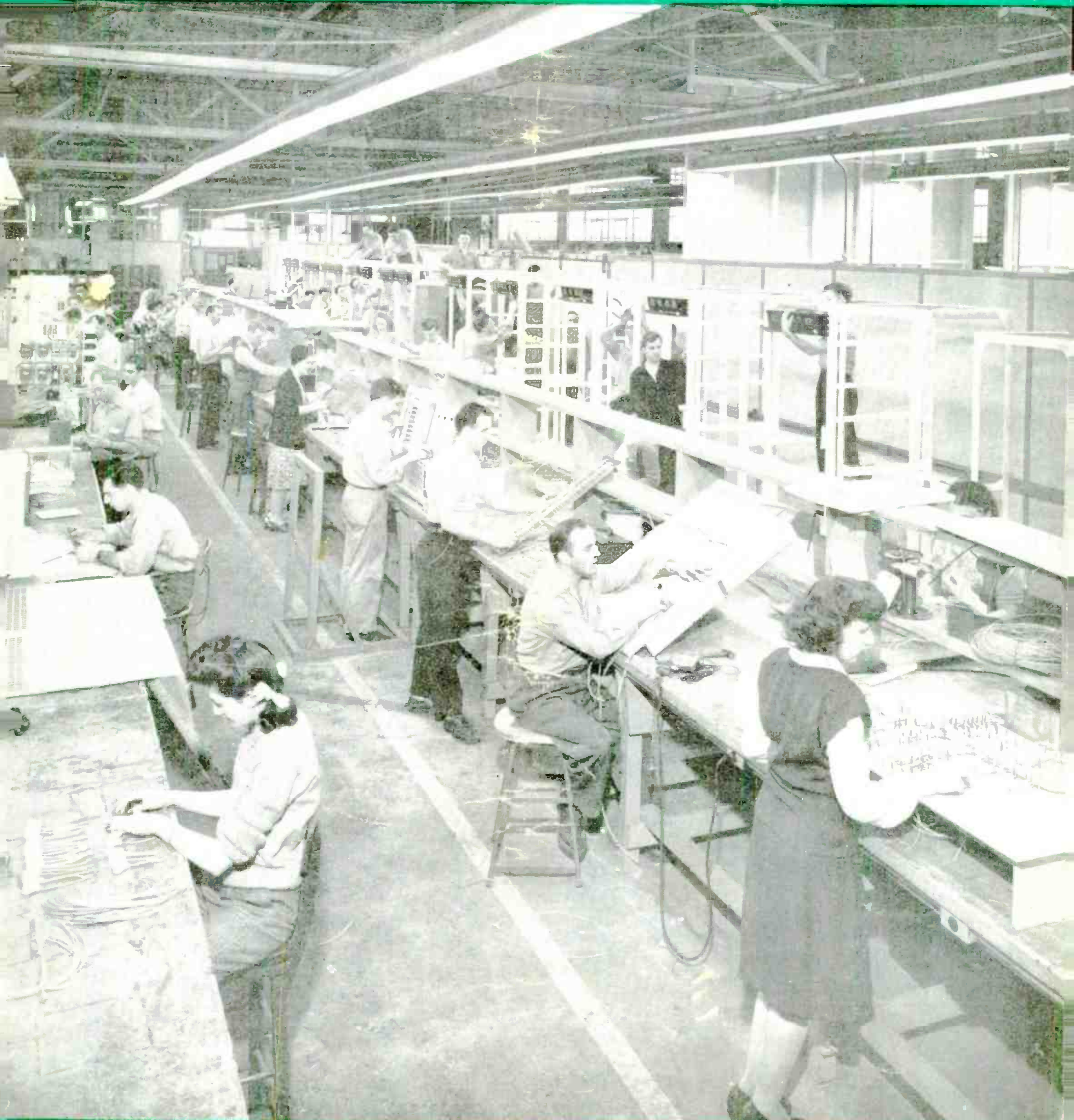
JANUARY, 1947

RADIO

HUEBNER

MANUFACTURING AND BROADCASTING

The Journal for Radio & Electronic Engineers



Design • Production • Operation

These Newspapers Have Selected

FM by Federal

for their new Broadcast Stations

ALL WILL BE ON THE AIR BY EARLY 1947

MEN WHO KNOW news pick the "big news in radio" — FM by Federal. From New York to Nebraska — from Wisconsin to Kentucky—these eighteen newspapers in eleven states are going on the air with new FM broadcasting stations. And — like so many major radio stations from coast to coast — they have *all* selected Federal equipment.

FM, in itself, means better broadcasting. But FM by Federal means FM at its best — the last word in center-frequency stability, radiation strength, and long trouble-free operation. Federal's 38 years of research and experience are at your service — to design, equip and install your complete FM station. Write today for detailed information. Dept. B143.

Federal's **SQUARE-LOOP ANTENNA** gives added effective radiation strength — up to 8 times that of the rated transmitter output.

The **"FREQUEMATIC" MODULATOR** is an exclusive feature of every Federal FM transmitter — assuring greater center-frequency stability, simplicity of operation and longer life.

Federal Telephone and Radio Corporation

In Canada:—Federal Electric Manufacturing Company, Ltd., Montreal.
Export Distributors:—International Standard Electric Corp. 67 Broad St., N.Y.C.

An IT&T Associate — FTR

Newark 1, New Jersey

JANUARY, 1947 Vol. 31, No. 1

CONTENTS

COVER

FM transmitter production line at Newark plant of Federal Telephone and Radio Corp. Wire harnesses being readied for installation into FM transmitter cabinets.

ARTICLES

RADIO Magazine (title registered U. S. Pat. Off.) is published monthly at Boston Post Road, Orange, Connecticut, by Radio Magazines, Inc. Executive and Editorial Offices at 342 Madison Avenue, New York 17, N. Y. Subscription rates—United States, U. S. Possessions & Canada, $3.00 for 1 year, $5.00 for 2 years; elsewhere $4.00 per year. Single copies 35c. Printed in U.S.A. Entered as Second Class Matter May 10, 1945 at the Post Office at Orange, Conn., under the Act of March 3, 1879.

How to Avoid Saving Money

by DANNY KAYE

To avoid saving money, the first thing is to cut off all your pockets. (Or throw away your purse and keep your lipstick in your snood.) Thus you will have to carry your money in your hand. Which will insure that you—1. spend it, 2. lose it, 3. get it taken from you—*quicker!*

Also to be avoided like crazy are piggy banks and sugar bowls. Keep these out of your home! The kiddies in particular are victimized by such devices, often saving quite a bale of moolah. Be stern even if the little ones cry—remember what money could do for them! And be sure to avoid budgets. It is best to draw your pay and walk down Main Street buying anything you don't particularly hate.

Above all, don't buy any U. S. Savings Bonds —or it's *impossible* not to save money! These gilt-edged documents pay fat interest— 4 dollars for 3 after only 10 years! There is even an insidiously easy scheme called the Payroll Savings Plan by which you buy bonds *automatically*. Before you catch on, you have closets full of bonds. You may even find yourself embarrassed by a regular income! Get-gat-gittle!

Danny Kaye

IF YOU MUST SAVE

SAVE THE EASY WAY...

BUY YOUR BONDS THROUGH PAYROLL SAVINGS

Contributed by this magazine in co-operation with the Magazine Publishers of America as a public service.

Transients

WHITHER FM?

★ Announcement by FCC chairman Charles R. Denny that 700 FM stations will be on the air before this year ends seems likely to presage a boom in FM receiver production. According to Major Armstrong, the radio industry should turn out at least a hundred million dollars' worth of FM sets this year. Dr. Manson, president of Stromberg-Carlson, is reported to have stated that FM receiver production will range between three and four and a half million units if the total production of all radio receivers reaches fifteen million this year. In any event, plenty of sets capable of receiving FM broadcasts are soon to be available to the public.

Whether FM will develop slowly or spread like wildfire depends largely on the character of programs offered the public by the new broadcasters. If the high quality of most present-day FM broadcasts in metropolitan centers is maintained and enhanced, then the radio manufacturing industry is in for a period of unparalleled expansion and prosperity. If, however, too many of these newcomers to the broadcasting field attempt to saturate the ether with propaganda programs, rebroadcasts of features already available on AM bands, small-time local programs over-seasoned with advertising of obnoxious character (now so often encountered on small hinterland stations), then the expected boom may not materialize.

As we see it, it develops upon the radio industry as a whole to see that the newcomers to the broadcasting field are helped and intelligently guided in establishing an FM broadcasting service which the public will be eager to receive. While broadcasters' associations can do, and undoubtedly will do, a great deal along these lines, it must be remembered that the responsibility is not alone theirs; it rests upon the entire industry and the Federal Communications Commission. Above all, the feud between AM and FM broadcasters should be called off. There will be plenty of business for both groups if they do a good job. Now, as never before the radio industry must see to it that factional strife is wiped out lest all suffer.

UNFAIR TAXATION

★ Now that agitation for the removal of excise taxes is before Congressional committees, it is well the excise tax committee of the Radio Manufacturers Association has called attention to the present inequities existing in the ten per cent excise tax on radios and phonographs. The radio industry is no gold mine insofar as earnings are concerned; the average net return is only 2.7 per cent. Thus, as the RMA points out, the tax is excessive in comparison with that applied to big profit industries. Furthermore, radio has educational and cultural value not possessed by most of the other products subject to excise taxes. And there are other good reasons why the tax should be abolished insofar as radio receivers are concerned.

Particularly to be emphasized are the points brought up in conjunction with the tax on FM, and the sound section of television receivers. It costs more to make FM than to make AM sets, and at a time when the public is showing increasing resistance to paying high prices for anything, the additional burden of the excise tax tends to injure a new branch of the industry which promises to add greatly to the national prosperity when it becomes established.

The contribution of the radio industry excise taxes, while large for the industry, amounts to but 1.2 per cent of the total government collections from all sources subject to excise taxes, so relief from this tax burden would involve negligible loss to the government from this source. On the other hand, the greater number of sales which would result at the lowered prices made possible by eliminating this tax would increase employment, individual earnings and therefore purchasing power, and bring greater returns to the government through income tax collections. Tell your congressman.

PRODUCTION INEFFICIENCY

★ Many who noted the extraordinary efficiency which was attained in mass production of radio apparatus during the war period predicted even greater production at lower unit costs in the post-war era. This, we have seen, has not come true. Few radio manufacturers are now showing a profit and unit costs are far higher than they were before the war. Much of this is due to individual inefficiency, resulting perhaps from war-weariness, and this loss of morale of those on the production lines is one of the greatest handicaps the industry now bears.

A great deal of money is now spent by larger manufacturers on their public relations staffs, but not enough attention is given to methods of stimulating enthusiasm for their work among the workers on the line. If some satisfactory substitute for the war stimulus can be devised so that workers acquire a greater interest in their work and in the companies for which they work, it should unquestionably benefit all in the industry more than any other single thing we can think of.

—J. H. P.

TECHNICANA

MICROWAVES FROM HEAT

★ Regarding radio waves as long infra-red waves, thermal radiation of microwaves may be expected from hot bodies, according to R. H. Dicke of M.I.T., reporting in *Review of Scientific Instruments* for July 1946. The article, entitled "The Measurement of Thermal Radiation at Microwave Frequencies" describes a wide-band receiver which was used as a radiometer in the experiments.

A block diagram of the receiver is shown in *Fig. 1*, which used a bandwidth of approximately 10^7 cps. Noise figure of the receiver was 20, with a response time for the d-c meter of one second.

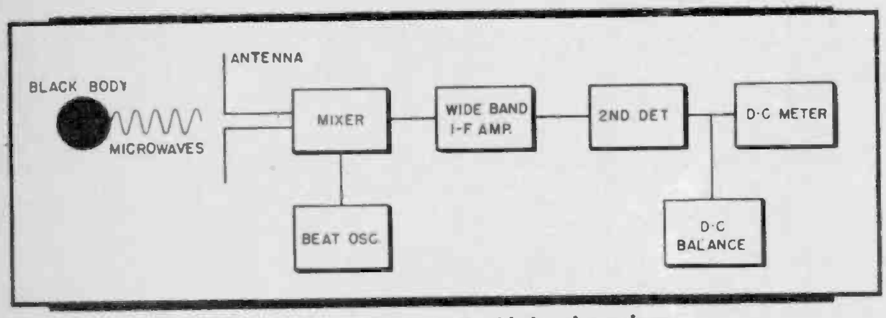


Fig. 1. Block diagram of wide-band receiver.

The microwave radiator was a black body, since to be a good radiator a body must also be a good absorber. A temperature of 300° K is typical of the range investigated.

Experimentally observed rms fluctuations of the output meter were worked up on a statistical basis, and yielded results comparing favorably with values derived on the basis of theoretical considerations.

Various radiometer refinements and a method of calibration using a variable-temperature resistive load are discussed in the original article, as well as the physical relation of Johnson noise and thermal microwave radiation.

ACOUSTIC FLUCTUATIONS

★ Analysis of high-fidelity sound reproduction must of course take into consideration acoustics of the room in which the speaker operates. The subject of fluctuation is significant in the over-all picture, as well as pointing up the fact that many subjective factors are at work, not all of which are completely understood. Blind persons are able to estimate accurately room size on the basis of fluctuation factors, for example.

An investigation of fluctuation phenomena in room acoustics has been made by Dah-You Maa, and reported in the *Journal of the American Acoustical Society* for the July-September quarter. It is pointed out that two types of fluctuation exist, one due to thermal variations which may be compared with thermal agitation voltages in conductors, and the other due to interference effects during reverberation and decay of a sound wave. The first is below the threshold of hearing, but the second is audible and is instinctively utilized by the blind when judging room size.

Fluctuation of sound pressure during sound decay is a function both of room size and its acoustic properties, not all of which may be discussed quantitatively in the present state of the art. It is believed that the liveness of a room is determined by both reverberation and fluctuation, increasing with both.

With a warble tone of 250 ±25 cps established in a room 20x14x8 feet, fluctuation was calculated at approximately 20%. This figure checked with measurements made repeatedly and recorded over one another, and a satisfactory confirmation was obtained.

Fluctuations arise because of interference between the normal modes of vibration excited before the reverberation. These normal modes do not have identical normal frequencies, and hence their relative phase relations change continually, and are superposed upon the decay wave.

With more exact knowledge of the subject, a criterion of the acoustic merit of a room in terms of its liveness could be formulated, although this will require an objective definition of liveness in the same manner as loudness and pitch are defined.

DETECTOR NOISE

★ Extensive investigations into the quantitative aspect of random noise in linear and square-law rectifiers, undertaken for the OSRD, are reported in the October 1946 issue of the *Journal of Applied Physics* by David Middleton. Statistical techniques have been used, because it is impossible to predict precisely the amplitude of the input or output noise at any given moment. Quantitatively, the probability of occurrence of noise peaks may be determined, distribution laws verified, and magnitudes computed in terms of average, mean-square, and higher moments.

A far-reaching consequence of the statistical nature of random noise is that there exists no relation between its mean-square amplitude and spectral distribution. For example, the spectra of clipped and unclipped noise are frequently identical, but the instantaneous voltage waves being compared are quite different as may be observed on the CRO. As would be anticipated, clipping of noise spreads the spectrum and reduces the power in the output waveform.

The author finds that random noise may be classified into broad-band, semi-broad band, and narrow-band types, resulting from varying ratios of circuit pass-bands to the center frequency. Rectification of noise in the first two circuits, for example, yields output spectra having approximately the same distribution as that of the incoming noise energy. Rectification of narrow-band noise causes an infinite number of separate noise bands to be generated, falling symmetrically about harmonics of the center frequency.

An interesting finding establishes that the noise power in the rectifier output depends only on the r-m-s input noise voltage and not upon the spectral distribution of the noise frequencies. Numerous graphical presentations are made in the original article, to which reference should be made for details of the investigation.

TUBE STEM BREAKDOWN

★ Stem cracks developed along leads during the life of rectifier tubes have been studied in a report by John Gallup and published in the *Journal of the American Ceramic Society* for October 1, 1946. These were found to be due to electrolysis occurring in the soft glass stems.

The potential which produced the rupture was the result of glass bombardment by reverse emission from the rectifier plates. Other attendant electrolysis phenomena are described by the author, who used a special double-

Radio Manufacturers!

NOW YOU CAN USE ALTEC LANSING SPEAKERS . . . AN ADDITIONAL MARK OF QUALITY, ANOTHER SELLING POINT, FOR YOUR FINE RECEIVERS.

THE ALTEC LANSING DIA-CONE SPEAKER

Model No. 600

When a radio manufacturer we know heard the famous Altec Lansing Duplex, his first words were: "You ought to design a speaker like this for my better receivers . . . at a price I can afford." And here it is . . . a popular priced speaker with a carry-over of Altec Lansing's premium priced features. This new model, No. 600, is a 12-inch edition of the Altec Lansing line. Now you can identify your finer receivers with Altec Lansing quality. Send for further technical information on the No. 600.

MODEL No. 600. Specially designed for better radio-phonographs. This Altec Lansing Dia-Cone Speaker incorporates a metal high frequency diaphragm and a 12-inch low frequency cone, coupled by a unique mechanical dividing network to a 3-inch voice coil of edgewise wound aluminum ribbon.

ALSO AVAILABLE IN 15-INCH DIA-CONE WITH A MULTICELLULAR HORN FOR HIGHER PRICED COMBINATIONS

"KEEP ADVANCING . . . ALTEC LANSING CORPORATION WITH ALTEC LANSING"

1161 N. Vine St., Hollywood 38, Cal.
250 W. 57th St., N. Y. 19, N. Y.

TECHNICANA

[*from page* 4]

ended tube to study gases produced in the electrolysis process.

An analysis of the gases by means of the mass spectrometer gave composition results agreeing with those expected from electrolytic decomposition of soft glass.

SPUN GLASS LACING CORD

★ To save maintenance man-hours, United Air Lines is using spun glass cord for lacing the wiring harness of two-way radio communications units in its fleet of Mainliners and Cargoliners.

Use of the spun glass cord reduces the need for frequent relacing of the wiring, say radio electric shop foremen, who found that heat and high humidity affected the linen cord formerly used. At United's Cheyenne maintenance base alone, time savings are estimated at approximately 600 man-hours a year. The new method also results in an overall material saving.

The glass cord is treated with beeswax to facilitate handling during the tying. Warren Rush, mechanic's helper at Cheyenne, received $75 from United Air Lines' employes suggestion conference for the idea.

DYNATRON AT UHF

★ While the dynatron affords ease of measurement of dynamic resistance of tured circuits at frequencies up to 25 mc, it has been supposed by various workers that tubes in this circuit present difficulties at higher frequencies. That this is not so has been established by G. A. Hay, reporting in the *Wireless Engineer* for Nov. 1946.

As a result of his investigation it appears that any limitation in use of dynatron techniques up to 100 mc are traceable to circuit conditions rather than transit time effects. A Mazda AC/SG was used in the experiments.

It was found that irregularities may occur as a result of resonance in power-supply leads, for example. When attention is given to circuit details, it is found that 100 mc marks the upper frequency limit attainable with usual tube types. The use of the dynatron at still higher frequencies would require a special tube, constructed with the various circuit limitations in mind.

TELEVISION GHOSTS

★ Simplified methods of estimating the probable intensity of ghosts are discussed in an article entitled "Approximate Method of Calculating Reflections in Television Transmission", by D. A. Bell, which appears in the *Journal of the Institution of Electrical Engineers* (Part 3) for Sept. 1946. Techniques are used which have been established in the field of optics.

The author concludes that the distance in wavelengths from the receiver at which an obstacle becomes a significant reflector is proportional to the square of its diameter in wavelengths.

MAGNETIC TAPE RECORDER

★ Recording on paper tape has been facilitated by development of a magnetic paint in the laboratories of Indiana Steel Products Co. Its magnetic characteristics are claimed to approach those of Alnico III, and in contrast with other tape powders is of metallic rather than oxide composition. A high coercive factor is obtained in the finished ferric product by special processing during manufacture.

Structural details of the playback

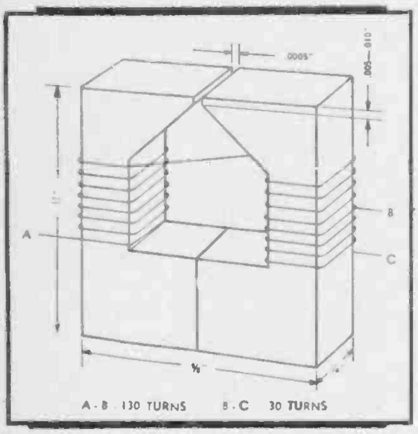


Figure 2.

head used with this tape are shown in *Fig. 2*. At a tape speed of eight inches per second frequencies to 6000 cps are accommodated. The tape width is ¼ inch, with a thickness of 0.002 inch, and has a break load of six pounds. An hour of recording is possible on a tape reel wound on a standard 16-mm movie film reel.

Particular advantages of the tape are cited to include economy, space conservation, and ease of handling.

LOW-TEMPERATURE DRY CELLS

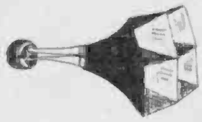
★ Interesting findings regarding dry cells are reported in the *Journal of the Franklin Institute* for Oct. 1946. The Japanese had developed a low-temperature dry cell during the war which would operate at −30° C., but was sufficiently unstable that it was not entirely satisfactory.

G. W. Vinal, *et al.*, in reviewing the formula, discovered that when equal or greater mol strengths of zinc chloride in proportion to calcium chloride were used, that the cell performed acceptably. Another type of low-temperature cell has been developed in which methylamine hydrochloride is substituted for ammonium chloride, but using a small amount of the latter to stabilize voltage,

[*Continued on page* 30]

Preferred FOR OVER 20 YEARS

RACON commercialized the "Morning Glory" loudspeaker horn back in the early 20's — was immediately recognized as the finest line of speakers obtainable. RACON is still out front! RACON commercialized in the early 30's cellular horns and air-column speakers — contributed to the success of "talkies" in sound pictures. And since then, throughout the 40's RACON has been engineering new advances in horns, speakers and driving units for public address, paging and sound distribution systems.



RACON introduced Marine Speakers (first ever approved by the Bureau of Marine Inspection & Navigation). RACON introduced the most successful "Blast-Proof" units to withstand gunfire. RACON has Re-entrant Trumpets, Demountable Trumpets, "High-Fidelity Tweeters", Radial Horns and Driving Units for all purposes.

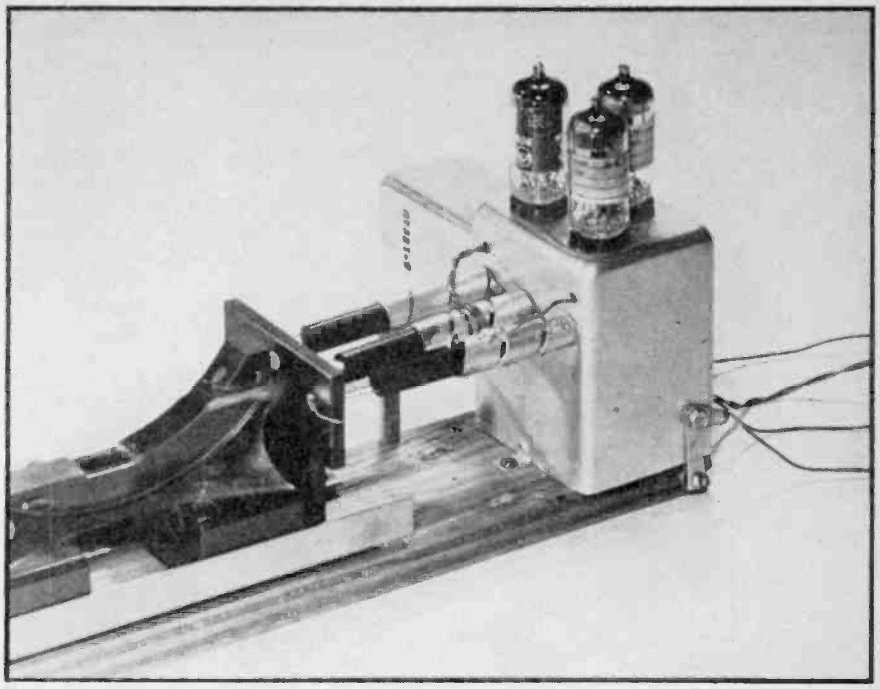
RACON introduced Acoustic Material that prevents resonant effects. Storm Proof Material that is impervious to any climatic condition. Driving Units having 60 watts peak and 30 watts continuous power ratings (which are higher capacity than other brands afford) . . . These are RACON achievements. You get the finest when you specify RACONS.

Send For Free Catalog

RACON ELECTRIC CO., INC.

52 East 19th St., New York 3, N. Y.

Experimental permeability tuning head for the new FM band.



Coaxial Coils For FM PERMEABILITY TUNERS

W. J. POLYDOROFF
Consulting Engineer

The inventor of permeability tuning shows how his system may be used for the new FM band

A CONSIDERABLE INCREASE in the number of postwar receivers which employ permeability tuning has been noted, particularly in auto receivers for the standard broadcast band and in sets designed for vertical antennas where iron slugs present no difficulties.

Some problems are still encountered in sets employing loop antennas, where a large inductance variation is required to cover the standard broadcast band. Because the loop is in series with the tuner (either directly or through a low-impedance step-up network) the tuning range is reduced. By using high-permeability core materials it becomes relatively simple to increase the inductance of a single-core inductor by a factor of 10 to 12, or 16 to 18 for twin-yoke, twin-core inductors, the latter being particularly well suited for loop tuning.* This system is already in use for broadcast receivers.

As the operating frequency is increased, the permeability tuning range becomes less. In order to maintain an acceptable Q at higher frequencies and thus retain adequate circuit selectivity, the iron granules must be made smaller and the material permeability must be reduced. In the short-wave region, a material permeability of 10 is all that can be used, compared with 40 in the broadcast band. This does not mean that the tuning range will be reduced proportionately. As shown in *Fig. 1*, the material permeability and the effective permeability also depend on the shape of the cylinders (their *L/D* ratio). The three shadowed areas represent the actual practice with regard to shape and permissible permeability from which we can see the practical limits of effective permeabilities in broadcast, "short-wave", and at very high frequencies (100-200 mc).

In practice these permeabilities further suffer on account of the necessary air-gap between the coil and the core, so that the final inductance-increase-due-to-iron, which we may call "apparent permeability", is of the order of 10-12 for standard broadcast frequencies, 4 to 5 for short waves, and still less for very high frequencies.

Furthermore, in the region between 10 and 20 mc, another adverse effect which causes a further reduction in the apparent permeability begins to become evident. As the frequency is increased, the coil inductance becomes smaller and smaller and the turns fewer. In a simple, non-variable inductor the turns would be wound close together or possibly spaced slightly for better Q. Spacing reduces the linkage between turns. In permeability tuned inductors, the reduced linkage causes a considerable decrease in the apparent permeability of the coil. Yet we are obliged to spread out the turns because a considerable range of movement of the core is necessary to provide the tuning mechanism with adequate operating range for readability over a broad dial range. In addition, the winding must be spread to increase the *L/D* ratio of the core and coil in order thereby to improve the effective permeability, as indicated in the diagram, *Fig. 1*.

To overcome these limitations, it has been proposed** to place several wind-

*Inductively Tuned Loop Circuits, W. J. Polydoroff, RADIO, April 1946.

**U. S. Patent 2,401,882

ings, connected in parallel, on a common form so as to obtain the same inductance value with a greater number of turns, thus making it unnecessary to increase the spacing between turns in order to secure a satisfactory *L/D* ratio. This expedient increases the apparent permeability and tuning range at frequencies above 20 mc. Somewhat similar results are secured if a number of strands of wire are laid parallel, thus forming a coil with a number of parallel paths. Similarly, an increased apparent permeability may be obtained if the coil is wound with wide, flat, metallic ribbon instead of thick, round wire.

Figure 2 shows methods of winding parallel coils and a suitable design for frequencies up to 100 mc. It is emphasized that these methods are only helpful in the case of permeability-tuned coils, which are of necessity spread out. In *Fig. 2A,* the parallel windings are arranged side by side; in *Fig. 2B,* the windings are reversed so that the center tap forms one terminal and the two joined ends the other; although more complicated, this produces a higher Q. The parallel-strand arrangement is shown in *Fig. 2C.* Each of these three methods increases the tuning range of the coil.

The new FM frequency allocation of 88-108 mc caught the industry unprepared. The winding techniques described above worked fairly well for frequencies up to about 50 mc, thus taking in the old FM band, with coils of the order of .2 to .4 μh. mainly because the core material permeability of 7-10 produced an adequate frequency range. For the old FM band ordinary variable condensers could also be used for tuning so that the choice of tuning method was largely a matter of economic con-

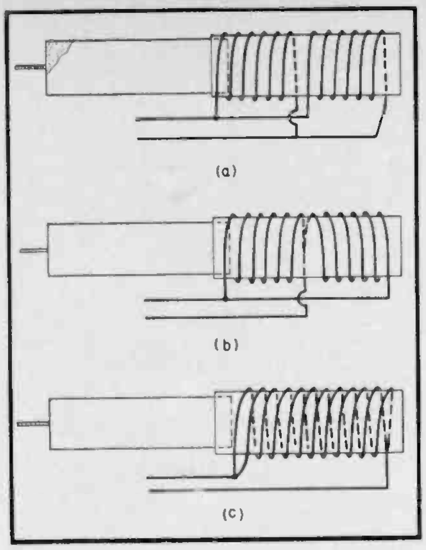


Fig. 2. Methods of making paralleled windings. The parallel strand arrangement is shown in (c).

siderations. The new FM band requires a coil inductance of from .05 to .1 μh in order to permit using a fixed shunt capacity of at least 25 μμf for circuit stability. One must bear in mind that a portion of the shunt capacity is represented by the tube input capacity, which varies with temperature changes and voltage fluctuations, hence the larger the lump circuit capacity the less effect these capacity variations will have. With such small inductance values, ordinary variable condensers become "too inductive" for tuning purposes, especially if the residual inductance changes in the wrong direction when the plates are rotated. While butterfly types with low-inductance milled plates can be used, the cost consideration definitely favors the variable inductor.

There is an iron core material*** suitable for frequencies of the order of 100 mc. Unfortunately its permeability is only 4 and reference to the chart shows an effective permeability of 2 to 2.5. Furthermore, with an elongated coil suitable for tuning, the apparent permeability will be but 1.5; using two parallel windings this becomes 1.7, the low value being due to reduced linkage and because of the necessary spacing between core and coil. While the range can be increased by using higher permeability iron (such as shown by the dotted extension of the area on the chart), this will result in a very noticeable drop in Q when the core is inside the coil. One may argue that the damping due to the tube (electron transit time at high frequencies) lowers the Q of the circuit to such a degree that we need not bother about the coil Q. But there are already tubes of much lower damping for v.h.f. which will eventually find their way into radio production. Thus, taking a long view of the situation, v-h-f circuits should have normal selectivity, manifested by circuit Qs of the order of 100 to 200, even for the new FM band. Such Qs pay dividends in the reduction of the number of circuits and tubes required in the pre-selector and oscillator stages.

At present the most economical practice for v-h-f circuits is to build the tuning head with permeability tuned circuits with coils of the usual dimensions, i.e., ¼" I.D. and 1¼" long with cores about 1½" long. The windings are either laid in parallel or made of thin copper strip cemented to the coil form. Alternatively, the metal may be sprayed or otherwise deposited on the surface of the coil form, providing excellent adhesion and stability.

A coil of the above type, to cover the band from 85-110 mc, will have about 4 turns for an inductance value of .05 μh. This will be augmented by approximately one and one-half times by the iron core, tuning to the lowest frequency when the lumped capacity of the circuit is fixed at 25-35 μμf. The measured inductance of the coil shown in *Fig. 3A* was found to be .057 μh and the total inductance variation was 1.5. At such low values of inductance the lead inductance can no longer be neglected. In actual practice, with the shortest possible lead to the tube at one end of the coil, we have to take into account the other lead, which will be at least as long as the coil. Calculations and measurements show that the inductance of this lead is .02 μh, equal to one-third the total coil inductance. Because this inductance is in series with the coil, it reduces the total inductance variation, and hence the frequency coverage, to 1.37 to 1. See *Fig.*

[*Continued on page 31*]

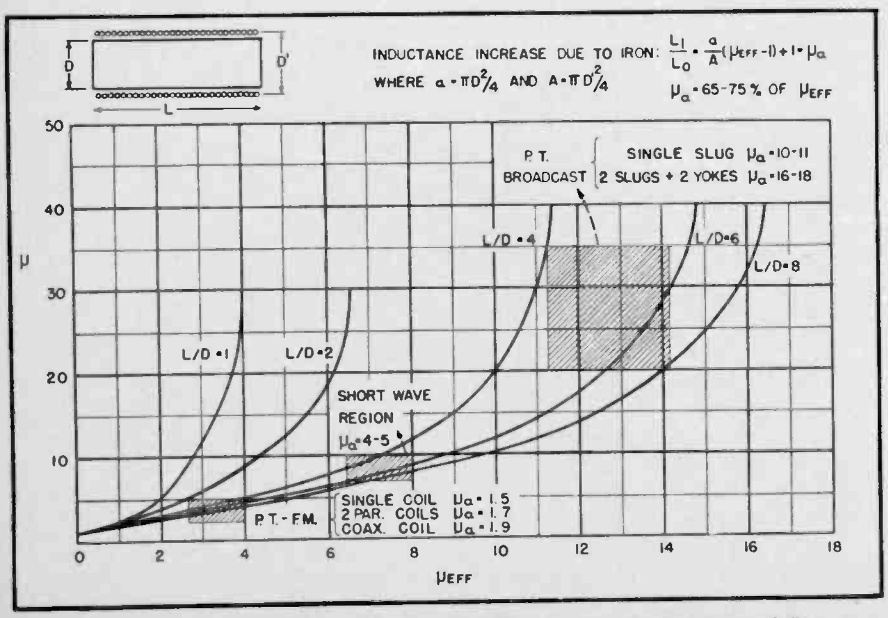


Fig. 1. Effect of material permeability and L/D ratio on effective permeability.

***Mepham IRN-8

Development of the Cascade Phase Shift Modulator

Features of the new cascade phase shift modulator and factors involved in the development of this system of modulation are described.

Engineering Dep't., Raytheon Mfg. Co.

THE DEVELOPMENT of the cascade phase shift modulator is the result of a painstaking effort to overcome the more prominent disadvantages of some present-day modulators used in broadcast FM transmitters. In the first place, a considerable circuit simplification is effected by eliminating the need for center-frequency-stabilization circuits through the use of a direct crystal-controlled phase modulator, which incidentally adds materially to the reliability of such transmitters. In the second place, the inherently low harmonic distortion of the new modulator allows the order of frequency multiplication to be kept low enough to avoid the use of frequency conversion stages — one of the disadvantages usually associated with phase modulators requiring a high order of frequency multiplication. In the third place, this modulator uses only standard, inexpensive tubes which are operated well within their ratings.

The following discussion will cover some of the technical factors involved in the development of this new system of modulation.

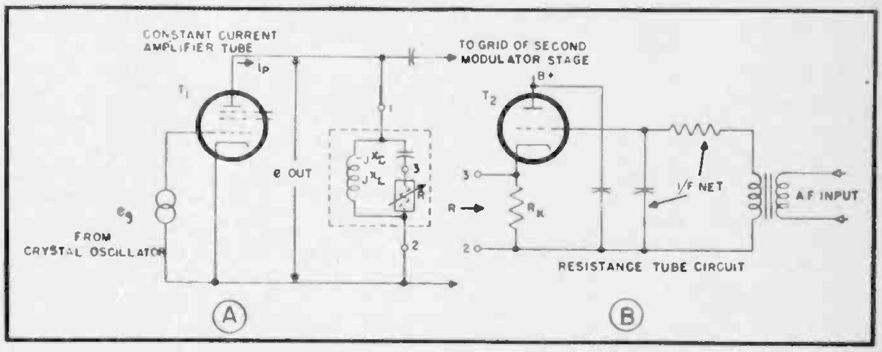


Fig. 2. (A) Basic phase shift stage and (B) schematic of resistance tube circuit.

General Theory

When a carrier wave is frequency modulated sufficiently to produce only the first pair of sidebands (this occurs when the modulation index equals 0.5 or less), any simultaneous amplitude modulation appearing in the output will add another pair of sidebands which will tend to increase the harmonic distortion because both pairs of sideband voltages, being of the same frequency, will add vectorially and thereby change the original proportions between the carrier and the sidebands of the frequency-modulated wave. The distortion is thus indelibly impressed on the frequency-modulated wave, and any limiting action in the following multiplier and amplifier stages can do little or nothing to erase it. The best way to prevent this type of harmonic distortion is to use a modulator which is inherently free from amplitude modulation.

The equivalent frequency deviation produced by a phase modulator may be shown to be equal to the phase shift (in radians) times the rate of phase shift (the audio modulating frequency in cps) times the frequency multiplication from the modulator to the final carrier frequency. Since the multiplication factor (M) is constant for a given transmitter, it follows that for the frequency deviation to remain constant, as is required for FM waves, the a-f signal level applied to the modulator must vary inversely with frequency. This function is performed by the inverse frequency ($1/f$) network, which will be described later.

The equation given above may also be used to calculate the phase variation necessary to keep the multiplication factor M low enough to eliminate the use of frequency converters. Assuming a crystal operating frequency around 100 kc as being high enough to avoid trouble from high-order harmonics of the audio modulating signal, and a final operating frequency of 100 mc, M becomes 1000. To give the modulator a factor of safety it is well to make the calculation for 100,000 cycles frequency deviation. A 30-cycle signal requires 191° phase shift and a 50-cycle signal requires 115° phase shift under the above conditions.

The difficulty of obtaining such large phase variations with low distortion may be appreciated when it is realized that until the recent invention of the Phasitron tube, phase modulators being used in broadcast FM transmitters could obtain only about 15° phase shift. A thorough investigation was made of most of the well-known methods of producing phase modulation. Of these, the Phasitron gave the best results. However, independent research on a new system of phase modulation, called the "cascade phase shift modulator", disclosed that it had lower harmonic distortion, used standard easy-to-get receiver-type tubes, and could be adjusted rapidly without external test equipment. There were enough points of superiority to warrant complete development and then production of this type of modulator.

Cascade Phase Shift Modulator

The complete schematic diagram of the cascade phase shift modulator, together with the first multiplier section, is shown in *Fig. 1.* The path of the r-f signal may be traced from *7V-1*, a conventional crystal oscillator, through the six simple modulator stages (*7V-2* through *7V-7*), and finally the frequency multiplier stages having a multiplication factor of 12 (*7V-8* through *7V-11*), and then to the output jack, *7J-1*. From this point the signal is fed to an additional multiplier section with a factor M of 81 and is then amplified

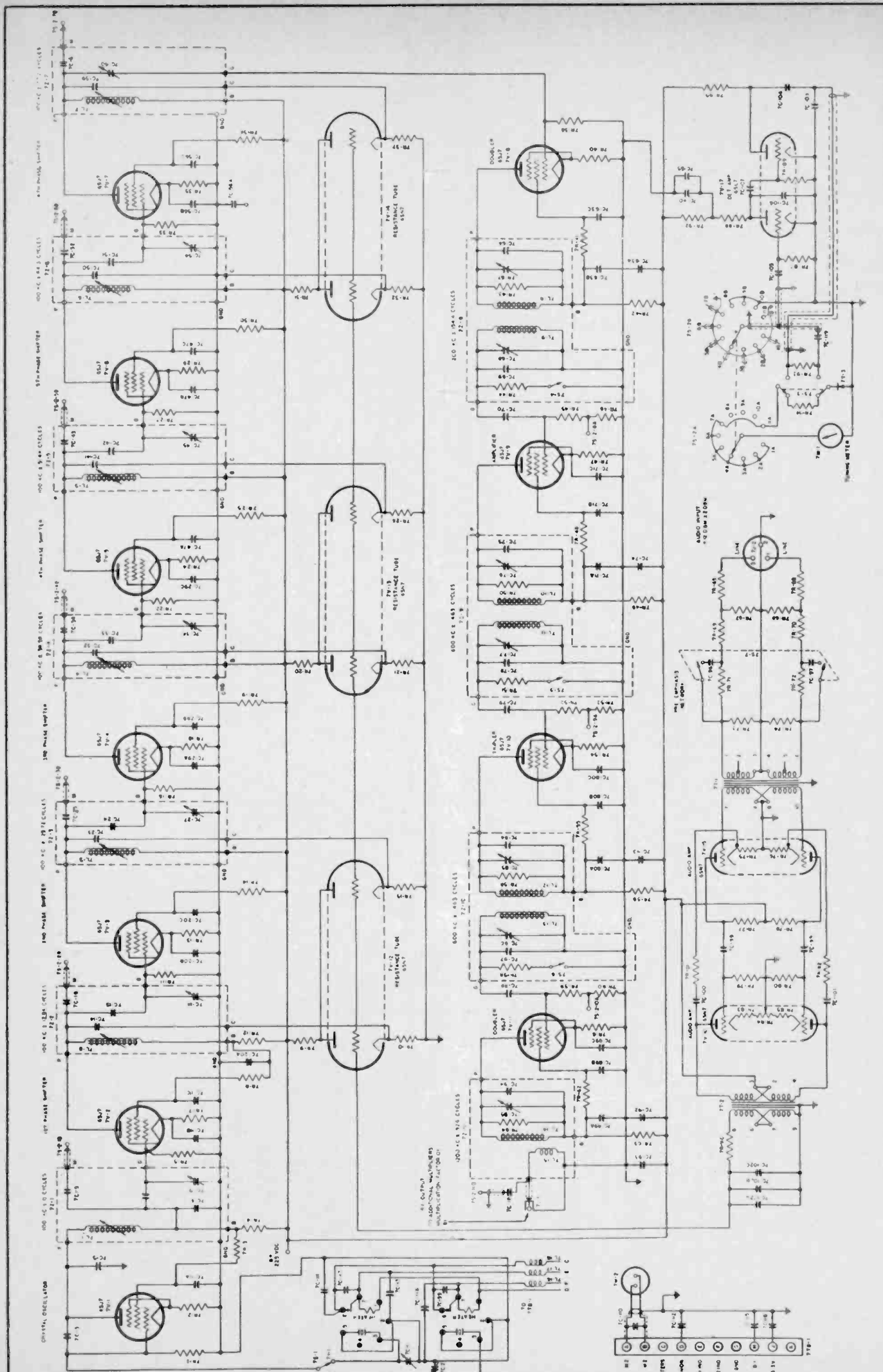


Fig. 1. Complete schematic diagram of the cascade phase shift modulator.

by the final power amplifier to 250 watts output.

The path taken by the modulating a-f signal may likewise be traced successively from the input jack *7J-2*, through a line isolation pad, a standard 75-microsecond pre-emphasis network, a conventional push-pull a-f amplifier, the inverse frequency network (*7C-102* and *7R-86*) and then to all the grids of the twin-triode resistance tubes (*7V-12* through *7V-14*).

Cascading Modulator Stages

It is well known that the total phase shift of a multi-stage amplifier is equal to the sum of the phase shifts through each stage. If the output of a single phase modulator stage is used to drive the input of a similar phase modulator, while a modulating signal is applied to both stages in parallel, the phase shift of the system will add in like manner to give twice that obtainable from a single stage. In general, if N similar phase shift stages are placed in cascade, the total phase shift of the system will be increased by a factor N times the phase shift per stage. Thus, for six cascade stages the required phase shift per stage is 31.8° for a 30-cycle modulating signal and 100-kc frequency deviation, and 19.2° for a 50-cycle modulating signal and 100-kc frequency deviation. This phase shift is easily obtainable at low distortion with the new simple phase modulator stage described in the following section.

Basic Phase Shift Stage

The basic phase shift stage is shown in *Fig. 2A*. It consists of a 6SJ7 constant-current amplifier tube, T_1, and its plate load network connected across terminals *1* and *2*. When properly adjusted, this network has the remarkable property of presenting a constant impedance across the two terminals while the resistive element R is varied to produce a change in the phase angle of the impedance. The general impedance and phase equations for this network have been derived in Appendix I and have been plotted in *Fig. 3* to show the operational characteristics in the vicinity of the constant impedance adjustment. The output voltage, e_{out}, appearing across the network, is equal to the plate current of the tube, i_p, times the impedance vector $Z \angle \theta$, and when the network is adjusted for constant impedance operation X_C/X_L equal to 0.5, there can be little or no amplitude modulation of the output voltage while phase modulation is taking place. The tube, however, must be a source of constant current — one whose plate resistance is high when compared with the load impedance.

Such a single-ended phase shift stage is ideally suited for cascading because the output voltage from the first stage may be capacitively coupled to the grid of the next stage with a minimum of tubes and components. The use of a pentode for T_1, besides furnishing a constant current, also serves to provide isolation between stages which must operate at the same frequency.

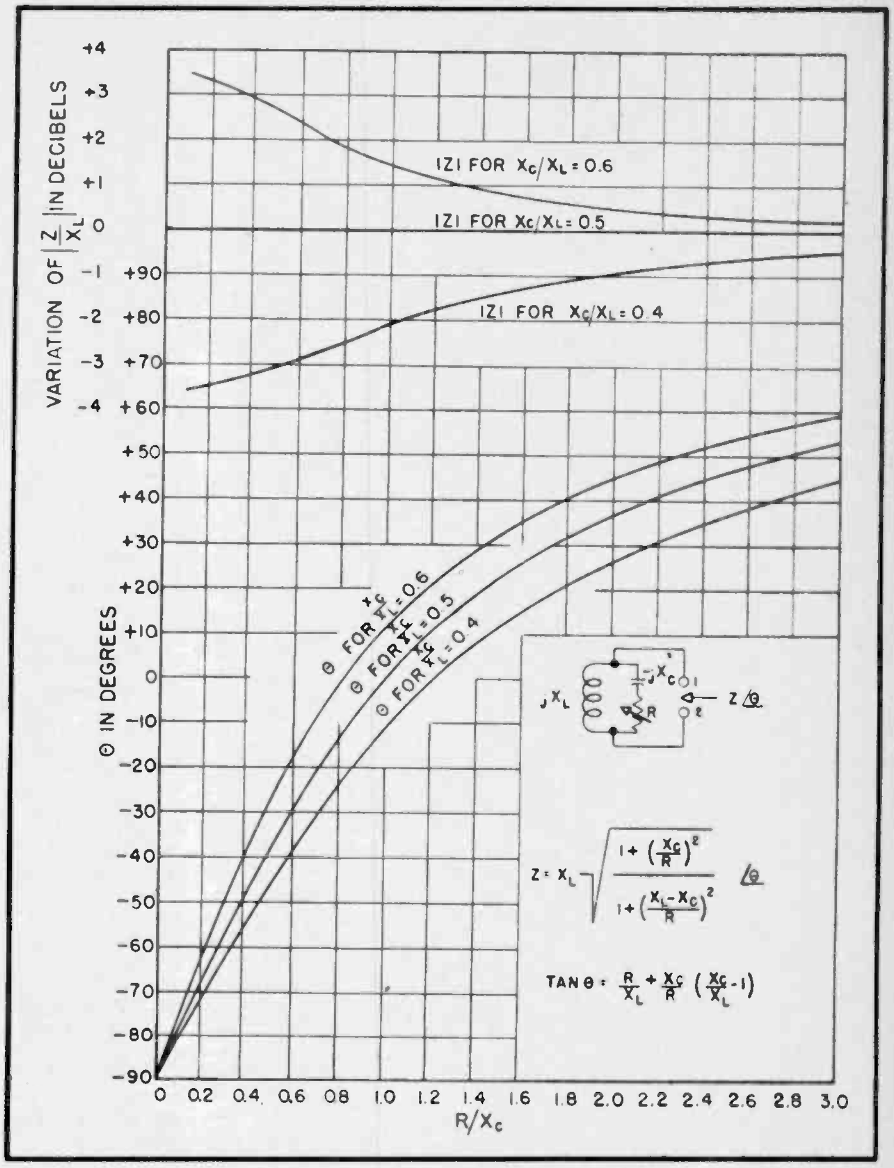
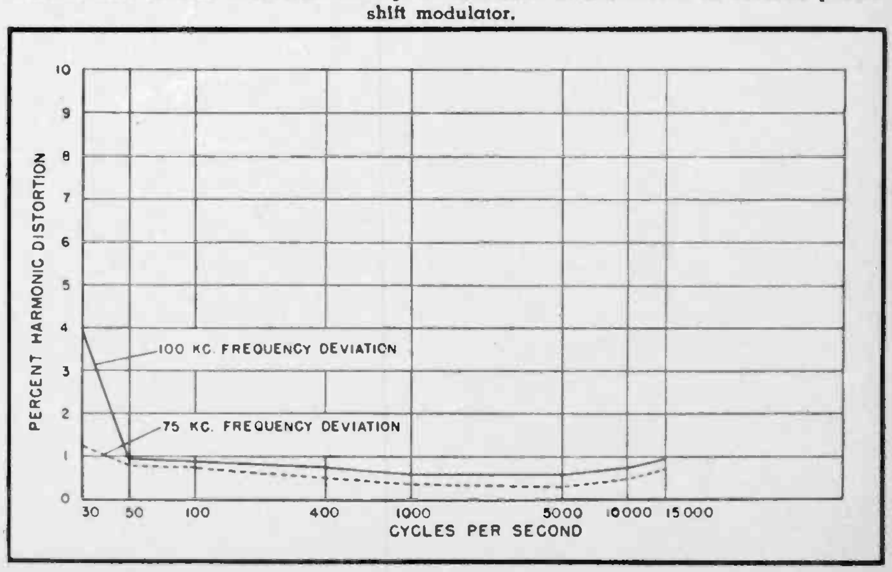
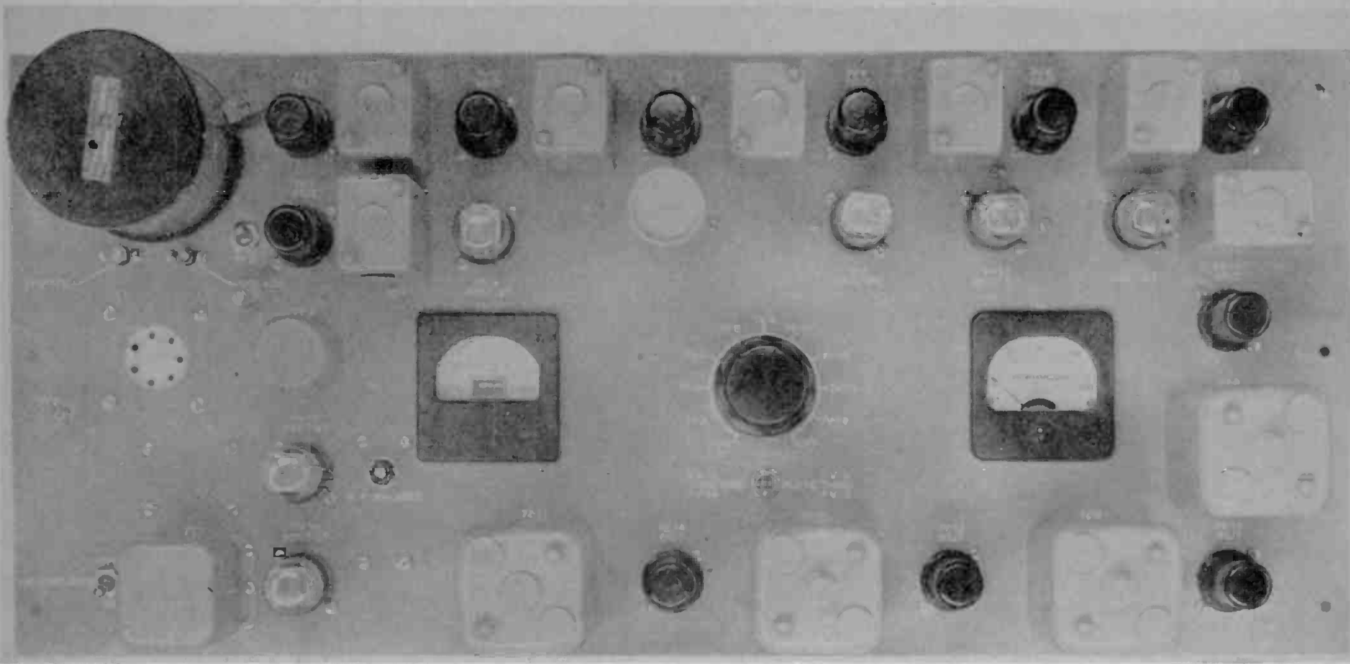


Fig. 3. (above) Phase and impedance curves for parallel inductance, with resistance-capacitance network. Fig. 4. (below) Typical distortion measurements on cascade phase shift modulator.





Front view of the cascade phase shift modulator, including first multiplier stage.

The Resistance Tube

The most practical method of obtaining a voltage-controlled variable resistance for use in conjunction with the constant-impedance network, the phase characteristic of which is shown in *Fig. 3*, is to control the grid of a vacuum tube with the modulating a-f voltage. Then use is made of the resulting variation of conductance through the tube together with any other incidental conductance to replace the resistance *R* in the network.

A glance at the phase characteristic mentioned above (X_C/X_L equal to 0.5) will show that it is not linear over a wide portion of the curve. Nevertheless, it is possible to obtain essentially linear phase modulation by designing the operating characteristic of the resistance tube to match the network phase vs. resistance curve. In general it is a good idea to avoid using bias adjustments for curve matching because they tend to become critical and are subject to change with individual tubes and with tube aging. The circuit shown in *Fig. 2B* does an excellent job of curve matching, requires no bias adjustment, and is relatively insensitive to tube change.

The adjustment for curve matching is accomplished by setting the r-f voltage level which appears across terminals *3* and *2* of the constant impedance network. This adjustment is most conveniently done by varying the input voltage applied to the grid of the phase shift amplifier tube by means of a variable capacitor shunting the grid. The fact that inductance tuning is used for tuning the modulator over the band and for making the adjustment for constant impedance operation means that the inductance tuning will have a small part in determining the r-f level applied to terminals *3* and *2*. This can be seen to be so by remembering that e_{out} is proportional to *Z*, which in turn varies with the tuning. Additional data on the operation of the resistance has been given in a previous paper[1].

Metering System

In a practical modulator employing six cascaded phase shift stages it is evident that the design must be such that production, adjustment, and maintenance are not too difficult. Therefore a metering system is incorporated in the modulator chassis which indicates all readings necesary to obtain optimum operation of the modulator with as little use of external equipment as possible. This involves finding the proper combination of X_L and X_C (*Fig. 3*) to give constant impedance operation of the phase shift network, plus the best match of the resistance tube operating characteristic (control voltage vs. resistance) and the phase shift vs. resistance curve of the phase shift network as explained above.

The first metering system devised to provide this information measured the grid current to each amplifier tube in turn so as to indicate the r-f level ap-

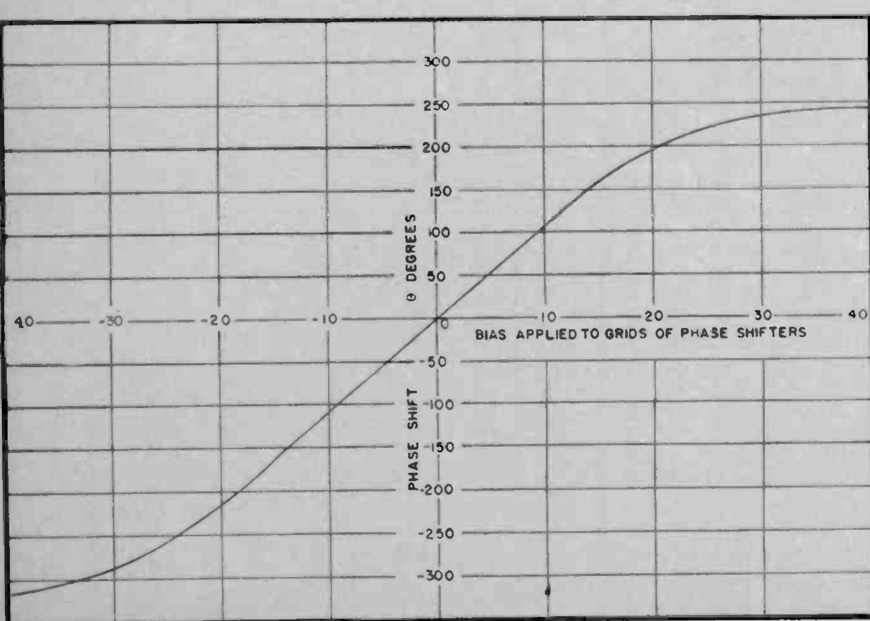
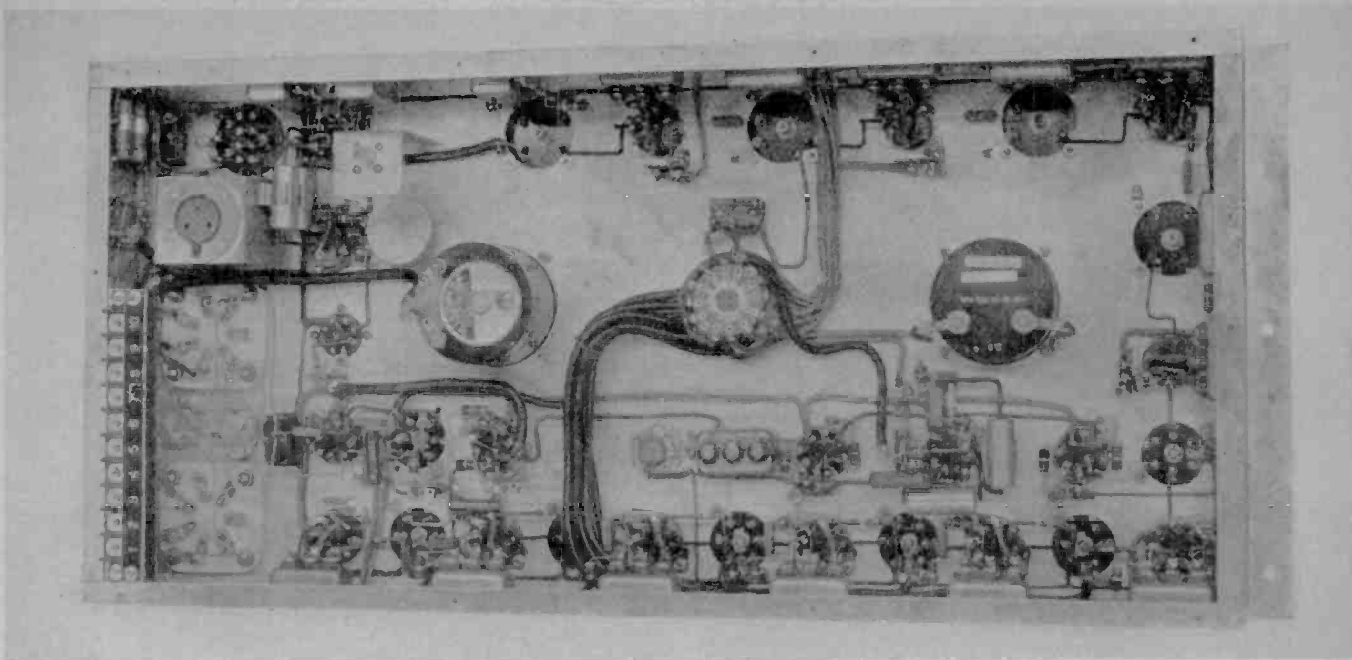


Fig. 5. Linearity of the modulator response curve shown indicates low distortion.

[1]Marks, M. Cascade Phase Shift Modulator, *Electronics*, p. 107, Dec. 1946.



Back view of the modulator unit with rear cover removed.

plied to each resistance tube, and, by appropriate switching, the amount of AM present on the FM carrier while a low-frequency modulating voltage was applied to the modulator. Since the grid current reading was indicative of the resistance tube r-f level, it provided a ready means of resetting r-f levels to pre-determined values for best curve matching. The AM reading gave an indication of constant impedance operation of the phase shift network. Physically, the AM indication was accomplished by feeding a small portion of the r-f voltage at each amplifier tube plate to a grid leak detector, followed by an audio amplifier and a crystal rectifier to give a d-c meter reading (*7V-17* and *7Y-3*).

This system has been slightly modified to provide more positive evidence of a tube failure anywhere along the line; it was also found that this final modification measures the r-f level much more accurately. The present system utilizes the same crystal rectifier used either as an AM detector or an r-f detector.

Tuning of low-frequency multiplier stages on the modulator chassis is accomplished in simple fashion by observation of the grid current on each succeeding stage and by use of a push-button arrangement to change the coupling of the coils. In production, cans containing slightly over-coupled transformers for these stages are each equipped with the push button which, when depressed, shunts the secondary of the double-tuned coil with a resistor so that coupling between primary and secondary falls below critical coupling. The transformer may then be tuned for maximum output for both primary and secondary. When the push button is released, coupling again goes beyond critical and the response reassumes the familiar flat-top shape.

In actual production or field work the metering system enables each modulator to be quickly adjusted to low distortion operation and to proper frequency with a minimum of apparatus.

Voltage Regulation

Center frequency, distortion, response, and noise were found virtually unaffected by a ±10% change in line voltage. However, the level or percentage of modulation was changed as much as four db. For this reason some form of regulation was necessary. Subsequent checks showed that filament voltage was more critical than B plus in this respect. Since it was impractical to regulate filament voltage alone, a 250-watt Raytheon Voltage Stabilizer was installed in the transmitter to regulate the a-c line to the modulator power supplies. With its use a ±20% line-voltage change will not affect the operation of the modulator in any way.

Performance

Actual performance of a typical modulator is given in *Fig. 4*. Distortion of 0.8% at 50 cycles with 75-kc deviation as compared with the F.C.C. maximum limit of 3.5%; 0.3% at 1000 cycles compared with F.C.C. maximum limit of 2.5%; 0.7% at 15,000 cycles compared with F.C.C. maximum limit of 3.0%. Distortion of 1.2% at 30 cycles with 75-kc deviation as accomplished by this modulator has not been equaled in other phase modulators. Low distortion, even at 100-kc deviation provides a wide margin of safety against "break-up" of modulation with inadvertent overmodulation. The linearity of the curve in *Fig. 5* is graphic proof of the low-distortion capabilities of the modulator. Response and noise are correspondingly well within F.C.C. limits.

Add this performance to the advantages of direct crystal control, simple circuits, simple adjustments and lack of external equipment, and standard parts, and it is evident that all of the objectives set up at the outset of the project eighteen months ago have been successfully met.

APPENDIX I

THE EQUATION FOR THE IMPEDANCE LOOKING INTO TERMINALS 1 AND 2 OF THE PARALLEL INDUCTANCE, AND CAPACITANCE AND RESISTANCE NETWORK GIVEN IN FIG. 3 MAY BE DERIVED AS FOLLOWS:

$$Z = \frac{jX_L(R - jX_C)}{R + j(X_L - X_C)}$$

$$Z = \frac{X_L^2 R}{R^2 + (X_L - X_C)^2} + j\frac{\left[X_L R^2 + X_L X_C (X_C - X_L)\right]}{R^2 + (X_L - X_C)^2}$$

$$Z = \sqrt{\frac{(X_L^2 R)^2 + \left[X_L R^2 + X_L X_C (X_C - X_L)\right]^2}{\left[R^2 + (X_L - X_C)^2\right]^2}} \angle \tan^{-1} \frac{X_L R^2 + X_L X_C (X_C - X_L)}{X_L^2 R}$$

$$Z = X_L \sqrt{\frac{R^2 + X_C^2}{R^2 + (X_L - X_C)^2}} \angle \tan^{-1} \frac{R}{X_L} + \frac{X_C}{R}\left(\frac{X_C}{X_L} - 1\right)$$

$$Z = X_L \sqrt{\frac{1 + \left[\frac{X_C}{R}\right]^2}{1 + \left[\frac{X_L - X_C}{R}\right]^2}} \angle \tan^{-1} \frac{R}{X_L} + \frac{X_C}{R}\left[\frac{X_C}{X_L} - 1\right]$$

THE CONDITION FOR CONSTANT IMPEDANCE MAY BE FOUND BY EQUATING THE NUMERATOR OF THE FRACTION UNDER THE SQUARE ROOT SIGN TO THE DENOMINATOR.

$$1 + \left[\frac{X_C}{R}\right]^2 = 1 + \left[\frac{X_L - X_C}{R}\right]^2$$

$$X_C^2 = (X_L - X_C)^2$$

$$X_C = X_L - X_C$$

$$2X_C = X_L$$

$$\frac{X_C}{X_L} = 0.5$$

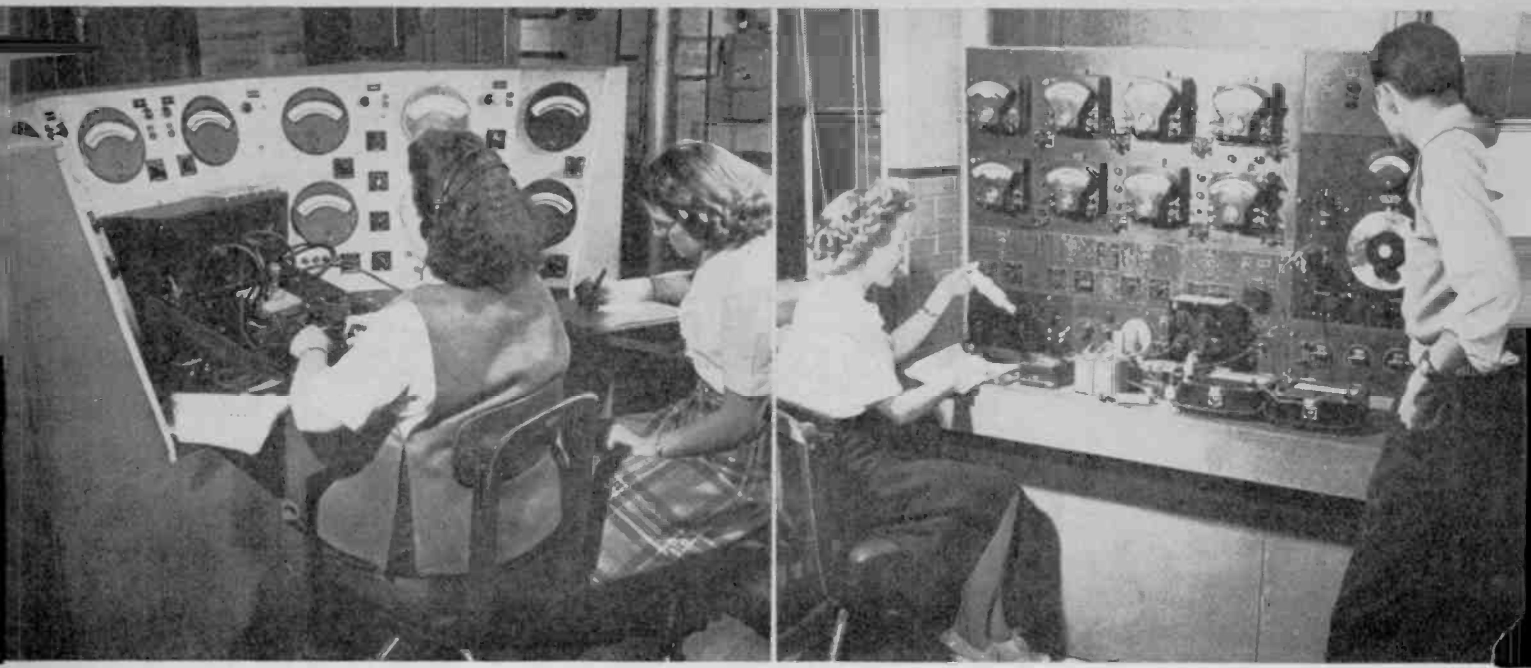


Fig. 4. (left). Precise measurements are made on small samples as a check on the design. Fig. 5. (right). Laboratory tests are made to determine suitability for new applications.

ELECTRON TUBE

J. R. STEEN

Sylvania Electric Products, Inc.

IN THE PAST there has been a certain amount of misunderstanding between the producers and the users of electron tubes. It is hoped, therefore, that the following information will serve not only to clarify this situation but also to present some reasons why it is possible for such a condition to exist. Fundamentally, of course, there is no good reason for discrepancies in the viewpoints of producer and user. Each can see the picture most clearly from his own position so that our main problem here is one of explanation, with the hope that each will try to understand the other's problems.

As a typical example, reference will be made to a specific tube, the Type 7A7. This is a remote cut-off r-f pentode, similar electrically to the 6SK7, metal and GT varieties. Its published ratings and characteristics are given in *Fig. 1.* These data represent average values about which some variations can be expected. These variations may be small or large, depending upon the amount of control exercised during the manufacturing processes. The degree of control required depends upon application requirements which are, after all, the determining factors in establishing test limits. Once established, however, and subsequent to general acceptance by the public, it becomes very costly to make changes in test limits.

These controlled variations are not significant insofar as their effect is concerned on performance in conventional circuits that have been designed with tube tolerances in mind. But when a new circuit design is being considered careful attention should be given to the tube types which are available and to their respective tolerances as determined by usage and application, and to a resume of the test results of as many samples as possible. If the new requirements are more severe than those formerly encountered, consideration should be given to the development of a special tube type for the new application.

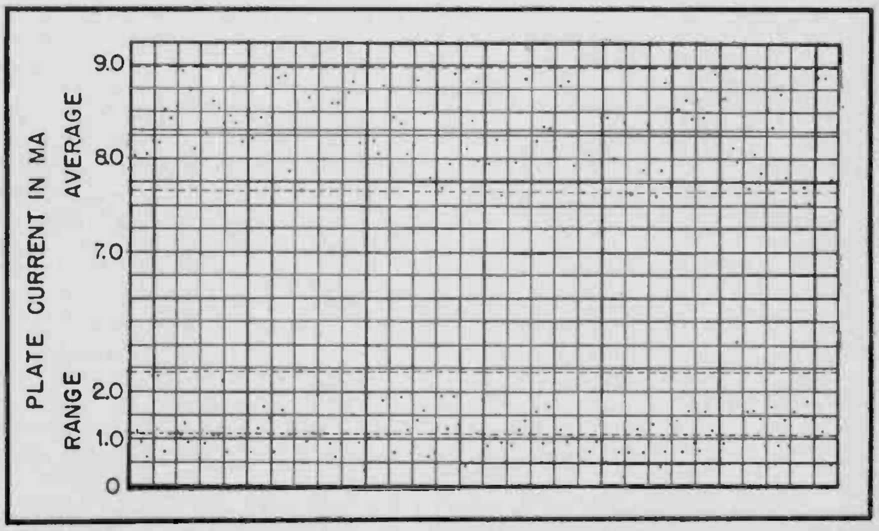
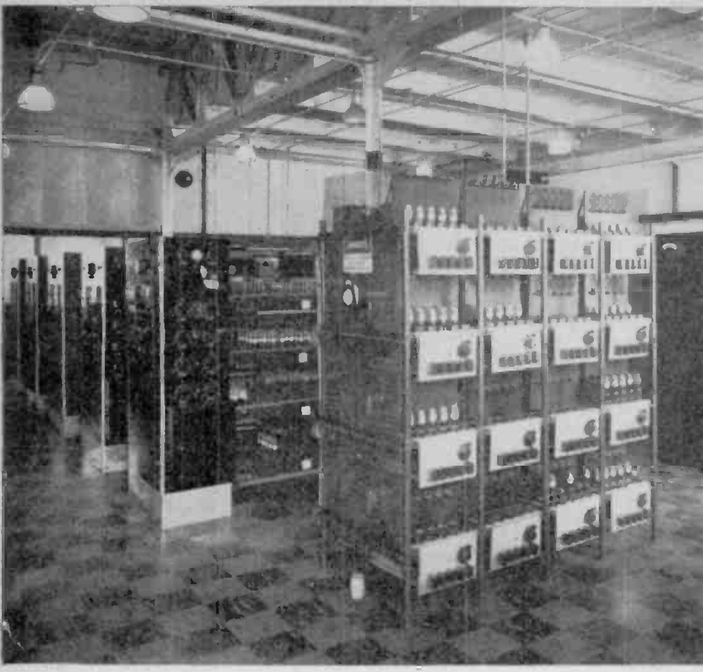


Fig. 2. Type 7A7 Control Chart, showing average and range for plate current.



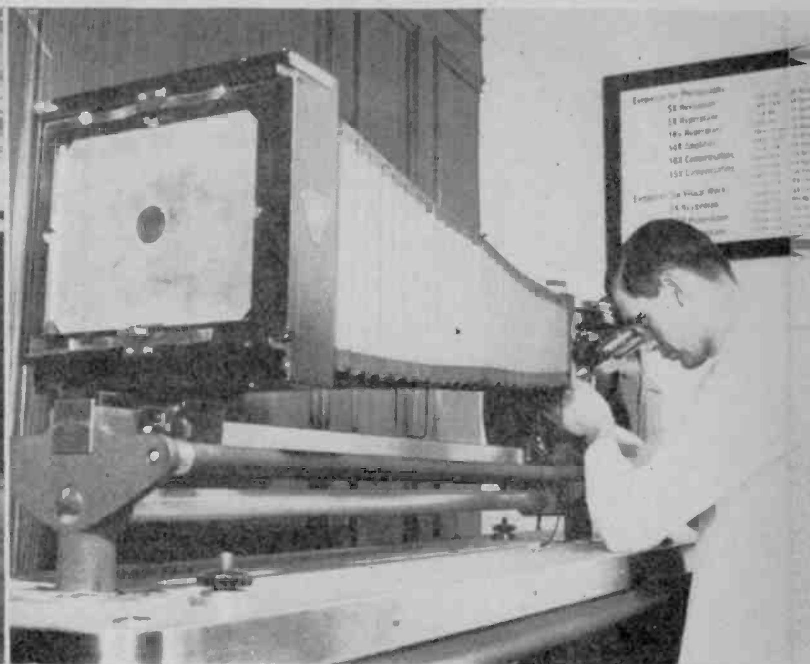


Fig. 6 (left). Life tests are conducted periodically on samples selected at random. Fig 7 (right). Microphotographs check quality of materials.

QUALITY CONTROL

Quality control of radio tubes has become highly organized in recent years. In this article, the author covers in detail present-day practice.

Once published ratings and test limits have been established for a particular tube type, it becomes the problem of the manufacturer to see that the various characteristics remain within control. These control methods are based on sound statistical theories which have been found ideal for controlling the quality of a manufactured product, especially where the production process is continuous and where similar items are being produced constantly and in large quantities.

With a few exceptions it was general policy prior to about 1940 to test all electron tubes for the characteristics which were considered to be of sufficient importance to cause trouble. From about 1940 to 1945, considerable progress was made in the application of scientific principles of quality control. As more and more people became familiar with these techniques it became apparent that production costs could be lowered if sampling were substituted for 100% testing. This of course presupposed that a certain amount of process control would be maintained on the parts and sub-assemblies as they moved along the production line.

Statistical Control

The concept of statistical control is based on the fact that small samples are taken periodically and that the data are plotted chronologically. After a certain amount of data has been taken and plotted, it is possible to calculate and place on the charts control limits within which points will fall any given percentage of the time. Although 3-sigma*‡ limits, which include 99.7% of the distribution, are used more often than any other it is sometimes advantageous to use what we shall call, for want of a better term, "Modified Limits". These modified limits are determined in a manner similar to standard 3-sigma limits except they are spaced a certain distance inside the test limits rather than at a predetermined distance from the average.

Figure 2 shows the type of control chart that is used, including the average and 3-sigma limits. Specification limits and modified limits have been omitted because of the scale used. Specification limits are shown elsewhere and Modified limits or "Reject limits", as they are sometimes called, are calculated in accordance with approved statistical procedures.*†

Three-sigma limits and modified limits are used for averages of small samples whereas test limits serve for individual items. There is a definite mathematical relationship between the normal distribution of averages based on small samples and a distribution of the parent population or universe from which the samples are taken in that the former is equal to the latter, divided by the square root of the sample size. For example, if a large number of samples of four are taken the distribution of these small samples will be exactly one-half the distribution of the universe and the average of the samples of four will be the same as the average of the universe.

Although considerable progress has been made toward the elimination of 100% testing there are still some types,

‡Sigma (σ) is used to denote standard deviation which is the root-mean-square (r-m-s) deviation of a set of observed values from their average.

*Control Chart method of controlling quality during production — American War Standard Z1.3—1942, American Standards Association, New York, N. Y.

†A.S.T.M. Manual on Presentation of Data, April 1943, American Society for Testing Materials, Philadelphia, Pa.

or perhaps characteristics of some types, which require this procedure because it has not been possible to maintain the items within statistical control. Eventually it may be possible to test for operation only, and that on a sampling basis, because the product has been brought so well under control. By operation testing is meant an over-all performance test in a representative circuit in which consideration is given to as many as possible of the various important tube parameters. Operation tests have been specified for some time, a good example being the a-c amplification test with which many are familiar.

CONSUMER ACCEPTANCE SPECIFICATION
Type 7A7
Description: R-F Pentode, Remote Cut-Off

	Ef	Eb	Ec1	Ec2	Ec3	Pp	Pg2	Ehk
Ratings: Absolute	V	Vdc	Vdc	Vdc	Vdc	W	W	v
Maximum:	6.3±10%	330	...	140	...	4.4	0.44	100
Test Conditions:	6.3	250	—3	100	0	...	...	...

Height:	Max. 2.80 in.	Diameter:	Max. 1.19 in.
Base:	Lock-In, 8-Pin	Cathode:	Coated Unipotential
		Envelope:	T-9

Pin No.:	1	2	3	4	5	6	7	8
Element:	h	p	g2	g3	sd	g1	k	h

Test	Conditions		Min.	Max.	Unit
Heater Current		If:	275	325	mA
Plate Current		Ib:	6.5	12.0	mAdc
Screen Current		Ic2:	0.5	4.0	mAdc
Grid Current	Note 1	Ic1:	0	1.0	μAdc
Insulation:	Ehk = 100V	Ihk:	0	20	μAdc
Transconductance:	Note 1	Sm:	1600	2400	μmhos
Transconductance:	Ec1 = —35 Vdc	Sm:	1.0	30	μmhos
Capacitances:	Shield No. 308	Cg1p:	...	.005	μμf
	Shield No. 308	Cin:	4.0	8.0	μμf
	Shield No. 308	Cout:	5.0	9.0	μμf

Note 1: Acceptable Quality Level (AQL) = 1.5%. For other tests, AQL = 6.0%.
Note 2: All paragraph references apply to the JAN-1A Basic Specification dated May 1, 1946.

Figure 1 (above). Figure 2 (below).

TYPE 7A7
Remote Cut-Off R-F Pentode

RATINGS AND CHARACTERISTICS

Heater Voltage (Nominal) AC or DC	7.0 Volts
Heater Current (Nominal)	0.320 Ampere
Maximum Plate Voltage	300 Volts
Maximum Screen Supply Voltage	300 Volts
Maximum Screen Voltage	125 Volts
Maximum Plate Dissipation	4.0 Watts
Maximum Screen Dissipation	0.4 Watt
Minimum Eternal Control Grid Bias	0 Volt
Maximum Heater-Cathode Voltage	90 Volts
Direct Interelectrode Capacitances:*	
Grid to Plate	.005 μμf Max.
Input	6.0 μμf
Output	7.0 μμf

**With 15/16" diameter shield (RMA Std. M8-308) connected to cathode.*

TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

Class A1 Amplifier

Heater Voltage (AC or DC)	6.3	6.3	Volts
Heater Current	0.300	0.300	Ampere
Plate Voltage	100	250	Volts
Screen Voltage	100	100	Volts
Grid Voltage	—1.0	—3.0	Volts
Self-Bias Resistor	60	260	Ohms
Suppressor Voltage	Connected to Cathode		
Plate Current	13.0	9.2	Ma.
Screen Current	4.0	2.6	Ma.
Plate Resistance (Approx.)	.12	0.8	Megohm
Mutual Conductance	2350	2000	μmhos
Grid Voltage for Mutual Conductance = 10 μmhos (Approx.)	—35	—35	Volts

CIRCUIT APPLICATION

Type 7A7 is a single-ended triple grid super-control amplifier of lock-in design suitable for R-F or I-F service in A-C or auto receivers. For AC-DC sets, the lower heater current of Types 14A7 or 7B7 will be more generally used.

For most services the internal shield connected to pin No. 5 and the metal base will provide adequate shielding. Critical high gain circuits, however, may require a tube shield.

Electrical characteristics are identical with Type 6SK7GT/G, but the lock-in construction provides greater compactness and desirable mechanical features.

Tests

At the present time, however, most characteristics must be read in order to keep them within control. An idea of what these tests are may be gained by reference to *Fig. 3*, which indicates a typical consumer acceptance specification for Type 7A7. This specification includes maximum ratings, test conditions, physical specifications, pin connection data and a number of the more important fundamental tube characteristics for which test conditions and limits have been established, as well as Acceptable Quality Levels for these same characteristics also.

Acceptable Quality Levels have been determined for characteristics which are very critical and for characteristics which are not so critical. Once these AQL's have been established it becomes relatively simple to select a sampling plan which, in the long run, will allow percentages of defectives not to exceed the values specified by Note 1. Note 2 refers to paragraph headings in the JAN-1A Basic Specification, dated May 1, 1946. The reason for this is that during the war period a great deal of work was done in cooperation with the Service groups and a fairly complete basic specification was evolved. Because practically all equipment manufacturers and other interested groups have copies of this specification it was felt desirable, at least for the present, to refer to it rather than to publish an independent test instruction manual.

If sampling tests indicate that a particular tube characteristics is running well within control, 100% testing is omitted until such time as the periodic sampling indicates sufficient increase in the variation or dispersion of the characteristic to warrant its resumption.

It has been found in practice that all, or at least most of the regular tube characteristics, follow the normal distribution law. That is, a graph of filament current, plate current, transconductance, etc., plotted against the number of times a particular reading occurs will result in a bell-shaped curve, very high at the center and dropping off rapidly on either side as the characteristic under consideration departs from its average value. For example the heater current limits of Type 7A7 are 275 to 325 milliamperes, inclusive, as indicated by reference to *Fig. 3*.

Let us assume that a group of 1024 tubes** is selected at random from a large homogeneous lot and that each tube is read for heater current. If the

**This exact number selected because approximately 1000 readings give a very good average and because it illustrates the point by allowing just one reading at each test limit.

tube is read for heater current. If the average heater current of the tubes is exactly 300 ma, that is, exactly centered according to the rating sheet, and if the 1024 tubes were produced under controlled conditions which resulted in a range of exactly 275 to 325 ma, and if the measuring instrument were calibrated to read in multiples of 5 ma steps only, the following distribution could be expected.

Heater Current in ma	No. of tubes with this heater current
275	1
280	10
285	45
290	120
295	210
300	252
305	210
310	120
315	45
320	10
325	1
Total	1024

An analysis of the above table indicates that 672 of 1024 tubes would be within the range of 295 to 305 ma both inclusive. In other words, over 65% of the readings would be within 20% of the allowable spread and just under 90% of the total readings would be within 40% of the allowable spread.

In addition to those tests which are indicated on the Ratings and Characteristics sheet and on the Consumer Acceptance Specification sheet are many others. These include such items as hum, noise, microphonism, heater-grid leakage, shock, vibration, immersion, base torque and many more. Reference to *Figures 4* and *5* indicates the nature of many of these tests and the type of specialized test equipment required.

It is realized, of course, that while a tube must perform initially it must also have a long and satisfactory life. Therefore samples are placed on test periodically and the results are watched very closely indeed. In case any difficulties develop the production represented by those tests is withheld from shipment and released at a larger date, provided additional life tests performed on a much larger quantity of tubes indicate satisfactory performance; or scrapped if the verification life tests indicate an unsatisfactory product.

Because of these specialized services the customer is assured that when a tube is received and placed in service the probability will be very great that it will operate satisfactorily and that it will continue to operate in like manner throughout many hundred hours of trouble-free life. An idea of the scope of life test facilities available for this service may be obtained by reference to *Fig. 6*, which illustrates the type of life test equipment to be found in a modern tube plant.

Fig. 8 (below). Coated cathodes are weight on precision balance to insure uniformity. Fig. 9 (right). A 100% test is made on final product if sampling indicates "Out of Control".

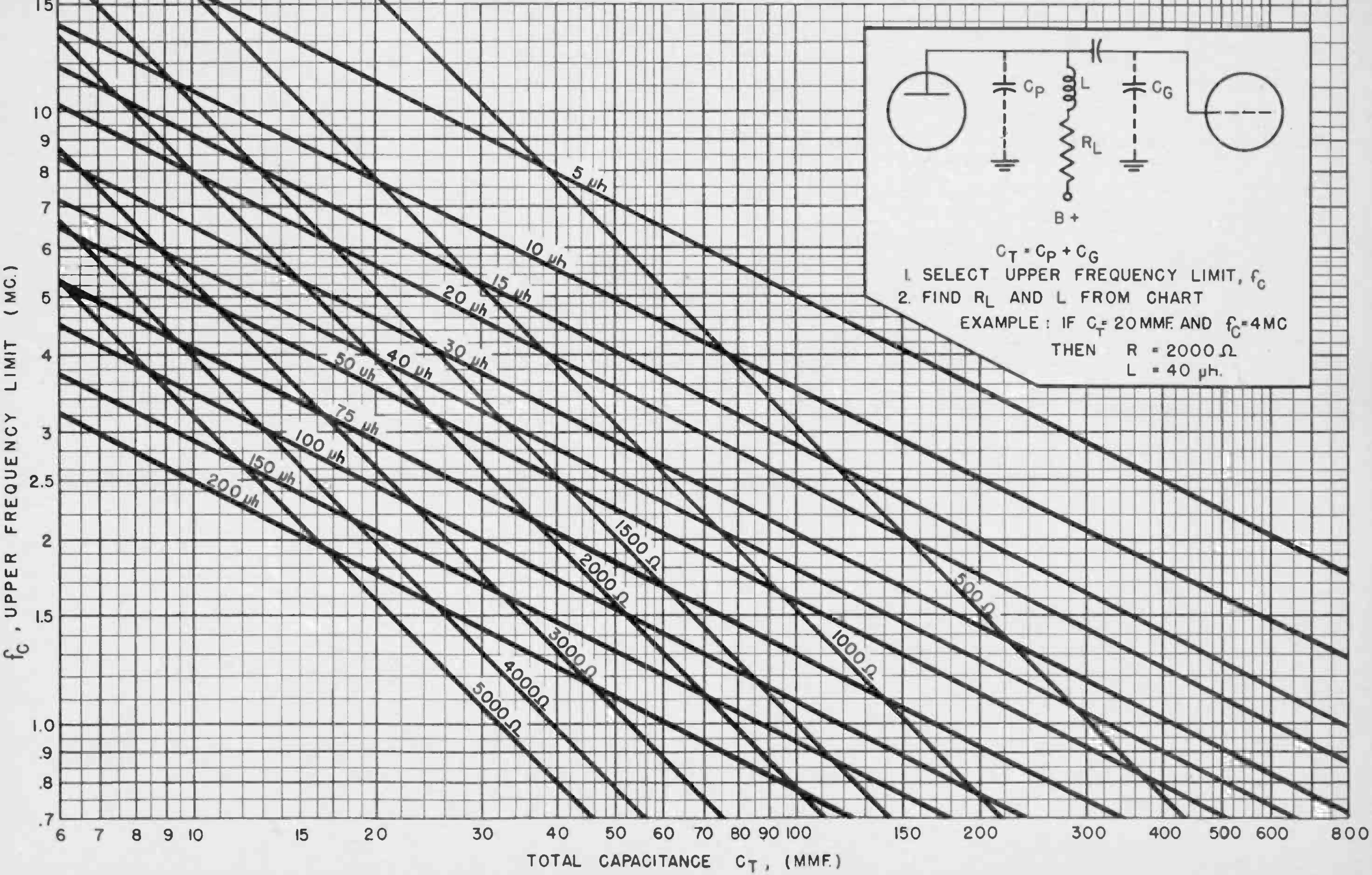
Quality Control is not something which can be practiced today and forgotten tomorrow. It is something which must be practiced constantly, not only by those assigned to quality control work but by everyone in the plant, including the president of the company right on down the line to each and every operator. Quality must be built into any product by the man on the bench. If he is encouraged by his foreman and the foreman by his superior and so on up the line a superior product will result. If the opposite attitude is taken not only will quality suffer but also quality control will be something almost impossible to attain. In other words, quality-mindedness or quality-consciousness is more important than any other factor in the manufacture of a high-class product.

Even though everyone in an organization is quality-minded there are a great many things which must be watched carefully or something is sure to go wrong. Not only must the composition and processing of materials be controlled carefully but also all dimensional variations, spacings and processing must be given constant attention lest they affect adversely important tube characteristics. Reference to *Figures 7* and *8* indicates the painstaking care exercised in connection with the approval and acceptance of materials and small parts and the accuracy with which these parts are held to specifications.

If there were perfect control of all processes, 100% testing or even sampling should be unnecessary. This of course probably never will take place, but with properly established limits for raw materials and close control of processing, sampling should be sufficient to assure a completely satisfactory and uniform product from the point of view of the user. That such an ideal condition does not exist at present is evidenced by reference to *Figure 9*, which shows that provision is made for testing all items when sampling says to do so and for rechecking again on a sampling basis before acceptance into warehouse stock.

Today "Quality Control" is one of the most important departments in every tube plant. Its importance is recognized, with the result that some of the best engineering talent is being directed along the lines of reducing the number of rejects (shrinkage) as well as minimizing the number of test operations required to maintain production within the limits established by industry.

DESIGN DATA FOR VIDEO AMPLIFIER



RECENT RADIO INVENTIONS

These analyses of new patents in the radio and electronic fields describe the features of each idea and, where possible, show how they represent improvements over previous methods

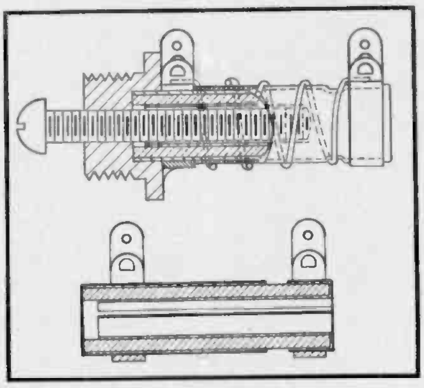
Combination Coil and Capacitor

• To eliminate the distributed inductance of shunt capacitor leads in the 30-300 mc range, C. E. Dolberg has designed a combination coil and capacitor which was granted a patent July 2, 1946.

The circuit with which the device is used is shown in *Fig. 1B*, with its equivalent circuit in *Fig. 1A*. Distributed lead inductance is indicated in the latter circuit by means of additional series inductances inserted in the various interconnecting leads. The combination coil and capacitor is able to eliminate all three series inductances shown.

The new device is illustrated in *Fig. 2A*, from which it is observed to consist of a modified ceramic capacitor, about which the coil is wound, and containing a non-ferrous machine screw for purposes of trimming. Modification of the ceramic capacitor consists of longitudinal insulating grooves cut through the inner and outer silver coatings as indicated in *Fig. 2B*. The purpose of these grooves is to interrupt the circumferential flow of eddy currents so that the Q of the coil is not unduly impaired.

Since the capacitor leads terminate immediately with the inductor leads, all distributed lead inductance is eliminated within the resonant circuit itself. Further, by connecting the device directly to the grid terminal of the tube, the distributed inductance in the tube lead is minimized.



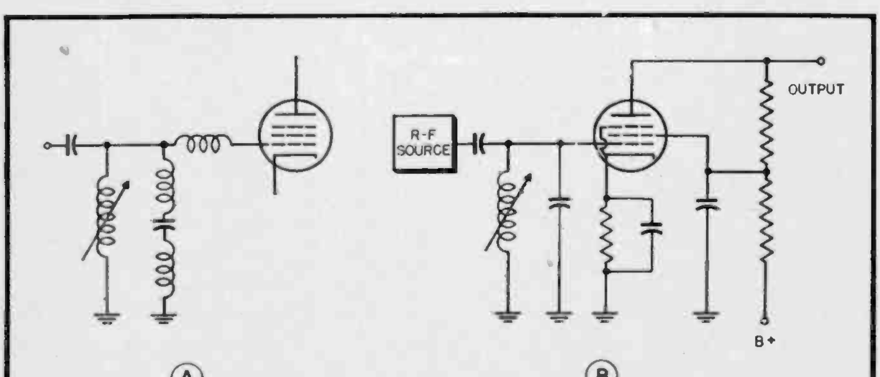
Patent No. 2,403,349. Fig. 2A (top) and 2B (bottom).

In a test model, a 100-μμf capacitor was used, ¼″ in diameter and 1″ long. The coil consisted of four turns of No. 18 silver-plated copper wire, and resulted in a resonant frequency of 60 mc. Constructional details were as shown in *Fig. 2A*.

The patent, No. 2,403,349, is assigned to Philco Radio & Television Corp.

Frequency Discriminator

• Non-critical center-tapping and greater ease of adjustment in production are claimed for a new frequency discriminator patented July 23, 1946, by M. E. Bond. The bridge-type discriminator with its equivalent circuit is shown in the diagram.



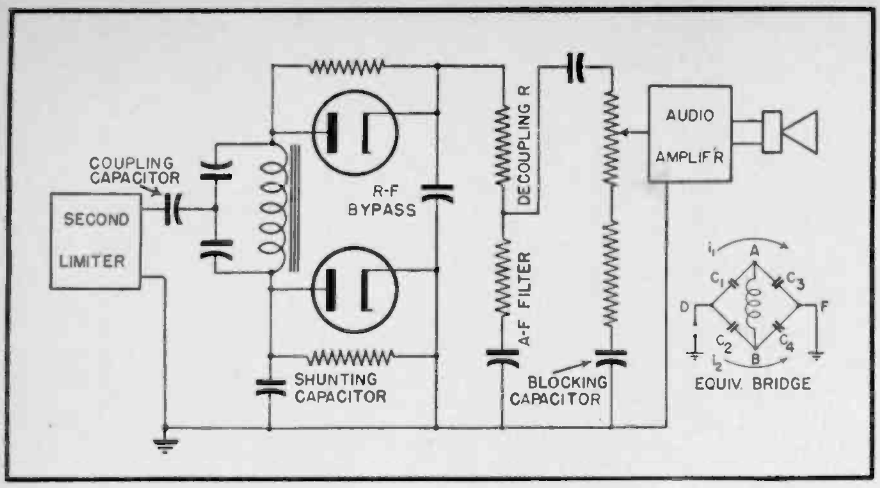
Patent No. 2,403,349, Figure 1.

The frequency discriminator comprises a tapped capacitance branch in shunt with a permeability-tuned inductance. The output circuit consists of a pair of diode rectifiers which deliver their d-c currents to the two indicated load resistors. The discriminator is essentially a four-arm, four-terminal bridge as shown in the equivalent circuit. Capacitance C_3 is formed of interelectrode and stray capacitance, while C_4 represents the combined interelectrode capacitance of the lower diode plus the shunting capacitance shown.

Circuit constants of the discriminator bridge are so chosen that it is resonant at the nominal i-f carrier frequency. Response is made sufficiently broad that the necessary sidebands of the FM carrier may be detected and impressed upon the input of the audio amplifier. Output voltage from the second limiter energizes the discriminator network through the coupling capacitor indicated.

The load resistors shunting the diodes have resistances much in excess of the reactances of the bridge arm capacitors indicated, and their influence upon the operation of the reactive elements is negligible. The second limiter energizes the bridge between *D* and *F*, and the voltage appearing at the output side of the discriminator is the difference between the absolute values of the voltages to ground at terminals *A* and *B*. From an examination of the bridge it is seen that if $C_1 = C_2$, and $C_3 = C_4$, so that the bridge is balanced, currents i_1 and i_2 produce equal voltage drops across capacitors C_1 and C_2. Accordingly, no voltage drop exists from *A* to *B*, irrespective of frequency.

In the actual circuit, however, C_3 is less than C_4 (although $C_1 = C_2$) by an amount equal to the capacitance of the shunting capacitor shown, and the bridge is accordingly unbalanced. Current i_2 therefore exceeds i_1 so that a current i_3 is caused to flow through C_1 and C_2. The magnitude of this current depends upon the impedance of *L* at the operating frequency, and the direction of flow is such that the drop across C_1 is increased and across C_2 is decreased. By



Patent No. 2,404,359

suitably proportioning the impedance of *L* with respect to the reactances of C_1 and C_2 at a particular center frequency, currents i_1, i_2, and i_3 can be caused to produce equal absolute voltages from points *A* and *B* to ground.

These voltages however, being out of phase with each other, yield a difference voltage between *A* and *B* equal to the vector sum of the two absolute voltages. The frequency at which the absolute voltages become equal represents the center frequency, at which the voltage appearing between the output side of the discriminator between the cathode of diode D_1 and ground becomes zero. Equal d-c voltages are then obtained across the load resistors; these are oppositely polarized so that no voltage exists at this frequency between the cathode of D_1 and ground.

As the impressed frequency rises above center frequency due to audio modulation, the relative magnitudes of i_1, i_2 and i_3 change so that the voltage from *A* to ground is greater than from *B* to ground; the discriminator output voltage is positive with respect to ground under this condition. As the impressed frequency falls below center frequency, the discriminator output becomes negative with respect to ground.

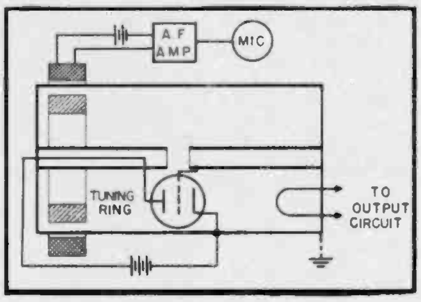
In this manner, the discriminator bridge converts the FM modulation frequencies to equivalent AM frequencies without the usual requirements of accurate center-tapping and adjustment of inductances.

The patent, No. 2,404,359, is assigned to Galvin Mfg. Co.

Permeability Tuning Arrangement

• Tuning of concentric lines or cavity resonators by use of magnetic material within the cavity and controlled by permeability variation forms the basis of a patent granted July 2, 1946 to Wendell L. Carlson.

A ring of suitable powdered magnetic material is included within the u-h-f field as illustrated, at a point where the magnetic lines of forces are dense and the electrostatic flux is at a minimum. Saturating flux for the core or ring is produced by a coil preferably situated as shown outside of the u-h-f device. The powdered magnetic material is so



Patent No. 2,402,948

designed and energized that it works over a region of approximate linearity.

In this region, an increase or decrease of external flux causes a corresponding change in the permeability of the core material, resulting in an effective increase or decrease in resonant frequency of the cavity or line. Frequency modulation of the oscillator frequency is obtained by this means, using the circuit shown.

The patent, No. 2,402,948, is assigned to Radio Corporation of America.

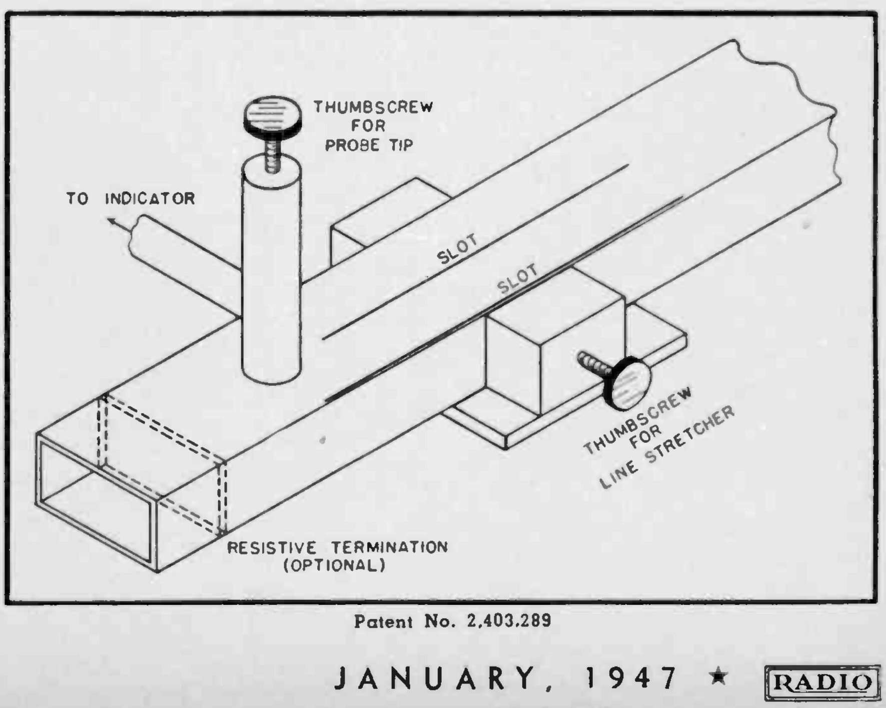
Standing Wave Detector

• To avoid the reflections resulting from slotted line sections used in conventional standing-wave detectors, Nathaniel I. Korman has designed a stationary-probe detector which was granted a patent July 2, 1946. To allow variation of the effective position of the probe, line-stretching techniques are used. Essentials of the design as shown illustrate the line section with fixed probe and coupling for energizing an indicator. A control is provided for variation of probe depth.

Effective probe position is controlled by means of pressure exerted on the walls of the line or guide, by means of the thumbscrew mechanism illustrated. A longitudinal slot is provided to allow compression of the walls; since this slot is much narrower in width than the slot used in conventional standing-wave detectors, reflections from this source are minimized. It is pointed out that when measuring small standing-wave ratios, errors introduced by wide slots are frequently of the same order of magnitude as the quantity being measured.

Compression of the walls enables the effective position of the probe to be changed as a result of the relationship between phase velocity and guide width. Basically, the principles used in design of the new standing-wave detector are those used in other applications where line-stretching techniques are indicated. The device is intended for use in the centimeter wave region.

The patent, No. 2,403,289, is assigned to Radio Corporation of America.

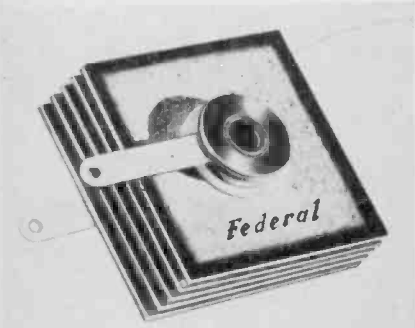


Patent No. 2,403,289

New Products

LEADING RADIO MANUFACTURERS ADOPT SELENIUM RECTIFIER

Over thirty leading manufacturers of home radio receivers have adopted the new Federal miniature selenium rectifier as a standard component of one or more



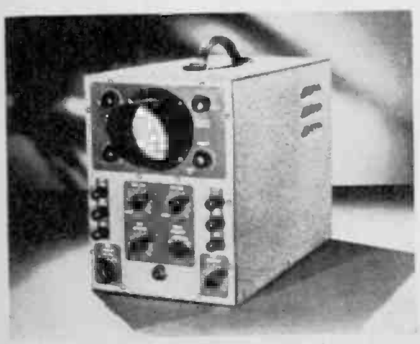
of their models, according to an announcement by Norman E. Wunderlich, executive sales director, Federal Telephone and Radio Corporation, Newark, New Jersey. Federal's selenium rectifier replaces the rectifier tube in AC-DC portable, table and console radio sets. An original development by Federal, manufacturing associate of the International Telephone and Telegraph Corporation, the new component is one of the important innovations appearing in pst-war home receivers.

Selected models produced by the following well-known radio set manufacturers will be equipped with Federal's miniature selenium rectifier: Admiral, Automatic, eBndix, Clarion, Colonial, Crosley, Detrola, ECA, Electone, Emerson, Federal, Hoffman, Home Tone, Jefferson-Travis, Jewel, Karola, Lear, Lewyt, Meck, Midwest, Motorola, Pilot, Promenette, RCA Victor, Remler, Sentinel, Skyrad, Temple, Trav-Ler, Wells-Gardner, Westinghouse and Zenith.

C-R SCOPE

A new cathode ray oscilloscope featuring portability, low cost and practical design for radio set servicing and general service applications has been announced by the Radio Tube Division, Sylvania Electric Products Inc., 500 Fifth Avenue, New York 18, N. Y.

The new oscilloscope, weighing only 18



pounds, is mounted in attractive steel gray crackle finished cabinet measuring 10¾" high, 8⅛" wide and 13¾" deep. Signal frequency range from 15 to 40,000 cycles is provided with a five range selection control and a fine frequency control which permits close adjustment to any desired frequency. Visual study of wave form is provided by a 3" cathode ray tube designed for 650 volt deflection plate operation.

Sweep circuit of Sylvania type 131 oscilloscope is built around a type 884 gas triode oscillator. Tube complement includes 3AP1 cathode ray tube; 5Y3GT/G rectifier; 7Y4 rectifier; two 707 amplifiers; and the 884 gas triode oscillator. The oscilloscope is rated at 105/125 volt; 50-60 cycle; 40 watt input.

H-F VOLTMETER

The increasing use of frequencies beyond a few megacycles has indicated the need for improved measuring equipment. The Alfred W. Barber Laboratories has met this need with their new High Fre-

quency Electronic Voltmeter Model 32. By equipping this voltmeter with a radio frequency proble having the extremely low input capacity of ¾ $\mu\mu$f, they have developed an instrument which extends the range of measurement ten times — from 50 to 500 mc. Since many other existing probes have an input capacity of 5 $\mu\mu$f or more, the loading and detuning of very high frequency circuits has been a serious problem. Barber's Model 32 offers a practical answer to the problem of measuring voltages in high frequency circuits far beyond the range hitherto attained.

Descriptive bulletins are available from Alfred W. Barber Laboratories, 34-14 Francis Lewis Blvd., Flushing, New York.

UHF SIGNAL GENERATOR

The -hp- 610A UHF Signal Generator is a compact, highly-practical source of u-h-f current for general laboratory use. Within its frequency range of 500 to 1350 mc, it is a particularly valuable laboratory

standard for determining gain or alignment, obtaining antenna data or measuring standing-wave ratios; for reading single-stage or conversion gain, signal-to-noise ratios, circuit "Q", or transmission line characteristics.

This instrument is unusually stable, and over its frequency range will supply accurately known voltages ranging from 0.1 microvolt to 0.1 volt. R-f output may be continuous, amplitude modulated, pulsed, or square-wave modulated. Pulse length can be readily controlled between 2 and 50 microseconds, and pulse rate is variable from 60 to 3000 times per second.

This new -hp- instrument includes postwar refinements and a simplified direct-reading control system. Operating charts are not necessary.

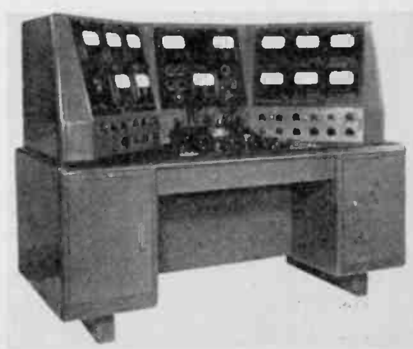
For further data, write Hewlett-Packard Company, Pala Alto, Calif.

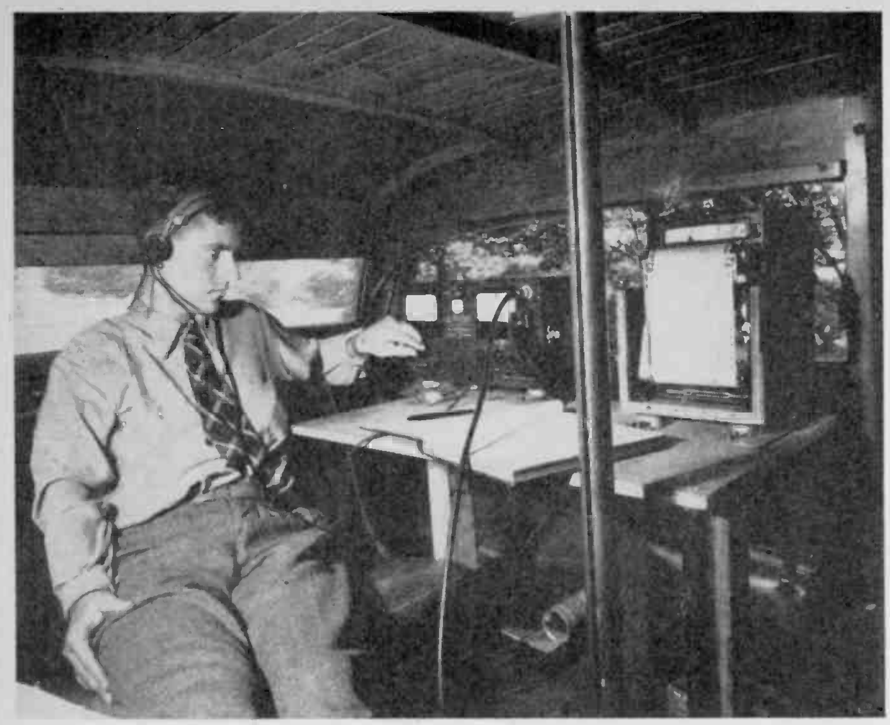
V-T BRIDGE TEST SET

A vacuum tube bridge characteristic test set designed to reduce operator fatigue and eliminate personal errors frequently resulting from circuit arrangement, has been announced by Sylvania Electic Products Inc., Electronics Division, 500 Fifth Avenue, New York 18, N. Y.

The console unit includes bridge and auxiliary switch gear mounted on the

[*Continued on page 27*]





Signal sensitivity measurements used to determine radiation pattern of a square loop antenna developed by Federal Tel. & Radio Corp., Newark, N. J. (Mfg. affiliate I. T. & T.)

This Month

MICROWAVE SPECTROSCOPE

Radar waves from 1.2 to 1.6 centimeters in length have found a new use in a microwave spectroscope developed for the analysis of chemical substances. Like the infra-red spectroscope to which it is analogous, the microwave spectroscope can identify the more complicated molecules such as hydrocarbons without the laborious chemical processes involved in breaking them down and analyzing their various components.

Identification of whole molecules is accomplished by beaming microwaves through the vapor of the substance to be analyzed. Just as all the colors of the visible spectrum except blue and yellow are absorbed by a green screen certain wavelengths of these microwaves are absorbed by those molecules which they cause to rotate in resonance. Molecules of different substances absorb a different series of wavelengths. Thus for each substance there is a characteristic pattern of absorption lines which when projected electronically on a screen present an easily identifiable fingerprint of the vapor under investigation.

The basic elements of the microwave spectroscope as developed by Drs. William E. Good, Donald K. Coles and T. W. Dakin of the Westinghouse Research Laboratories are an oscillator tube or radar tube, waveguide, crystal detector, oscilloscope and sweep generator.

Microwaves emitted by the oscillator tube are directed through a rectangular waveguide which contains the sample gas or vapor to be analyzed in a gas cell section that is sealed off with plastic tape. At the far end they are picked up by a sensitive crystal detector which passes the impulse received on to the oscilloscope. For clearer definition of the absorption lines the vapors in the gas cell are held to a pressure of about 0.1 millimeter of mercury.

The oscillator tubes used to obtain microwaves in wavelengths varying from 1.2 cm to 1.6 cm are reflex klystrons tuned by changing the size of the resonant cavity. Several tubes are used to cover the band of frequencies required.

The frequency of the oscillator tube, or klystron, is swept in synchronism with the horizontal sweep of the oscilloscope tube, and the output of the crystal detector is applied directly to the vertical plates of the oscilloscope so that absorption at a particular frequency will be recorded as a vertical deflection of the oscilloscope trace.

Ammonia has been found to have a pattern of 30 distinct absorption lines in this region which is its "fingerprint." Other compounds that have been tagged by this method are water vapor, acetone, cyanogen bromide, and carbonyl sulfide. The limitations of the microwave spectroscope are not yet known, but it promises to be a very valuable tool in the study of molecules and even of the atomic nuclei within the molecule.

SLACK PROMOTED

Dr. Charles M. Slack, who developed an electronic tube making possible millionth-of-a-second X-ray exposures, has been appointed director of research for the Westinghouse Lamp Division, Ralph C. Stuart, Vice President, announced recently.

Dr. Slack succeeds Dr. Harvey C. Rentschler, director of Westinghouse lamp and electronic tube research for the past 30 years. Dr. Rentschler, who is approaching retirement, will devote himself to completing certain research projects in addition to serving in an advisory and consulting capacity.

RCA PLANS BIG TV SET PRODUCTION

Television home receivers having a retail value of approximately $65,000,000 are scheduled to be manufactured by the RCA Victor Division of the Radio Corporation of America during the coming year, George L. Beers, Assistant Director of Engineering of the RCA Victor Division, reported recently to the F.C.C.

G. R. ENLARGES PLANT

Work has been started on a new four-story addition to the plant of the General Radio Company, 275 Massachusetts Ave., Cambrdige, Mass. This new building, located at the corner of State and Windsor Streets in Cambridge, will add approximately 30,000 square feet to the company's manufacturing space, bringing the total plant space to 140,000 square feet. It will be used to house manufacturing operations now being carried on in rented quarters and will also provide space for an increase in manufacturing capacity.

NEW SYLVANIA V.P.s

Robert H. Bishop, Director of Sales, and Conda P. Boggs, Director of Manu-

Left: Robert H. Bishop, right: Conda P. Boggs.

facturing, were elected vice presidents of Sylvania Electric Products Inc. at a meeting held here today, it was announced by Don G. Mitchell, president.

CHICAGO I.R.E. CONFERENCE

Plans are well under way for the second Chicago I.R.E. Conference, which will be held on Saturday, April 19, at Northwestern Technological Institute.

This conference will feature an all-day series of technical sessions and discussions on the practical side of electronic engineering, with emphasis on applied electronics. Outstanding engineers in the various fields will lead the discussions, which will be of vital interest to engineers in all branches of electronics.

This conference is sponsored by the Chicago Section of the Institute of Radio Engineers, second largest section in the country.

SCOTT APPOINTS COTTER

William F. Cotter, who pioneered many major developments of radio communication systems, has been appointed chief engineer for the Scott Radio Laboratories, Inc., of Chicago, it was announced recently by Hal S. Darr, president of the corporation.

A veteran of 29 years in the radio engineering field, Cotter played an important role in the development of the point-to-point duplex telephone, ship-to-shore telephone systems, police radio communication systems, and home broadcast receivers.

William F. Cotter

CONCORD NAMES SNYDER

Concord Radio Corporation of Chicago and Atlanta have announced the appointment of Mr. Jack E. Snyder as manager of the Concord Export Division, supervising the extension of Concord service to the radio and electronics industry throughout the world.

Mr. Snyder has been with the Concord Corporation for the past sixteen years and with his thorough knowledge of the export field is well qualified to maintain and extend Concord's excellent position in foreign markets.

NEW PRODUCTS

[from page 24]

control shelf; electronically regulated power channels; bridge signal source; amplifier; meters; and other accessories. All meters except those for gas and heater cathode current are located on sloping panels. Voltmeters and respective current meters are mounted close together. All current meters have circuit jacks for external calibration.

Operating from a 1500 watt, 200 volt, three phase, 60 cycle a-c source, the unit will provide 0-600 volt, 100 ma. supply for plate and screen grid; 0-300 volt, 100 ma. for auxiliary and heater cathode; 0-300 volt, 400 ma. for emission; and 0-100 volt, 2 ma. for bias. A reverse polarity switch is provided for heater supply which can also be used as a second auxiliary. Filament supplies include 0-128 volts a-c, 100 voltamperes; 8 volts d-c, 5 amperes; 35 volts d-c, 2 amperes; and 128 volts d-c, 1 ampere.

The console is approximately 55 inches high, 70 inches long, 34 inches deep and weighs approximately 1500 pounds.

WIRE STRIPPER

A new "Hot Blade" Wire Stripper for continuous production stripping is announced by Ideal Industries, Inc., 4027 Park Avenue, Sycamore, Illinois.

Through use of two electrically heated stripping blades, the unit will strip cotton, silk, synthetic (plastic) insulation or rubber covering from fine stranded or solid conductors. There is no possibility of cutting strands, nicking, scraping or injuring wire in any way, for the blunt blades cannot harm the finest wire.

Operation is very simple. When a wire is inserted between the special heat resistant blades and foot pedal is depressed, two parallel grooves are instantly burned through the insulation, down to the conductor. A slight twist completes the groove and a pull removes the insulation—leaving a clean edge. A built-in exhaust draws smoke and fumes of burning insulation away from blades. The strippings fall into a water drawer where any burning particles are quickly extinguished.

Since different wire insulations strip differently, each blade has an individual heat control and transformer to permit raising or lowering the burning temperature as required for the particular insulation. A "Hi-Lo" switch, mounted between the blade controls, controls the adjustment of heat for heavy, average, and light insulation. The blades may be set at exact wire diameters, and an easily adjustable stop controls the length of stripping. This stripper is easily installed on present production line bench or table. 115-volt, 50-60 cycle standard, other voltages and frequencies available.

H-F CABLE

A new, improved twisted dual conductor high frequency cable specially designed for FM and television receivers to free them from locally induced interference even under the most adverse conditions has been developed by Federal Telephone and Radio

Corporation, Newark, N. J., manufacturing associate of International Telephone and Telegraph Corporation. Known as KT-51, this cable is for use wherever a balanced transmission line is needed.

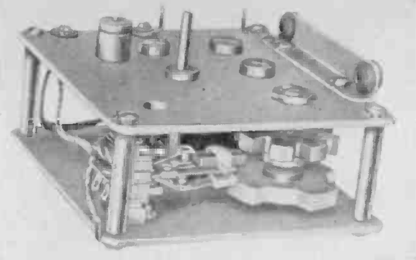
Combining in construction detail every known transmission line technique, the KT-51 represents one of the most highly engineered products of the industry resulting in long life, a high degree of stability, low attenuation, and a capacity unbalance maximum of only 1 per cent.

Due to its structural design — use of twisted dual conductors which enables a high degree of balance, and two metal braids — this cable virtually eliminates all noise pick-up. Only the signal that is generated in the antenna is transmitted to the r-f input. Furthermore, use of the Federal developed non-contaminating jacket assures a low attenuation, long-lifed cable which is extremely durable, has remarkable abrasive resistance and is highly resistant to acids, alkalies, smoky atmospheres, oils and greases.

The characteristic impedance of KT-51 is 95 ohms while its attenuation is 1.7 db at 30 mc, and 10.0 db per 100 foot at 400 mc. Although the maximum capacity unbalance is given as one per cent it is a very conservative figure as most actual measurements show a lesser degree of unbalance.

CONSTANT SPEED D-C MOTOR

An improved model of the Constant Speed D-C Motor has been developed by the Amglo Corporation of Chicago. The new motor is adapted to many uses here-



tofore beyond the scope of the d-c field, particularly in industrial and commercial applications where synchronous units are required.

Approved by the Bureau of Standards, the FCC, and CAA, the new model utilizes the principle of polarized magnetic drive of a vibrating reed, the nucleus of speed control under d-c power. This results in a powerful attraction and repulsion force which assures immediate self-starting at all times, as well as much longer periods of operation without maintenance.

For complete information on the new Amglo Constant Speed D-C Motor, write for illustrated literature and technical data to the Amglo Corporation, 4234 Lincoln Avenue, Chicago 18, Illinois.

CALCULATOR

A new pocket-size Ohm's Calculator incorporating a number of new features has just been announced by Ohmite Manufacturing Co., 4937 Flournoy St., Chicago, manufacturers of electrical rheostats, resistors, and tap switches.

The new calculator, like the previous Ohmite calculator of which close to one-half million copies have been distributed to engineers, students, and teachers, provides a simple and handy means of solving resistance calculations. With one setting of the slide it gives the answer to any Ohm's Law problem — reading directly in ohms, volts, amperes, and watts. It will also solve parallel resistance and series capacitance problems, and will multiply, divide, and find squares and square roots. The range covers all currents, resistances, voltages, and wattages commonly encountered in industrial and radio work.

All computing scales of the new calculator are printed on one side. On the opposite side are given the Composition Resistor Color Code and the catalg number of stock resistors and rheostats of various resistance values. The new calculator is made to handy pocket size (9" x 3") of heavily varnished cardboard.

SUPER-SENSITIVE VOLTMETER

The production of a new, highly sensitive vacuum tube Audio Voltmeter for use in industry, laboratory, and radio servicing,

designed to measure a-c voltages over ranges of frequency and amplitude far beyond the limits of ordinary a-c voltmeters, has been announced by the RCA Engineering Products Department.

The unusual sensitivity of the new Audio Voltmeter (RCA Type WV-73A) makes it possible to measure the electrical conductivity of switches, circuit breakers, relays, buses and grounds, in addition to transmission losses in lines and circuits and the response of special filters and compensators.

The new instrument is also applicable for testing radio receivers and sound systems and is used to measure gain and noise level in power amplifiers and ripples voltages in power supplies. The meter is also used to locate sources of frequency distortion and faulty amplifier components in receivers, phonographs, and public address systems.

The RCA WV-73A includes an input circuit with low capacity and high resistance which makes it particularly suitable for measuring voltages in high-impedance circuits. This makes it possible for the electronic meter to measure the response of audio frequency power amplifiers and loudspeakers without disturbing their frequency characteristics. The range of the meter is 20 cycles to 20 kilocycles.

The main components of the RCA WV-73A consist of a precision attenuator, a three-stage high-gain stabilized amplifier, a balanced diode rectifier, a special d-c microammeter, and a regulated power supply.

The voltage to be measured is fed to

the attenuator through a shielded cable attached to a jack on the front panel. The attenuator consists of an 11-position switch connected to non-inductive resistors, arranged in such an order that consecutive switching ranges overlap by 10 db. The meter can measure one millivolt to 1000 volts.

From the attenuator, the voltage is fed to the high-gain amplifier, which employs a conventional feedback circuit to obtain stabilization and sharply reduces the input capacity of the first tube. Output voltages from this amplifier are fed to a balanced diode rectifier in order to produce d.c. for energizing the meter.

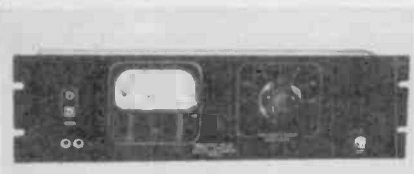
The high-level rectifier is designed to produce an output voltage that is proportional to the average value of the full wave, thereby giving a meter reading that agrees very closely with an r-m-s meter for all usual distorted waveforms. Because a balanced diode rectifier is used, the meter indicates the true value of both halves of the wave, avoiding the polarity or "turn-over" error of half-wave circuits.

Other applications of the new Audio Voltmeter include: use as an audio amplifier which gives high gain with essentially perfect fidelity, and whose sensitivity makes it especially adaptable for use with microphones having low output; bridge measurements which readily indicate the null point at either high or low audio frequencies; measurement of the output of a phototube with sensitivity that will indicate extremely slight variations in light intensities to which the tube is exposed; and measurements of currents as low as 1 ma, or if a 0.1 megohm external resistor can be used, currents as low as one microampere.

FREQUENCY METER

The Daven Company, 191 Central Avenue, Newark 4, N. J., announces the new Daven Frequency Meter Type 838.

This unit, with application in electrical, radio, acoustics measurement recording, telephone and telegraph laboratories, is a



direct reading instrument, designed to measure frequencies in the audio and supersonic spectrum. Seven overlapping ranges are available for frequency determination between 20 to 100,000 cycles per second.

For additional information write direct to the Sales Department, The Daven Company, 191 Central Avenue, Newark 4, N. J.

NEW BULLETINS

Three attractive new bulletins describing electronic test instruments manufactured by the Electronics Division and distributed by the Radio Tube Division of Sylvania Electric Products Inc. are now available on request to the company at Emporium, Pennsylvania. Instruments described include Sylvania Tube Testers, type 139 and 140; Type 134 Polymeters; and Type X-7018 Modulation Meter.

TECHNICANA

[from page 7]

amperage, and to prolong shelf life.

W. J. Hamer, *et al.*, find that a vinyl-resin plastic coating 1 mm thick will protect dry cells from deterioration and will extend their shelf life at 130° for periods ranging up to six months.

The problem of dry-cell reactions has been re-examined by H. F. McMurdie, *et al.*, who reports that a complete explanation has not yet been worked out. Small amounts of soluble manganese and manganese oxide crystals are guide-posts in the reaction, the nature of which is quite different in acidic and basic solutions. The valence charge is two in the former case, and one in the latter.

The data indicate that in the conventional dry cell the most important equilibrium reaction is that resulting in the formation of hetaerolite: $ZnO{\cdot}Mn_2O_3$.

R-F POWER SUPPLIES

★ Compactness, light weight, and stability under adverse climatic conditions are designed into 2- and 4-kv r-f power supplies described by R. D. Boadle in the *A.W.A. (Australia) Technical Review* for September 1946. A schematic diagram of the 4-kv unit is shown in *Fig. 1.* At an operating frequency of 200 kc the 807 oscillator is able to supply filament power for the 879 from a 300-v source as well as to deliver the 4-kv supply to the CRT.

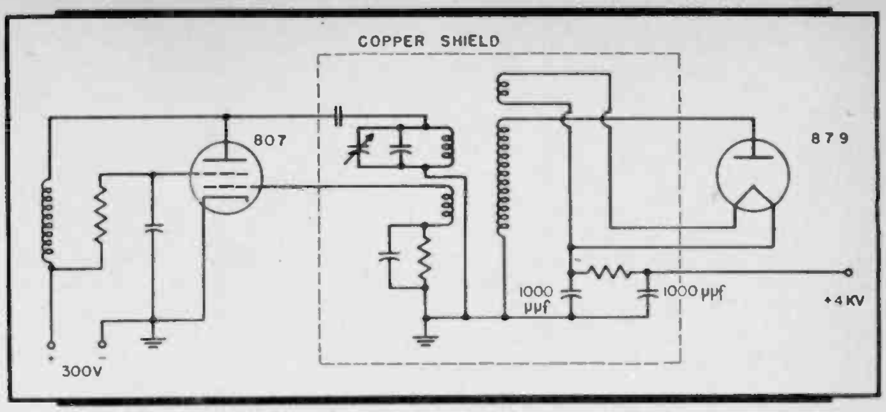


Figure 1.

Oil-filled capacitors of 1000 µµf are used for filtering, and the regulation characteristic affords safety for the operator as the output falls to zero for drains in excess of 1.5 ma. At a drain of 1 ma the output is 3 kv. Most important are the small overall size, 8x4x7½ in., weight of 6 lb., and great stability achieved by use of sealed, impregnated components.

GROWING QUARTZ CRYSTALS

★ A successful German hydro-thermal method for growing quartz crystals is described in a report prepared by Major Allyn C. Swinnerton of the U. S. Signal Corps, now on sale by the Office of Technical Services, Department of Commerce.

The hydro-thermal method was developed by Professor Richard Nacken at the University of Frankfurt am Main after 10 years of experimentation, and is the only significant German advance in quartz growing, according to the report.

The method is based on the fact that at temperatures above 350 degrees centigrade silicon dioxide in its vitreous form dissolves ten times more quickly than in its crystalline form. A seed plate of natural quartz is suspended in a vessel to which finely broken glass and water have been added. The vessel is then placed in an autoclave and heated to about 375 degrees. The resultant fluid solution of silicon dioxide feeds the seed plate, and crystalline accretion occurs rapidly and clearly, according to the report.

The report (*Report of Investigations in European Theater;* PB-28897; photostat, $3; microfilm, $1; 40 pages including diagrams; photographs, and drawings) also contains a description of two less successful methods for synthesizing quartz. One involves the use of low-temperature melts, and the other, the chemical reaction of silicon chloride with various oxides.

A discussion of the hydro-thermal method is also included in an earlier OTS report (*Artificial Quartz Crystals;* PB-6498; photostat $1; microfilm, 50 cents; 7 pages).

Note on "Cylindrical Cavity Wavemeter Design"

We wish to thank Mr. R. W. King, editor of the Bell System Technical Journal, for pointing out that an article appeared in the July, 1946, issue of the BSTJ, entitled "High Q Resonant Cavities for Microwave Testing", by I. G. Wilson, C. W. Schramm and J. P. Kinzer. This should be added to the list of references given in the article, "Cylindrical Cavity Wavemeter Design" by H. J. Peake, presented in RADIO for Nov. 1946

COAXIAL COILS

[*from page* 10]

3B. This barely covers the range, and if a higher permeability core material is employed to increase the tuning range, the Q of the circuit will suffer.

A method of overcoming these deficiencies is shown in *Fig. 3C*. As illustrated, the longer lead is threaded through the center of the coil. When this is done, the minimum inductance

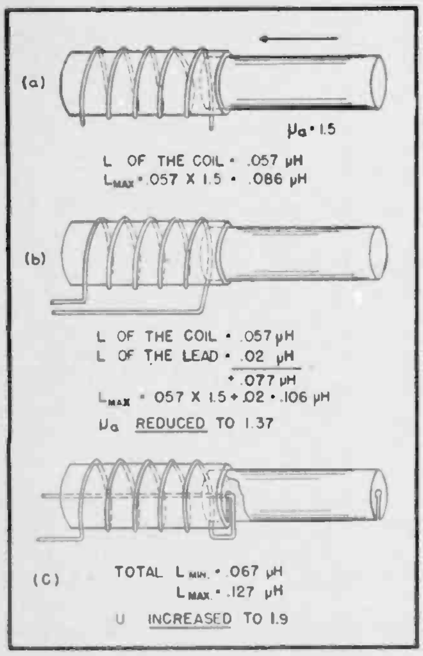


Fig. 3. Coil designs for the FM band. In (c) a method of increasing the apparent inductance is shown.

decreases from .077 μh (with the lead outside) to .067 μh, without decreasing the Q. But when the core is moved into the coil, the inductance is increased by a factor of 1.9, as compared with 1.37, found in the previous example. Both coils had the same dimensions and lead length.

Such a coil, with the lead threaded through the horizontal axis, is termed a coaxial coil. From a great number of measurements, it appears that placing the lead inside the coil changes the distribution of the magnetic field so that the already weak linkage field between the turns now links with the coaxial wire, thus further reducing the inductance.

The inductance of a straight wire is

$$L = 0.002L_e \left(2.3 \log \frac{4L_e}{d} - 1\right) \ldots \mu h/cm$$

where L_e is the length and d is the diameter of the wire in cm.

As indicated in the formula, the thicker the lead, the lower the inductance, and this applies to the total coil, yet the Q of the coil remains substantially the same. Therefore the inductance drop cannot be attributed to the effect of placing a metal body in the field of the coil, which invariably introduces losses and thus lowers the Q.

It is interesting to note that the coaxial coil cannot be compared with a coaxial transmission line, insofar as its analysis is concerned. For a coaxial line, the inductance increases as the inner conductor is made thinner (diameter of outer conductor constant), while for a coaxial coil such as has been described the reverse is true. It has been verified again and again that the greater the diameter of the coaxial wire the more the apparent permeability is increased. This may be explained as follows: 1) Without the core the total inductance is composed of the inductance of the coaxial lead plus the reduced inductance of the coil. 2) When the core is moved in, it increases the inductance of the coaxial lead as well as that of the coil. 3) When the core is completely inserted it shields the coaxial lead so the field-weakening effect is no longer present. These three effects work simultaneously in the same direction, hence the unusual increase in apparent permeability as compared with an ordinary coil of the same size.

The production design of the coaxial coil represents a radical departure from conventional coils. Instead of the coil being wound on a piece of tubing, the coil itself is made from a brass tube 0.4″ inside diameter, .020″ thick, along the periphery of which a helical groove is cut on the lathe. In this way no winding stresses are introduced into the thick metal spiral ribbon thus formed and its stability is therefore excellent. One end of this helix is connected through a very short heavy welded lead to the tube grid. A thick coaxial lead (#10 or #12 gauge) is welded to the other end. Because the coil is strong and simple in design, no special mounting provisions are necessary. The tuning core is composed of v-h-f core material* whose resistivity is of the order of megohms, so that no insulation between the core and coil is required. A groove one-eighth inch wide, extending to the center of the core, is provided for the bent end and the center lead.

The Q of such a coil is about 200 at 110 mc, decreasing to 160 at 80 mc when the core is moved in. This is a typical antenna or r-f coil for an FM tuning unit. For the oscillator, when operating on the fundamental frequency, the range must be somewhat less for tracking purposes. This is obtained by using either a thinner coaxial lead or by not cutting through the last turn on

*Stackpole's designation GY-8

either end, thus reducing the inductance variation. More turns are cut through if the oscillator operates on the second harmonic with larger fixed capacity — the scheme often adopted to secure oscillator stability.

A three-terminal oscillator coil can be used for a Hartley circuit, the third intermediate connection being taken from the joint point of the coaxial lead and the coil. At that point or nearby the "electrical tap" remains substantially constant when the inductance is varied by the core.

The coils and cores of this new type are adaptable to still higher frequencies up to 200 mc, becoming smaller in size and having one single slot, corresponding to one turn. Similar inductances (0.02 μh) can be constructed with a longer coil, to get a wider range of movement, in which case the inductance of the coil itself is decreased by cutting a double thread, one turn making in effect two turns in parallel. Beyond 200 mc, as at present appears, variable p-t coils cease to have practical applications and a coaxial line then could be used, provided that suitable core materials are developed.

We have carefully investigated the production problem of the proposed coax coils. Its present dimensions are large enough for ease in handling yet small enough to accommodate into any design. Tape winding vs. slotted tube were compared and, in the interest of stability, the drawn brass tube was chosen, since there are no strains in this construction which could ultimately change electrical constants of the coil. Once the cutting wheel is set to a given pitch on the lathe the reproduction within less than a thousandth of an inch is assured in every case. After cutting the coils are cleared from burrs and silver plated. The great majority of tuning cores are side pressed. To add a longitudinal groove in this kind of pressing constitutes no problem at all.

The construction of mechanical tuners easily adapts itself to new coils with the exception that coil assembly is an integral part with tube sockets (miniature type) so that variation in lead length is eliminated and complete circuits are wired, including adjustable condensers by a competent maker.

(Lecture delivered at the 1946 Fall Meeting of the Institute of Radio Engineers)

ADVERTISING INDEX

PRESS OF THE WILSON H. LEE CO.
ORANGE, CONN. PRINTED IN U.S.A.

SYLVANIA NEWS

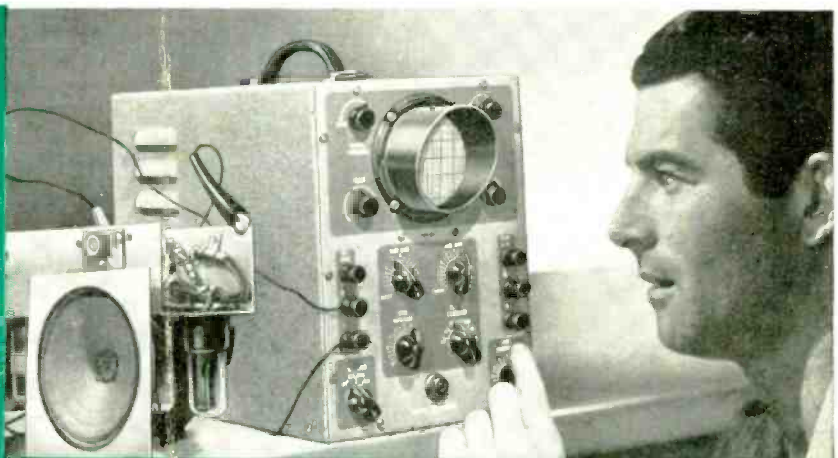
CIRCUIT ENGINEERING EDITION

JAN. *Prepared by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. 1947

NEW OSCILLOSCOPE DEVELOPED TO HELP SOLVE PROBLEMS MET IN RADIO AND ELECTRONIC EQUIPMENT

Latest Sylvania Instrument Especially Useful For Rapid Receiver Alignment and Trouble-Shooting

In anticipation of the need for greater accuracy in trouble-shooting, alignment, distortion locating, etc., Sylvania has developed the Oscilloscope, Type 131. This accurate measuring device takes its place beside the numerous radio and electronic devices that have been Sylvania-developed to facilitate the solving of problems encountered in radios and electronic equipment.



Oscilloscope, Type 131; cabinet is steel constructed, properly ventilated with louvers, finished in durable, attractive pearl-grey baked enamel.

CHARACTERISTICS AND SPECIAL FEATURES

1. Sylvania 3AP1 Cathode Ray Tube — Accelerating potential, 650 volts. Electrostatic deflection and focus. Tube is shock-mounted and well protected from stray magnetic and electrostatic fields by efficient shielding. Panel visor shades face of tube permitting oscilloscope use in well-lighted rooms. Removable calibrating screen also included.

2. **INPUT IMPEDANCES** —
   Vertical amplifier — approximately 1 meg., 30 mmf. at full gain.
   Horizontal amplifier — approximately 1 meg., 50 mmf. at full gain.
   Vertical direct—approximately 0.68 meg., 45 mmf.
   Horizontal direct — approximately 0.68 meg., 60 mmf.

3. **AMPLIFIER FREQUENCY RESPONSE** —
   Sine wave uniform within 3 db. from 10 cycles to 100 kilocycles.

4. **DEFLECTION FACTOR** —
   Through amplifiers — 0.5 volts per inch.
   Direct — approximately 17 volts per inch.

5. **HORIZONTAL SWEEP** —
   Direction — left to right.
   Frequency range — 15 to 40,000 cycles.
   Synchronizing signal sources —
   Internal (vertical signal).
   External; 60 cycles.

6. **POWER SUPPLY** —
   105-125 volts, 50-60 cycles.
   40 watts power consumption.
   1 amp. line fuse provided.

7. **CABINET DIMENSIONS** —
   10⅛" high, 7¾" wide, 13⅜" deep.

See your Sylvania Distributor.