-way key, which is thrown into one position to operate the contacts on the relay, and thrown into the other position to release the contacts. The relay opens its operating circuit immediately upon operation; thus, operating current is consumed for only about one-tenth of a second. The release circuit is similarly opened upon release.

The electro-mechanical locking arrangement used is said to offer proof against false operation or release, even under extremely severe conditions of shock. Operation is said to be unaffected by any normal temperature changes from —30 to +55 degrees C. (—22 to +131 degrees F.) Dependable control operation is said to be further assured by providing twin contacts of precious metal on all contact springs.

The relay can be supplied with a maximum of 18 springs for control purposes.

* * *

### *PANORAMIC RADIO-SPECTROSCOPE*

A Radio-Spectroscope, operating from its own power supply, in conjunction with an ordinary radio receiver of the superheterodyne type, having an i-f between 450 and 480 kc., and affording a visual observation of the characteristics of all signals present over a wide band of the frequency spectrum, which is adjustable in width, and which extends equally on each side of the frequency to which the receiver is tuned, has been produced by Panoramic Radio Corp., 242-250 W. 55th St., N. Y. City.

The observation of a 100 kc. band is made visually on the screen of a cathode-ray tube, without in any way disturbing the normal aural reception of the receiver. The weakest audible signal is said to be visible.

As the receiver is manually tuned

(*Continued on page 32*)

(*Continued from page* 31)

through its tuning range, a constant band width of 100 kc. passes in view of the operator, and all signals contained therein, appear simultaneously on the cathode-ray screen, as deflections indicative of the frequency and amplitude of each signal encountered. Signals less than 3. apart can be resolved.

The operator listening to the aural output of the receiver will hear only that signal which is visible in the center of the screen, and will see all signals 50 kc. above and below that signal.

* * *

### RECORDING-PA SYSTEM

The Western Laboratories, Inc., 311 W. Kilbourne Ave., Milwaukee, has announced a new 35-watt dual-recorder, public address system.

The recorder will cut to 11" blanks at 100 lines per inch, with crystal cutter. Its frequency response is said to be from 40 to 10,000 cycles $\mp 2$ db. The tube complement consists of 2 6F5, 3 6N7, 2 6L6G and 1 5X4G.

* * *

### ARC RESISTANT LAMINATED INSULATING MATERIAL

A new type of laminated insulating sheets, tubes and rods made with recently developed materials has been announced by the Formica Insulation Company, Cincinnati, Ohio. Tests are said to show that this new material has approximately ten times the arc resistance that has been available in laminated insulating material heretofore.

Under American Society for Testing Materials, arc resistance test, D-495-41 this material is said to stand up from 130 to 190 seconds in the fiberglas grade. Previous materials are said to be able to withstand this test only for from 13 to 18 seconds.

The material is provided in all the usual laminated grades, e. g., paper base, canvas base, muslin base, fiberglas base. It is also made in sheets, tubes, rods and parts that may be machined from those forms.

* * *

### MACHINABLE CERAMIC BODIES

To facilitate the development of sample or test pieces, Henry L. Crowley & Co., Inc., West Orange, N. J., can now furnish ceramic bodies in the semi-plastic or unfired state. Such bodies can be machined to desired size and shape, and then returned to Crowley for proper firing and conversion into finished Crolite.

The blocks, rods or tubes furnished for outside machining, are usually of pure magnesium silicate, providing excellent electrical and mechanical characteristics in the final fired state.



* * *

### ELECTRICAL CONTROL DATA

A catalog and reference book, just published by Automatic Electric Company, 1033 West Van Buren St., Chicago, Ill., contains useful data on the relays and other electrical control apparatus. It includes comprehensive data on over 30 major types of relays and their mountings, stepping switches of various types and capacities, and other electrical control parts such as switching keys, signal lamps and sockets, cords and plugs, dials, microphones, handsets, solenoids, coils.

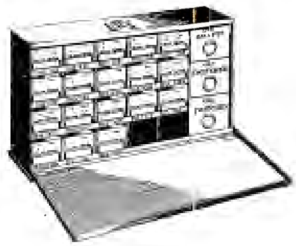
Complete operating data on all relays and stepping switches are included, and listings of standard assemblies with their characteristics simplify the selection of apparatus for particular applications.

* * *

### IRC CONTRO-POTENTIOMETER METAL CABINET ASSORTMENT

A convenient assortment of IRC volume and tone controls, and potentiometers supplied in an attractive metal cabinet at no exra charge has been made available by International Resistance Co., 415 N. Broad St., Philadelphia, Pa. The cabinet includes a factory-packed assortment of 18 IRC type D universal controls in the most popular ranges and types, along with 6 extra switches and 5 extra tap-in shafts of special design.

Shafts and switches for IRC type D universal controls can be selected to suit individual needs. These attach to any of the 18 controls, which are supplied in 17 different frequently-needed resistance values from 10,000 ohms to 2.0 megohms, and in a number of different types including potentiometer voltage divider, tapped for a-v-c, friction clutch type, and various others. Measuring 14½" long, 7⅜" high and 4½" wide, it provides individual compartments for 20 controls. Three drawers accommodate the switches and special shafts as well as providing ample room for other hardware or parts.



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### 840-WATT P-A SYSTEM

An 840 watt rack and panel p-a unit designed and built by the Rauland Corporation, 4245 N. Knox Avenue, Chicago, Ill., has recently been installed at a large ordnance plant. The equipment contains 48 high-powered reproducers and over 16 miles of connecting cable. The central control unit is capable of supplying radio programs and phonograph or microphone programs to all of the reproducers and provides audible coverage over an area of more than 30 square miles.

The system is used primarily for instantly locating personnel who might be any point within the limits of the grounds and is instrumental in providing up-to-the-minute broadcasts to all of the employees throughout the plant.

* * *

### OHMITE RHEOSTAT CAGES

A variety of rheostat cages have been developed by the Ohmite Manufacturing Company, 4835 Flournoy St., Chicago, Ill., for use with Ohmite rheostats. This cage enclosure, a convenient form of table top or surface mounting is advisable where there is possibility of mechanical injury to the rheostat or human contact with electrically "live" parts.

Ventilated cages with perforated sides are most generally applicable. Other types available are: dustproof cages, cages to

*(Continued on page 34)*

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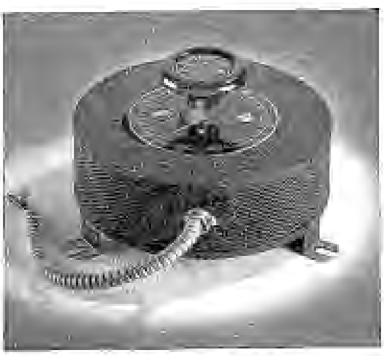
house rheostats in tandem, explosion proof cages, ventilated cages with one-half closed as a splash guard, and a laboratory type semi-enclosed table-top cage. Various types of terminals can be supplied.



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### AERO MECHANICAL LATCH-IN, ELECTRICAL RESET RELAY

A new mechanical latch-in, electrical reset relay for aviation purposes has been announced by Struthers Dunn, Inc., 1335 Cherry Street, Philadelphia, Pa. Known as Dunco Relay Type 6X3190, this unit is said to operate from a brief impulse without the necessity of keeping the coils energized. Double-pole, double-throw contacts are rated at 6 amperes at 12 or 24 volts, d-c. An auxiliary contact breaks one coil circuit. All contacts are insulated from the frame for radio frequency. Coils are for operation on d-c only. Dimensions of the unit are 3 5/16" high by 1¾" wide by 1⅜" deep. Weight is 7 ounces. Other contact arrangements are also available.

Dunco Aviation Relay and Solenoid Bulletin No. P-249 describing Type CX3190 as well as various other units for aviation uses will gladly be sent upon request.

* * *

### VISUAL FREQUENCY MONITOR

A visual frequency monitor designed to measure the frequency deviation of medium or high frequency transmitters, supplied to operate on one up to four channels, changing from one to another by means of a switch on the front panel, has been developer by Doolittle Radio Co., 7421 Loomis Blvd., Chicago, Ill.

The unit consists essentially of a radio frequency converter tube operating in conjunction with an integral crystal controlled oscillator which heterodynes the signal being monitored producing an audio beat note. This note is amplified and applied to an electronic counting device which produces a direct indication of frequency deviation on a meter. The meter scale is calibrated from 0 to 1000 cycles per second. A switch with multiplier indications extends the range to 5000 and 10,000 cycles per second. The unit, known as the FD-8, may be coupled to the transmitter through a shielded lead and pickup coil or if a number of transmitters are to be measured sufficient pickup can usually be obtained from a short antenna. In this case the transmitter should not be over 100 feet from the monitor.

Its frequency range is 1600 kilocycles to 50 megacycles. Its accuracy of monitory frequency is said to be .002%.

* * *

### NATIONAL UNION MAKING TRANSMITTING TUBES

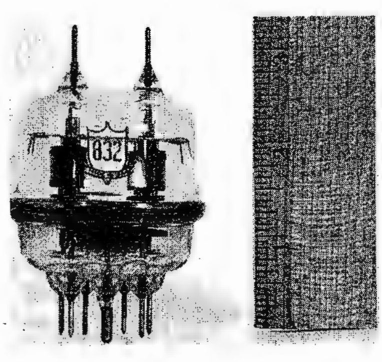
A line of transmitting tubes consisting of the most important types in all sizes up to 200 watts is now in production at National Union Radio Corp., 57 State Street, Newark, New Jersey.

Triodes in this new line, range in size from 2.5 watt plate dissipation type NU-14B to 200 watt type, NU-300. Beam tetrodes and pentodes range in size from the 15 watt NU-832 to the 125 watt NU-803. Rectifiers of the vacuum and mercury vapor types are available with outputs from 125 to 1250 milliamperes with maximum inverse voltage to 10,000 volts.

For commercial applications, there are types such as NU-845, NU-211, etc. For heavy duty industrial and diathermy applications, types NU-60, NU-200, NU-866A/866, etc., are available. For 12.6 volt application, there are types NU-832, NU-1625, NU-1626, etc.

High frequency types include the NU-75H, NU-807, NU-1625, and for ultra high frequencies there are such types as NU114B, NU615, NU829 and NU832.

During the process of transmitting tube manufacture, involving many delicate hand operations, extreme care must be exercised in checking up and testing each step of manufacture. Accordingly National Union has instituted a stringent series of such tests. Included in this plan, is the test covering base and cap torque, during which these items are tested after 72 hours immersion in hot water. Tubes are also tested for glass strain with a polariscope to prevent cracking possibility during use. In the vibration test, tubes are vibrated through .08 inches total movement at 15 to 50 cycles per second, while voltages are measured so that there is no chance of the elements shaking loose and causing low frequency harmonics in vibratory applications.



These new transmitting tubes are described in a new catalog that has just been released.

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## SQUARE WAVE ANALYSIS

(*Continued from page* 28)

22), we obtain

$$C_g = 0.0951 \text{ mfd.}$$
$$R_{g1} = 834{,}000 \text{ ohms}$$
$$R_g = 200{,}000 \text{ ohms}$$
$$C_b = 0.484 \text{ mfd.}$$
$$R_b = 165{,}000 \text{ ohms,}$$

and

$$\alpha = \mu\,(0.1652)$$

These are all feasible values. Furthermore, since $R_{g1}$ is so high, a relatively small condenser can be inserted in series with it to block out the d-c similar to the use of condenser C in Figure 8.

As mentioned previously, $R_b$ can represent a bias network. Thus, suppose a 150 volt supply, with a grounded positive terminal, is used for this purpose, and —2 volts bias is desired. A voltage divider consisting of 210,000 and 3,000 ohms in series will approximate this requirement. These two resistors in parallel are practically 3,000 ohms. From their common connections is run a resistance of 165,200—3,000 or about 160,000 ohms to the bottom end of $R_g$. This little bias network represents $R_b$, and is shown in Figure 10. (It is assumed that the internal impedance of the bias supply is negligibly small).

The networks shown in Figures 8 and 9 can be expanded to include two sections of plate de-coupling, i.e.—two condensers $C_F$ and two resistors $R_F$. Further details can be found in the references cited. Finally, it must not be assumed that Figure 9 applies to a triode tube, only. By suitable circuit transformations, an artificial, low $R_p$ of arbitrary value can be formed for a pentode tube (whose actual $R_p$ is exceedingly high), and then the equations (18) to (22) can be applied to give the same sort of configuration for a pentode tube.

These circuits are "kind" to a low frequency square wave, and give optimum performance where special care must be taken, as in high-grade oscilloscope work.

# Index of Advertisers





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# KEEPING THEM IN SERVICE

VERY FEW Variac auto-transformers give trouble even after years of fairly continuous use. Certain operating and maintenance precautions are necessary, however, to keep any Variac from passing out of the picture as did these in the illustration.

The five things to watch when using Variacs are:

- **WORN BRUSHES**
- **DIRT ON EXPOSED SURFACE OF WINDINGS**
- **CONTINUAL OVERLOADS**
- **GROUNDED OUTPUT CIRCUITS**
- **HIGH-VOLTAGE SURGES**

The brushes should be inspected regularly and replaced before excessive wear causes the brass holder to come in contact with the winding. When this happens the holder short-circuits several turns; immediate fusing results and the Variac is ruined.

Variacs, when exposed to dirt, dust, grit and corrosive fumes, must be cleaned frequently to insure positive contact between the brush and the winding, and to prevent arcing.

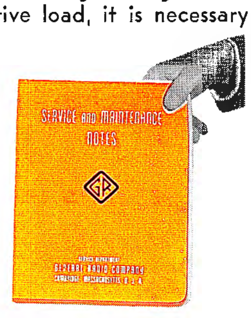
When the windings become blackened or corroded they should be cleaned with crocus cloth or very fine sandpaper. All rough spots must be smoothed. Loose particles can be removed with a fine brush; the windings should then be cleaned with carbon tetrachloride or some similar cleaning fluid.

Overloading may cause excessive heating. While the winding may not be damaged if the load is removed quickly, the carbon brush may disintegrate. A new brush should be installed. Lengthy overloads may cause a turn or two of the winding to be displaced and raised from the core with danger of damage to the brush.

To keep surges from damaging the Variac when it is used in the primary circuit of a high-voltage transformer or other highly inductive load, it is necessary that either the voltage setting of the Variac be reduced to zero or the *output* circuit opened before the line circuit is broken.

Since the Variac is an auto-transformer, it should not be connected to a load circuit containing a ground, *unless* the same sides of the line and the load are grounded.

With these simple precautions, and an adequate supply of replacement brushes and line- and load-circuit fuses, the users of the Variac should expect many years of service from these transformers.

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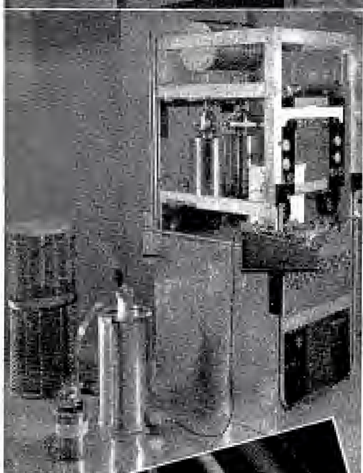

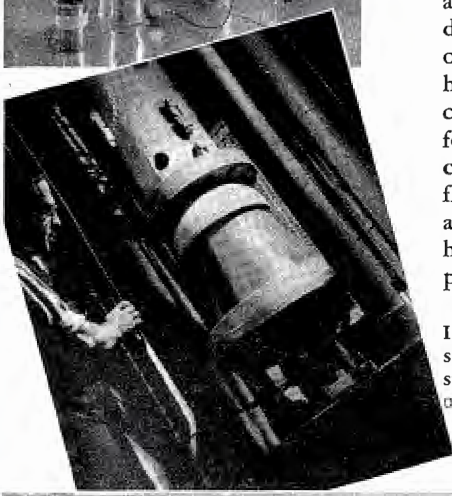

## PERFORMANCE CHARACTERISTICS OF LAPP RADIO INSULATORS ARE DEPENDABLE FACTORS

Lapp's contributions to radio broadcast engineering are recognized as highly significant in the advance of the science. Practically every development of antenna structure design, for example, has been worked out with the co-operation of Lapp engineers. Since Lapp developments have been wholly pioneering in nature, it has been necessary to maintain complete testing facilities. In the Lapp laboratory is the usual equipment for 60-cycle electrical, mechanical and ceramic testing. In addition is complete equipment for determining characteristics of units at radio frequency—heat run, radio frequency flashover, corona determination and capacitance. For mechanical testing (lower picture), a 1,500,000 lb. hydraulic testing machine is used—for test of new designs, and for proof-test of every insulator before shipment.

In the construction of new broadcast equipment—or the modernizing of old—the safe bet is to specify "insulators by Lapp." Descriptive literature on Lapp antenna structure insulators, porcelain water coils and gas-filled condensers is available on request. Lapp Insulator Co., Inc., LeRoy, N. Y.

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