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JULY

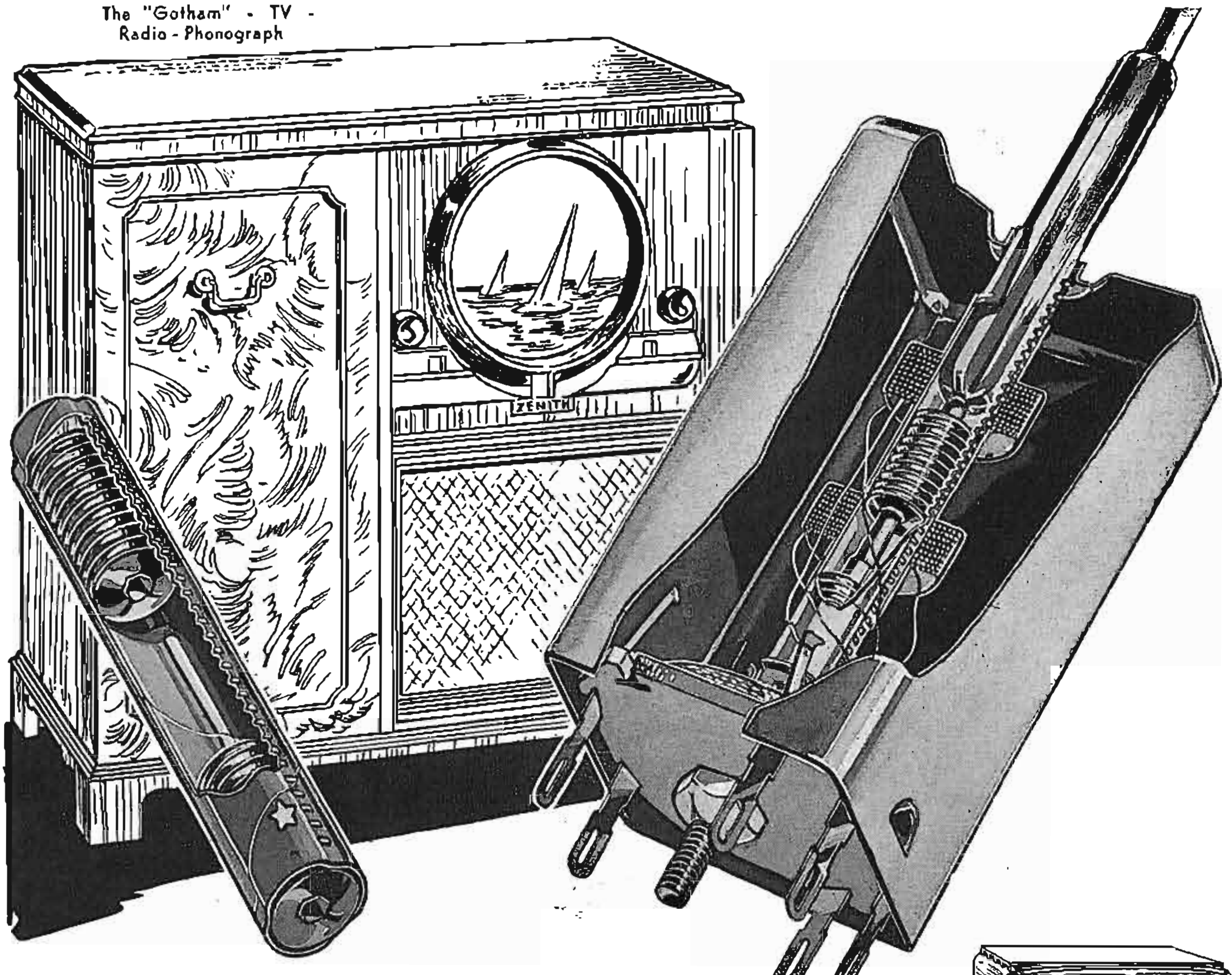
★ TV 16-MM FILM PROJECTOR SYSTEM

★ L-SECTION LOW-PASS FILTER DESIGN PROCEDURES

★ REMOTELY-CONTROLLED PROGRAM CIRCUIT-SWITCHING METHOD

1949

The "Gotham" - TV - Radio - Phonograph



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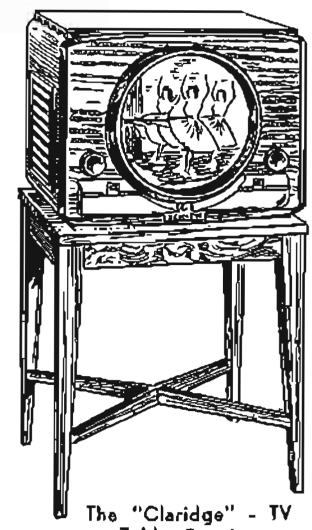

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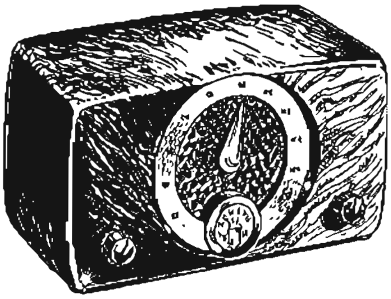

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COVER ILLUSTRATION

Bank of selenium high-voltage rectifiers used with a 50-kw AM transmitter. *(Courtesy Westinghouse Electric)*

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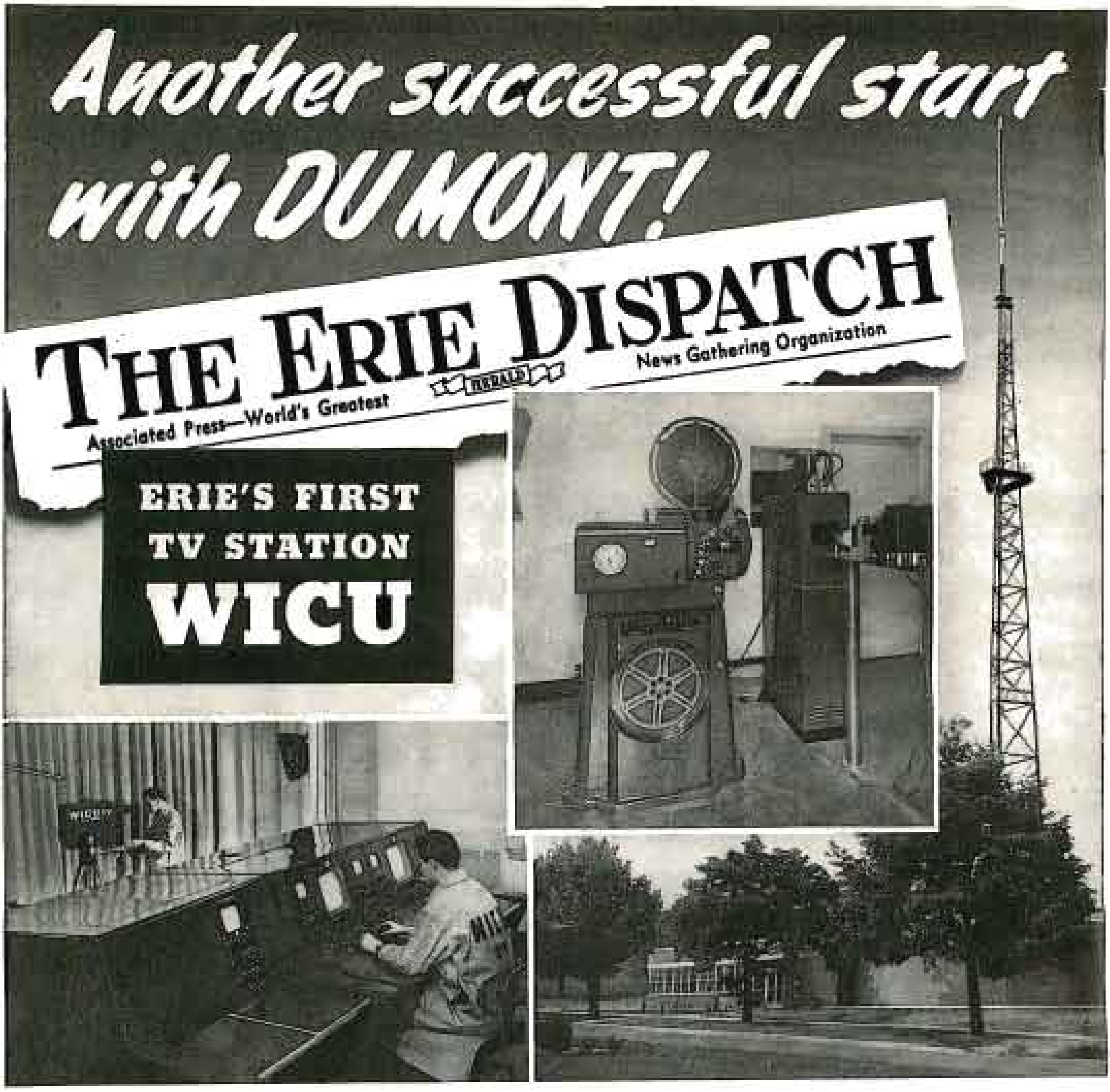
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COMMUNICATIONS

LEWIS WINNER, Editor

JULY, 1949

The New TV Veryhigh-Ultrahigh Channel Proposals

TV's future, which during the past year has been quite a crystal-gazing project, appears to have emerged from that mystic stage and acquired an enterprising pattern, with the blessings of government and many in industry. The government appraisal has been in the form of a seventy-six-page formula citing suggested allocations for the *vhf* and *uhf* bands, while a combined industry-government effort has provided the famous Ad Hoc committee report[1] and six other pertinent engineering analyses covering propagation.

In the official FCC proposal, which will be the subject of a hearing beginning August 29 in Washington, appears for the first time a complete evaluation of such factors as permissible interference ratios for co-channel and adjacent channel operation for three grades of service. For the first or grade *A* service a 55-db desired-to-undesired co-channel ratio is suggested and a 20-db desired-to-undesired adjacent channel ratio is proposed. For the second or grade *B* service, the co-channel ratio indicated is 46 db and 12 db for adjacent channels, while for the third or grade *C* service a 40-db co-channel ratio is proposed and 6-db adjacent channel factor suggested. The service availability for each of these grades has been indicated as 90% of the time and 90%, 70% and 50%, respectively, for the various locations of the three services. The FCC stated that they recognize that by means of sync or offset carrier operation some improvement in the interference ratios may be possible and cited that they will make every effort to encourage such operations, but will not use them as a means of reducing separation between stations but rather to extend the service area of the transmitter.

To interpret the field intensity of transmitters the Commission has proposed the use of iso-service contours which were discussed in a supplementary Ad Hoc report by William C. Boese. These contours express service in terms of the ratio between desired and undesired signal in db or the minimum required signals in db above one microvolt per meter. This has been done to facilitate computation of service and interference field intensities. The same terms may be carried over to the output of the transmitter, transmission line losses and antenna gain. The use of this system permits the application of the same unit throughout the service, whether in the transmitting equipment or in the field, and has the additional advantage that a db of power added at the transmitter results in a db of increased field intensity. So that these matters can be placed on a related basis, the db with respect to transmitter power and antenna gain as well as the field intensity, must be expressed as db with reference to some given level.

Analyzing the separations possible between co-channel and adjacent channel stations for the *A*, *B* and *C* services, the FCC reported that at 63 mc co-channel grade *A* stations, with an output of 10-kw, would have to be 148 miles apart, while grade *C* stations would have to be 252 miles apart. At 600 mc, over relatively smooth terrain, grade *A* co-channel stations with an output of 10-kw could be 103 miles apart and grade *C* stations 125 miles apart. Quite a difference in separation is indicated in adjacent-channel operation, with grade *A* stations in the 10-kw category requiring a separation of 50 miles at 63 mc and 43 miles at 600 mc.

The Commission cited that it has endeavored wherever possible to have a co-channel separation for metropolitan stations in the veryhigh band of 220 miles and adjacent channel separation of 110 miles. On the ultrahigh bands a co-channel spacing of 200 miles has been selected for metropolitan stations and 100 miles for adjacent stations. In the case of community channels, a co-channel separation of 140 miles and adjacent channel separation of 60 miles has been suggested.

In the new ultrahigh allocation plan forty-two 6-mc channels have been proposed, channels being numbered *14* through *55*, with *14* beginning at approximately 470 or 500 mc, depending on an action to be taken by the FCC with respect to the request of Bell Labs for the use of this channel for a broad-band mobile communications system. Thirty-two of the channels have been suggested for metropolitan and ten for communty station use.

According to the FCC plan, metropolitan stations will be authorized to employ an erp between 10 db (10 kw) minimum for channels *2* to *55*, and 20 db (100 kw) maximum for channels *2* to *13* with a 23-db (200 kw) maximum for channels *14* to *55*, provided the antenna height is a minimum of 500′ above average terrain. Where antenna heights of 500′ cannot be employed, the FCC cited that authorization might be granted but no increase in power will be allowed. Community stations will be authorized to operate with an erp of not less than 7db (5 kw) and not more than 13 db (20 kw).

No provisions for directional transmitting antennas have been provided in the new plan. The Commission stated, however, that they recognize that such antennas may be useful to cover particular sites, and accordingly they might be permitted in appropriate cases.

Detailing the procedures used to establish the required field intensities at the antenna, the Commission indicated that it assumed the connection of half-wave dipoles to a receiver via 50′ of RG59U coax for 63 to 195 mc operation. In ranges near 600 mc small rhombics with 300-ohm lines were assumed.

Commenting on the possible use of any channels for color, the Commission pointed out that any system proposed must be able to operate in the 6-mc channel and permit use of existing receivers, with only relatively minor modifications being required.

The members of FCC, industry and the independent consultants, who toiled around the clock, processing the data for these invaluable reports, certainly merit a round of ringing applause for their conscientious efforts. While all the proposals may not be letter-perfect, we do have the nucleus of a workable plan which can be applied to an urgently needed allocation program for expanding TV.—L. W.

[1] See pages 6, 7, 8, and 9, this issue.

The AD HOC

Study, by Group of FCC Specialists, Independent Consultants and Members of Industry, Covering Propagation Problems Involved in FM and TV Transmissions Between 50 and 250 Mc, Reveals New All-Important Information Which Has Served as a Base in Planning the Forthcoming *VHF/UHF* Allocation Program.

by RALPH LEWIS

DURING THE VERYHIGH-ULTRAHIGH allocation hearings in December, 1948, it became apparent that appropriate answers to many vital propagation issues were not available, and thus any immediate processing of an allocation plan would be impossible. Since the need for such a plan is so urgent, it was decided to appoint an impartial engineering committee, which would probe all the issues and provide the FCC with data which could be used to formulate an acceptable lower and upper-band program.

The committee, known as the Ad Hoc committee, have after six months, compiled a substantial report, which is replete with extremely pertinent data and which has been of material assistance in preparing the long-awaited allocations plan.

Broadly speaking the objectives of the committee were: (*1*), Prediction of service field intensities; (*2*), evaluation of the random variations in field intensity from median levels due to local terrain and buildings; (*3*), tropospheric propagation curve evaluation; and (*4*), method of combining the effects of the spatial and time variations of the desired signal and one or more interfering signals.

The Report[1]

(A) Prediction of Service Field Intensities: Four factors were considered in this study. The first concerned a modification of ground wave signal range curves. Although not specifically proposed by the FCC, the question arose at the conference of the desirability of revising the ground wave signal range curves appearing in part 3 of the rules. The committee considered this problem and decided that, for the purpose of making statistical comparisons between measured and calculated values of field intensity, the standard curves would be modified so that they follow the free-space inverse distance value, rather than twice this value, out to the point of departure of the smooth-earth theoretical curve below that value. This correction was made since the line corresponding to twice inverse distance represents the envelope of values expected under smooth earth conditions, rather than the median value, as exemplified by these curves.

In the second point, the apparent transmitting antenna height was probed. This factor was considered since it was found to be a prerequisite to the determination of some of the other factors. Several alternatives to the present practice of specifying the average height above terrain between 2 and 10 miles from the transmitter were considered; namely, (*a*) the determination of an equivalent ground plane, (*b*) the use of a residual height where high ground intervened between the transmitter and receiver, (*c*) antenna height above receiving point, and (*d*) an equivalent earth's radius passing through transmitter and receiver sites. Although individual investigation by several committee members indicated improved agreement in some cases between measurements and predictions made in accordance with one or more of the alternative methods, the committee agreed that the improvement was neither sufficiently systematic, nor the magnitude of the indicated improvement sufficient to warrant a departure from the 2-10 mile rule for the investigation of the statistical relationships between predicted and measured values. Consequently, the average height of the transmitting antenna above the 2-10 mile sector of the radial along which the measurements were taken was used as a basis for all of the report studies.

The decision to use the 2-10 mile rule in the studies made under the supervision of the committee for the purposes of formulating a general allocation, is not to be taken as a recommendation that alternate methods for the determination of the antenna height in specific cases should not be permitted under the Commission's rules. To the contrary, the committee felt that the rules should provide specifically for the use of applicable alternative methods of specifying the antenna height, such as those mentioned above. However, when such alternative methods are used, due consideration must be given to their effects upon the statistical predictions presented in this report, since these latter were based on the use of the 2-10-mile rule, and may no longer be valid for such alternative method.

The third factor involved the receiving antenna height-gain function. In comparing the coverage predicted by the FCC standards with the coverage as revealed by experience, it was necessary to use data obtained from field intensity surveys of operating FM and TV stations. A large portion of these data were taken by mobile surveys at

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[1]Commenting on their findings, the committee stated that this report is a final one on all of the problems, except that of evaluating the cumulative effect of two or more interfering signals. This proved to be a very difficult theoretical problem and a solution suitable for use in practical allocation problems has not yet been found. The committee felt that this aspect was extremely important and might seriously affect the allocation problem where several interfering signals are present. However, it was considered that the solution of this problem should not delay the issuance of this report, since it may be used to evaluate the effect of one predominant interfering signal. It is intended to continue a study of this problem with the hope that a report on this phase of the problem will be available prior to the conclusion of the Rule Making Proceedings, which are expected to be held within the next sixty days.

[2]The committee indicated that the information it has had to work with was far too scant for it to consider these curves to be more than a relatively rough approximation to the propagation conditions to be expected throughout the United States. Although an effort has been made to express the degree of accuracy of the curves, in most cases that has not been possible. It should be borne in mind, therefore, that additional experimental data may make it advisable to modify the curves, possibly to a considerable extent in some instances.

Committee Report

receiving antenna heights of from 8′ to 12′ above ground. In order to relate the field intensities measured at this level to the field intensities to be expected at housetop level, at a nominal height of 30′, it was necessary to evaluate the variation of field intensity with receiving antenna height. A study of available data taken at various receiving antenna heights was made to determine whether the assumption of a linear increase in field intensity with increasing height, which prevails for the plane earth and has heretofore been used, should be adopted for this purpose. The data indicated that the linear relationship could not be expected to apply specifically to any particular pair of measurements at a particular receiving location, and that the ranges of departure from linearity appeared to increase with frequency. However, the conclusion was reached that for the purpose of computing the gain which would be achieved on the average, on other than mountainous terrain, the linear height-gain relationship should be used. More specifically it was found that, with horizontal polarizations, the field exceeded for some specified percentage of the receiving locations varied approximately in direct proportion to the receiving antenna height.

Correction factors for standard curves was the fourth point probed. Studies involving comparisons of the predicted and achieved coverage of thirteen FM and TV stations in the *vhf* band were made by the Central Radio Propagation Laboratory of the National Bureau of Standards, under the sponsorship and guidance of the committee.

These studies consisted of a statistical evaluation of the ratios of predicted to measured field intensities along radials from the stations studied. The analyses provided factors for the correction of the smooth-earth theoretical values to relate them to median signal levels to be expected under average terrain conditions in the eastern part of the United States. These factors are shown graphically in Figure 1 and may also be computed from empirical formulas (*4*) through (*8*), in which the values are expressed in *db*.

In arriving at these empirical equations, formulas (*1*) to (*4*) were set up, where $E(L,T)$ denote the field intensity expressed in microvolts per meter for 1 kw of radiated power, and

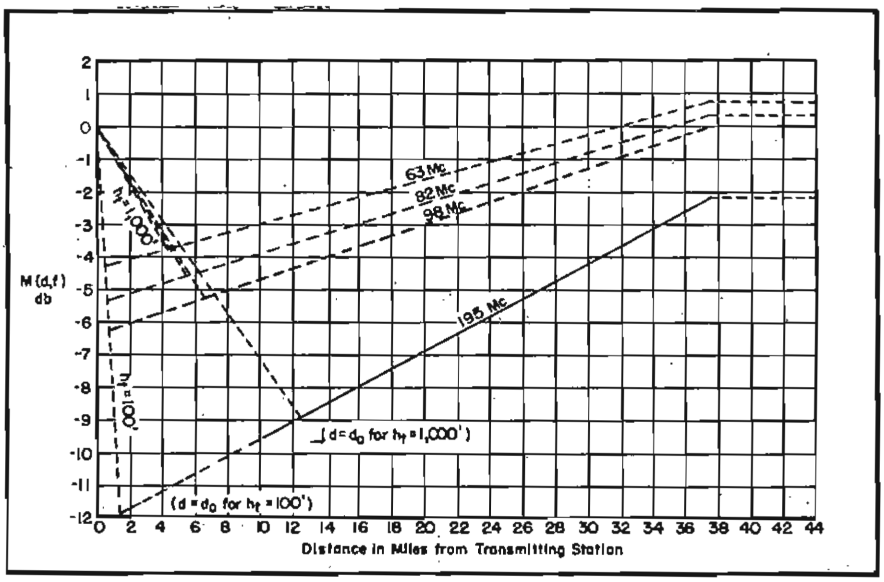


Figure 1

Correction to the theoretical smooth earth field intensity required to give the median of the fields, to be expected over irregular terrain for FM and TV stations. The theoretical fields were calculated by measuring the transmitting antenna height above the average level of the terrain between two and ten miles from the transmitting antenna; this correction was considered applicable for receiving antennas up to 30′ in height. At distances less than 12 $h'_T h'_R/\lambda$, the free space field rather than the theoretical smooth earth field should be used as the reference.

$F(L,T)$ denote the field intensity expressed in db above one microvolt per meter for 1 kw as follows:

$$F(L,T) = 20 \log_{10} E(L,T) \qquad (1)$$

In equation (1), L denotes the percentage of the receiving locations and T the percentage of the time. For example, $F(50,50)$ denotes the field intensity in db above 1 microvolt per meter for 1 kw exceeded at 50% of the receiving locations for 50% of the time.

The effective radiated power, P', is expressed in db above 1 kw radiated from a half-wave dipole and may be calculated by means of the following formula:

$$P' = 10 \log_{10} P - P'' + G \qquad (2)$$

Here, P denotes the actual transmitter power delivered to the transmission line expressed in kw, P'' denotes the transmission line and antenna power loss expressed in db, and G denotes the gain of the transmitting antenna array in the direction of the receiving location expressed in db relative to that of a half-wave dipole.

The formulas for the field intensity are different at distance d less than or greater than a certain distance, d_o, which is the distance expressed in miles beyond which the theoretical smooth-earth field is always less than the free-space field.

$$d_o = 2.31 \times 10^{-6} H_t' H_r' f_{mc} \qquad (3)$$

Within this distance the reference field is assumed to be equal to the free-space field.

Thus, for distances less than d_o, the formula for the corrected field is:

$$F'(50,50) = P' + 20 \log_{10}(137{,}600/d) + M(d,f) \qquad (4)$$
$$(d \leqq d_o;\ 50 < f_{mc} < 250 \text{ mc})$$

Where:

$$M(d,f) = d\left(0.072 + 0.001 f_{mc} - \frac{0.06 f_{mc} + 0.5}{d_o}\right)$$
$$(d \leqq d_o;\ 50 < f_{mc} < 250 \text{ mc} \qquad (5)$$

For distances between d_o and approximately two radio horizons, the formula becomes:

$$F'(50,50) = P' + S + M(d,f) \qquad (6)$$
$$[d_o \leqq d \leqq 2(\sqrt{2H_t} + \sqrt{2H_r});\ 50 < f_{mc} < 250 \text{ mc}]$$

Where:

$$M(d,f) = 0.001 f_{mc} d + 0.072d - 0.06 f_{mc} - 0.5 \qquad (7)$$
$$(d_o \leqq d \leqq 37.5 \text{ miles } 50 < f_{mc} < 250 \text{ mc})$$

and

$$M(d,f) = 2.2 - 0.0225 f_{mc} \qquad (8)$$
$$[37.5 \text{ miles} \leqq d \leqq 2(\sqrt{2H_t} + \sqrt{2H_r});\ 50 < f_{mc} < 250 \text{ mc}]$$

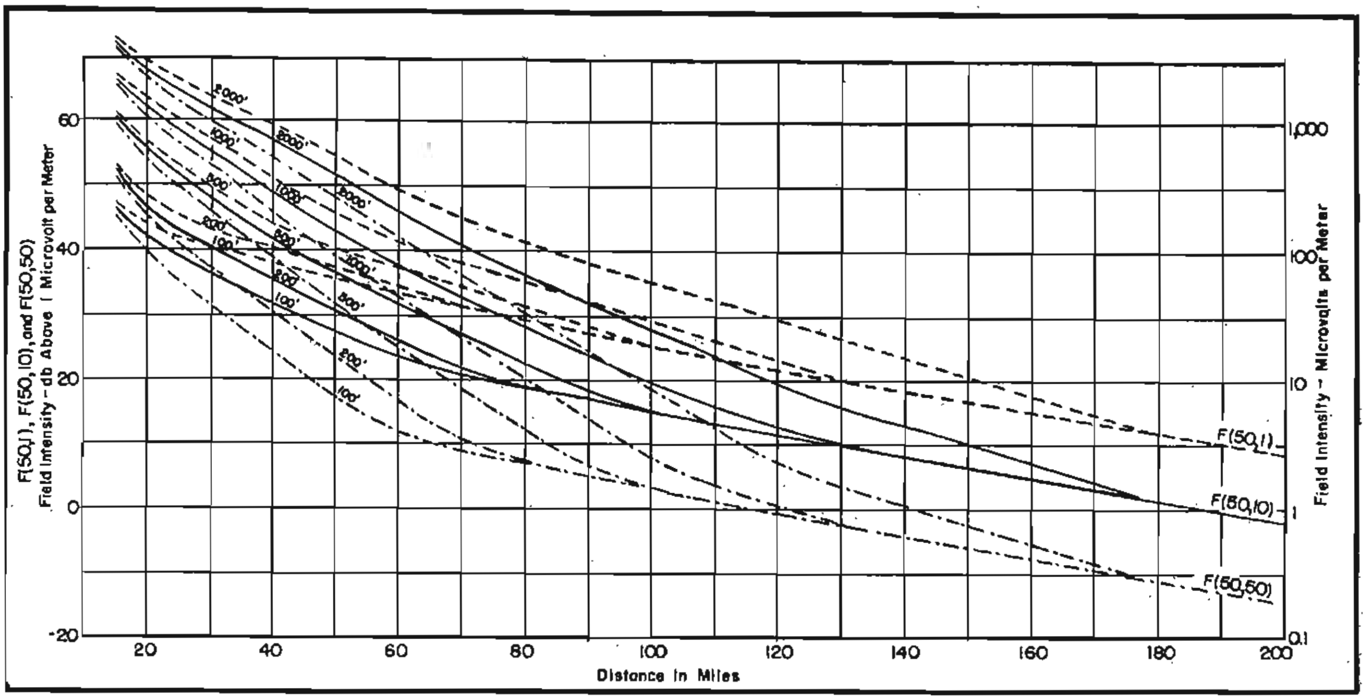


Figure 2
Estimated variation with distance of the tropospheric field intensities exceeded for 1%, 10% and 50% of the time: Radiated power, 1 kw; frequency, 63 mc; receiving antenna height, 30'; transmiting antenna height as indicated. The 1% fields within 95 miles were extrapolated from measured E_{10}/E_{50}, and the 50% fields beyond 95 miles from measured E_1/E_{10}, assuming that the distributions were db-normal. The values shown represent median terrain conditions.

In the foregoing formulas, F' (50, 50) is the field intensity in db above 1 microvolt per meter for a radiated power of P' in db above 1 kw, $M(d,f)$ is the correction to the smooth earth field to give the expected median field over irregular terrain, and is expressed in db, d is the distance in miles from the transmitting antenna, f_{mc} is the *rf* expressed in mc and S denotes the theoretical field intensity expected over a smooth spherical earth with a radius equal to 4/3 of its actual value; S is expressed in db above 1 microvolt per meter and is to be calculated for a power of 1 kw radiated from a horizontal half-wave dipole. The transmitting antenna height, H_t, to be used in these calculations is the height expressed in feet of the center of the actual radiating system above the average level of the terrain 2 to 10 miles from the transmitting antenna location in the pertinent direction. The receiving antenna height, H_r, is the height, expressed in feet, of the antenna above the level of the terrain immediately under it. H_t' and H_r' are the corresponding heights above a plane tangent to the earth of 4/3 radius at the geometrical ray reflection point and allow for the effects of earth curvature in determining d_o.

Figure 1 gives examples of the terrain correction factor, $M(d,f)$, as a function of distance for several frequencies of interest in television allocation problems and for two transmitting antenna heights $H_t = 100'$ and $H_t = 1,000'$. The dashed portions of these curves are extrapolations and thus may not be as reliable as the predictions shown for the intermediate distances.

(B) Evaluation of Random Terrain Variations: In a study* on ground wave propagation over irregular terrain at frequencies above 50 mc by K. A. Norton, M. Schulkin and R. S. Kirby of the Bureau of Standards, appears data which provides a relationship for the estimation of the spatial distribution of field intensities in suburban and rural areas in going around a station at a fixed distance where the median field intensity has been predicted using the foregoing formulas. This will permit the estimation as a function of the distance from the television station of the percentage of receiving locations at which a particular field intensity is available. Thus, it has been found that the field, $F(L, 50)$ exceeded at L per cent of the receiving locations for 50 per cent of the time may be determined from the cumulative log-normal distribution:

$$F(L, 50) = F(50, 50) + R(L) \qquad (9)$$

Where: $R(L)$ is the ratio in db of the field intensities exceeded at L per cent of the receiving locations to the field intensity exceeded at 50% of the receiving locations. For the available data and with the method of analysis used, the distribution function $R(L)$ was found to be approximately independent of the frequency, the distance, and the transmitting or receiving antenna height. As noted, the data were principally for suburban and rural areas. There was some opinion among committee members that the range of signal variation in heavily built urban areas increased with increasing frequency, but no data were available on this matter.

In using equations (*4*), (*6*), and (*9*) for estimating the field intensities expected to be exceeded at a specified percentage of the receiving locations at a distance d from some new station, three kinds of errors may be introduced: (*a*), the new station may be located in terrain which is markedly different from that involved in the measurements used to develop the foregoing formulas; (*b*), the median terrain factor, $M(d,f)$, may not be the true median value even for the kind of terrain encountered in the eastern part of the United States, since it was determined from the measurements on only a few radial lines from only thirteen television stations; and (*c*), the factor, $R(L)$, for very large or for very small values of L may also be somewhat in error. In the opinion of the members of the committee, these equations represented the best presently available data for determining the average effects of terrain and are sufficiently accurate as to be useful for

*See editorial.

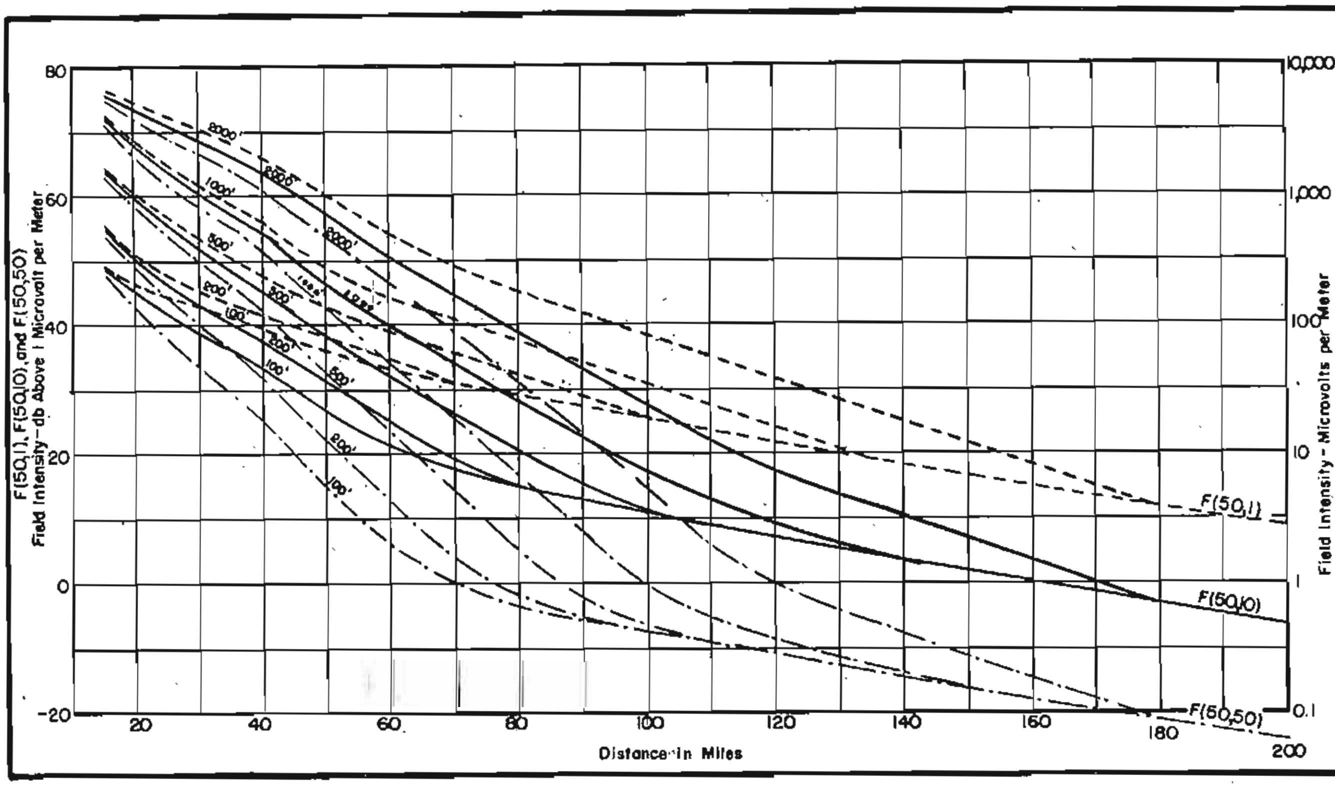


Figure 3
Estimated variation with distance of the tropospheric field intensities exceeded for 1%, 10% and 50% of the time: Radiated power, 1 kw; frequency, 195 mc; receiving antenna height, 30'; transmitting antenna height as indicated. The values shown represent median terrain conditions.

application by the FCC to broadcast station allocations.

(C) Tropospheric Propagation Curves: In its analysis of tropospheric propagation, the committee considered only variations expressed as levels exceeded for various percentages of the total period of recording. Some of the recordings were for the period of a year. Other data for lesser periods were weighted in accordance with the total period of recording so as to render them comparable thereto.

The curves produced indicate the levels of field intensity expected to be exceeded for the indicated percentages of time, at median receiver locations at various distances from the transmitter. They are therefore useful for the prediction of the variation in the intensity of service fields as well as of interference fields. In those cases where a station is so situated that interference does not occur within the distance ranges at which the signal is capable of providing service, the variation in the intensity of the desired signal will produce a limitation to the service rendered by the station, which is a function of time.

The committee found that inadequate theory and insufficient measurements made impossible a precise evaluation of tropospheric propagation at this time. Measurements made at individual recording locations for comparable distances, frequencies and antenna heights varied more than ±10 db, due both to the differences in the terrain and the troposphere. These variations, which tend to obscure the effects of power, antenna height and frequency, are presumed to be due mainly to terrain effects in the vicinity of the receiver, but conditions at or near the transmitting site may also be responsible for apparently systematic terrain effects which have been noted in connection with simultaneous recordings made at different sites in the same direction. In addition, some of this variability is undoubtedly due to differences in prevailing weather conditions over the various paths measured. In spite of these considerations, it is nevertheless considered that the prepared curves will much more nearly depict actual propagation conditions than the ground wave fields previously used, especially at the larger distances.

The data used in the report were unfortunately limited to a restricted number of paths principally along the Atlantic Coast. There are limited data available along the California Coast which indicate that these curves are not strictly applicable to that area. In still other areas, there is reason to believe that the conditions may be systematically different from those represented by these curves. However, the committee was unable to prepare curves for other areas of the country, either with regard to the effects of terrain or of the troposphere, and recommended that the FCC use these curves for all areas until more comprehensive information becomes available.

(D) Method of Combining the Effects of Spatial and Time Variations of the Desired Signal and One or More Interfering Signals: As previously indicated, it was the purpose of the committee to outline only the general principles of combining the several factors which determine the quality of service, since the ultimate application involves policy questions which were beyond the cognizance of the committee.

Before interpreting the practical implications of the studies embodied in this report, there are certain considerations affecting the minimum field intensity required for satisfactory service, which warrant reviewing:

First, there is the problem of interference to be overcome by the desired field intensity, with the interference considered to be constant with respect to time and location, as noise developed in the receiver and cosmic radio noise.

The ultimate limiting factor to reception in a receiver with adequate gain, barring external interfering sources, is the noise produced in the *rf* circuits of the receiver. This is measured in terms of the receiver noise figure, which is a characteristic of the particular receiver design. Cosmic radio noise, being of similar character, can be combined with the receiver

(*Continued on page* 30)

Figure 1
The fifty-position audio switch section, which is 4¾" square and is constructed like an attenuator.

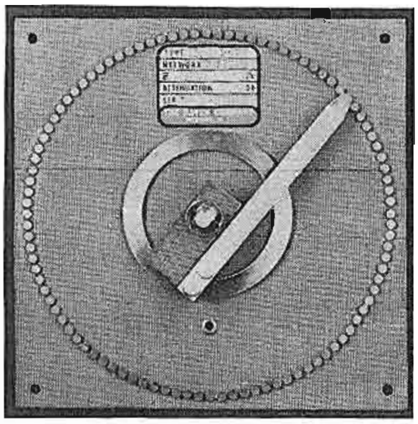
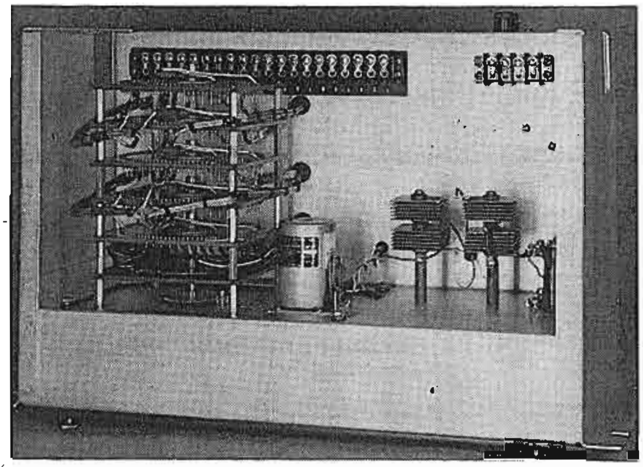


Figure 2
Top view of the *autopositioner* switch unit showing the ganged switch bank. Front section is a control switch. The second section operates lamp circuits and the last four sections are for audio work.



A System of Remotely-Controlled

A PROBLEM which has been ever present with the broadcast engineer, since the first days of broadcasting, is the switching of various program circuits. Switching from one program to another occurs many times during the broadcast day, and when multiple studio operation and several feeds are involved this process can become quite complex. Remote lines also call for their share of attention. Program switching has evolved through a number of stages which are familiar to all. Patch cords, lever keys, interlocking relays, and pulsed stepping switches are all used to good advantage.

In the case of multiple system operation — TV/FM/AM — where extra studios are on the outskirts of the city, it is necessary to operate many program loops and order wire circuits. a job often too big for the telephone cables. As a solution, to obtain full usefulness of all circuits with only a small number of interconnecting telephone cable pair between points, a remote switching system† was devised.

The system accomplishes audio switching right at the central termination point of all lines by a switch bank consisting of individual 50-position sections and 100 contact studs to provide 50 non-shorting circuits. Only every other terminal is wired so that the rotor blade can move from one position to the next without cross-connecting the incoming circuits. Two of these sections are required for each outgoing line from the switch unit. Fifty incoming pairs are then wired to the appropriate switch contacts. Since in this particular application each remote program line also requires an associated order wire, or engineering pair, four switch sections are ganged together to select these audio circuits.

Setting the switch bank to any predetermined position is the function of the head of the switching unit, which in turn is driven by a small two-phase motor. Basically, the remote device consists of an indexed circular plate, called a stop wheel, retained by a relay operated pawl. This wheel is coupled to a torque limiting friction clutch which is geared to the drive motor. The driven element, in this case the switch, is connected to the stop wheel. Whenever the relay is energized it retracts the pawl, the motor switch contacts close and the entire mechanism is set in motion. When the relay is de-energized the pawl drops into an indexing slot and there is a positive stop.

Control System for Relay

So that positioner device can be set up to desired points, a special seeking switch has been included on the main switch bank and a similar switch at the remote control point. The obvious means is to use switches with as many contacts and interconnecting control wires as there are positions to be selected.

One type positioner[1] has a seeking switch directly coupled to the stop wheel. Whenever the selector switch is set to any given position, current flows in the corresponding control wire energizing the relay, and the positioner runs until the seeking switch arrives at the same relative position. The notch on the rotor blade then disconnects the relay allowing the pawl to drop in the proper indexing notch on the stop wheel. The engaged pawl also opens the motor contacts, and the cycle is completed.

However, when a large number of positions are involved, fifty in this case, the interconnecting cable becomes very cumbersome. Also, a large cable is not very practical when the control unit and switching gear are to be separated by any great distance. To realize the full advantages of remote operation, control switches mathematically based on the binary number system were devised. In this way N number of wires plus a common or ground wire will yield 2^n combinations. In practice the number of positions is limited to $2^n - 2$, since there are two unique combinations in the number series which are not physically usable. If five wires and ground are used, the number of positions that can be controlled is $2^5 - 2$, or 30. Six wires and ground allow a possible sixty-two controlled positions. The fifty-position unit shown requires six control wires

†The *autopositioner*.

[1]Type 380.

[2]In the control system equation, $P = 2N—2$, where N equals the number of control wires and P equals the controlled positions.

**From a paper presented at the Third Annual NAB. Broadcast Engineering Conference.*

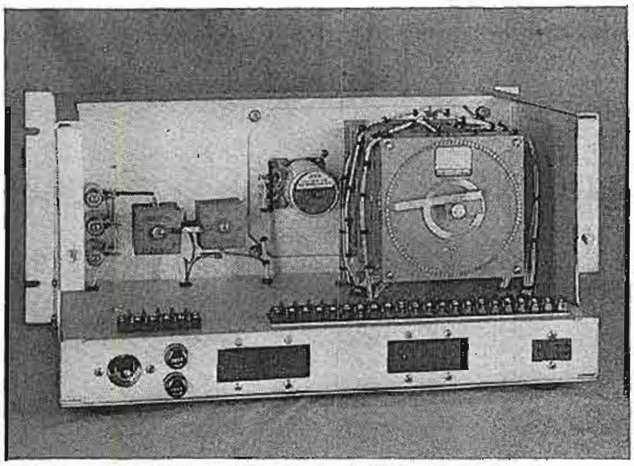


Figure 3
Rear view of the *autopositioner* switch unit. Only five incoming order-wire pairs and five incoming program pairs were wired in this particular switch bank to facilitate viewing.

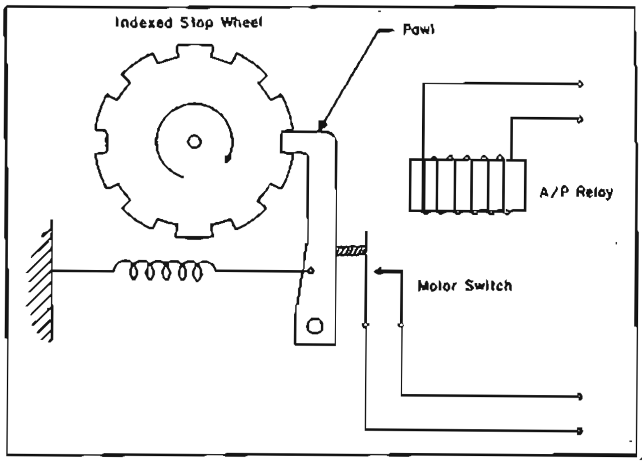


Figure 4
The stop wheel and relay.

*PROGRAM-CIRCUIT SWITCHING**

Switching Setup, Developed to Handle Remote Loops and Order Wire Circuits for AM, FM and TV Stations, Can Control Fifty Program Loops and Fifty Order-Wire Pairs from a Central Location.

by JOHN A. GREEN and ROBERT D. ESSIG
Director — Engineer
Broadcast Engineering Department
Collins Radio Company

and a ground wire, but not all of the possible combinations are used.

Selenium Rectifier Power

Power (*dc*) to operate the positioner relay is obtained from four selenium rectifiers connected in a bridge circuit. No filtering is necessary. An auxiliary relay is energized whenever the unit is running for the purpose of silencing the program output line during the switching cycle.

The remote control box is primarily a fifty-position rotary switch similar to the positioner seeking switch. For ease in setting to a desired channel, the switch has been driven by the knob through reduction gearing. The knob shaft also carries the detent mechanism. A circular dial coupled to the switch shaft has been marked with numbers from *1* to *50*, the set position being read through a small window. Further refinements are the spring return operate toggle and the holding relay which allows a channel to be chosen in advance to the time of actual switching. Lettered neon indicators show when the positioner is running and whether the dial is preset to a new condition or is indicating the channel in use.

Switching Cycle Timing

The positioner's switching cycle requires approximately 0.1 second per position. A ten-position unit, which

Figure 5
Schematic of the mechanical elements showing their relationship to one another. Any number of index notches on the wheel can be used as long as the correct reduction gearing between the index plate and the fifty-position switch shaft is used.

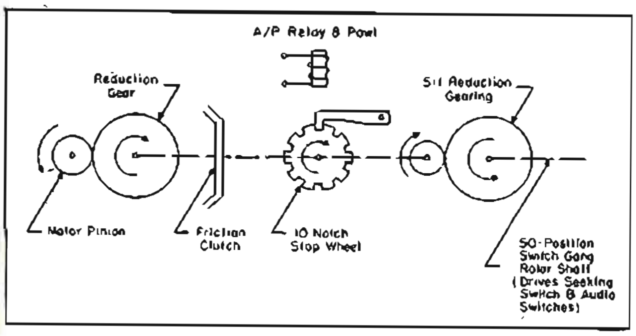
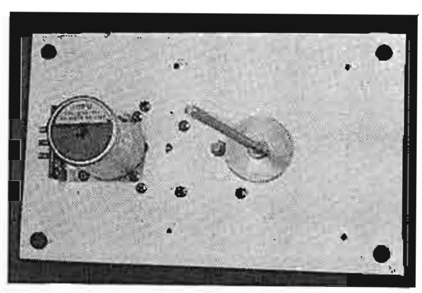


Figure 6
Rear view of the mounting plate, with the switch banks removed.



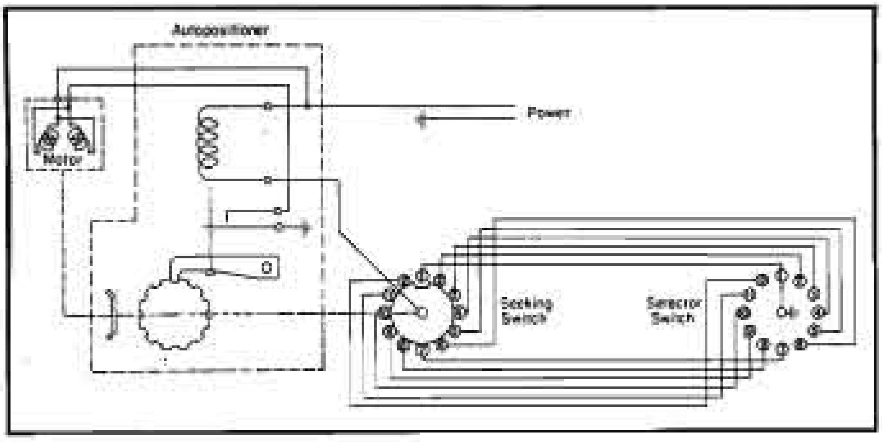


Figure 7
Diagram of the *autopositioner* motor and switch rotor shaft.

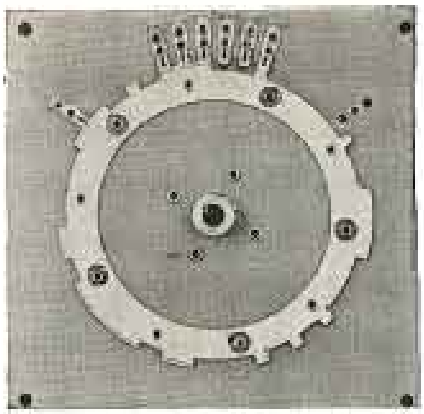


Figure 9
The position control switch. The large rotor has been cut to contact the six clips in fifty different combinations of the binary system.

would adequately serve the switching needs of most stations, would accomplish its most involved switching in one second or less. The fifty-position unit will make one complete revolution in four seconds.

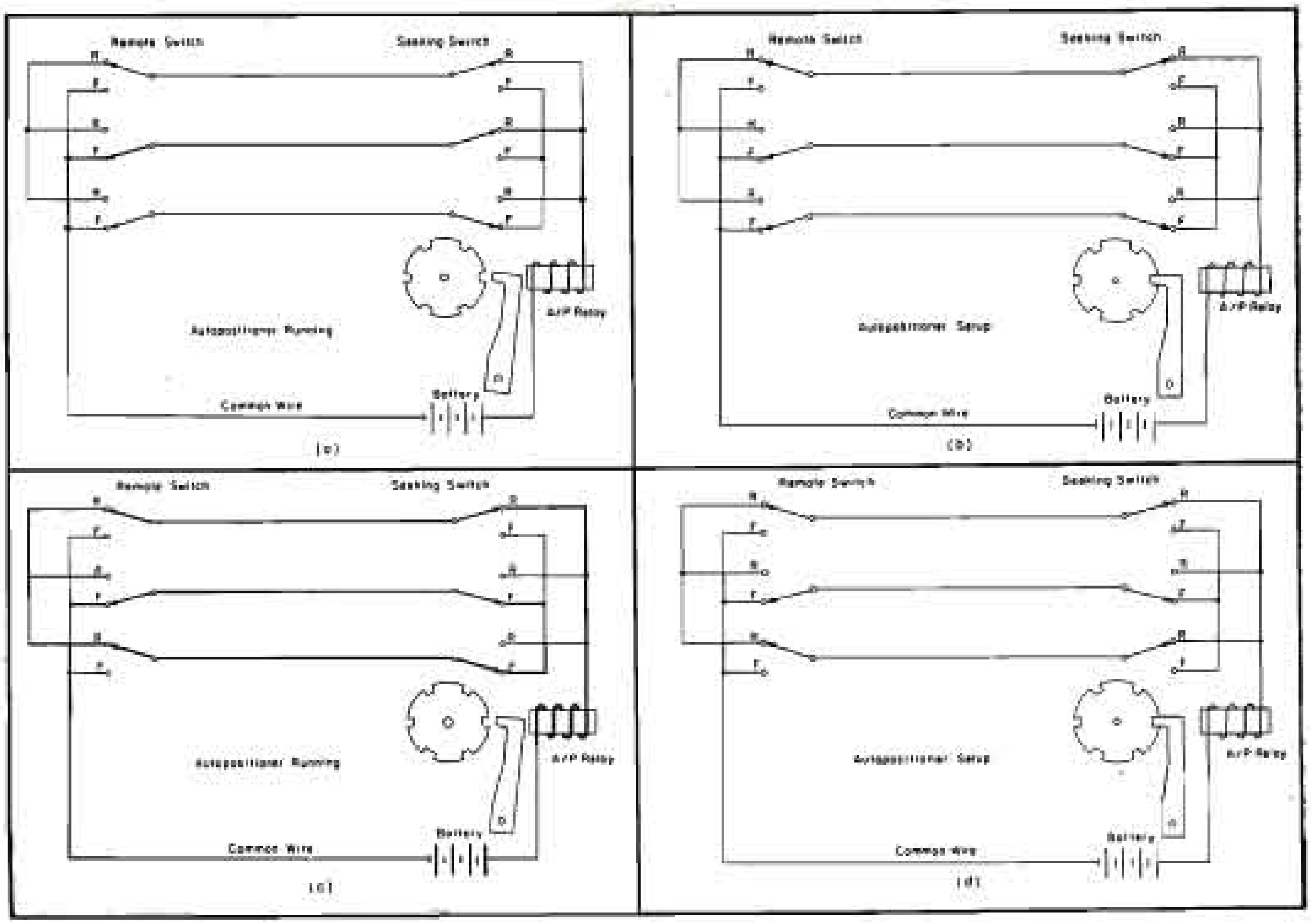
Additional Applications

The uses of the remote switching system are not limited to the broadcast industry alone. As a mechanical positioning device, the positioner can apply torques of 6 inch-pounds directly through the friction clutch, and the driven shaft will actually have a repositioning accuracy of ±0.05 degree. By an expedient of reduction gearing between the control head and the load, useful torque is easily multiplied. When this is done the stop wheel rotates at a higher speed and correspondingly fewer index notches are needed. The limiting case is a stop wheel with one notch. If such a reduction were employed on the fifty-position unit, the available load torque would be 6 inch-pounds multiplied by fifty, or 300 inch-pounds.

Any number of positioner heads can be ganged together and driven by a

(*Continued on page 31*)

Figure 8
Four operational possibilities: In *a*, after the control switch is set, the positioner motor runs until the seeking switch has set up to the same combination. The condition in *b* illustrates how the break in the circuit is made and the pawl is released, stopping the driven unit and shutting off the motor. The conditions in *c* and *d* indicate two other operational conditions, with the positioner running in *c* and setup in *d*.



FREQUENCY DOUBLERS With Low-Q Tank Circuits

Analysis Indicates That Frequency Doublers Can Be Applied Effectively in FM or AM Systems Where the Q May Be 25 or Less.

by R. W. BUCHHEIM

Instructor, Electrical Engineering
Yale University

THE TANK CIRCUIT Q of a frequency doubler may be of the order of *25* or less. Such operation is easily conceivable in a number of practical cases; for example, in a buffer-doubler stage of a transmitter in which the carrier frequency is to be made adjustable over a moderate frequency range without necessitating retuning of the buffer. If the doubler is an AM stage, its tank Q will usually be of the order of 10 to 15. Or, if the doubler is utilized in an FM transmitter in which the deviation is at all large, to prevent distortion it is necessary that the phase characteristic of the tank impedance be linear with frequency, thus requiring a low Q.

When a doubler is to be operated under these or similar conditions, the low tank Q causes the plate voltage wave to appear as shown in Figure 1. Alternate cycles are of unequal height. This faet can be attributed to the tank circuit by either of two modes of reasoning. It can be said that the plate current pulses deliver energy to the tank to overcome losses and thus maintain oscillations at the natural frequency of the tank. The high damping associated with the low Q causes the oscillations to die out at a fairly rapid rate, so that there is quite an appreciable decrement in the oscillations over the two-cycle period between current pulses. It can also be said that, due to the low Q, the impedance of the tank at resonance is not enormously greater than the impedance at a frequency one-half the resonant frequency. Therefore, a plate load of this nature presents a fairly high impedance to the second harmonie component of plate current, to which it is tuned, but it also presents an appreciable impedance to the fundamental current component. That the voltage wave of Figure 1 is a superposition of a fundamental and a larger second harmonic can be seen by inspection.

The fundamental component can be removed and the wave form purified by lowering the tank impedance at the fundamental. This can be done simply by shunting the tank with a series resonant eircuit tuned to the fundamental. A complete tank of this type is shown in Figure 2.

The tank components can be computed by using the following relations:

Let ω_1 be the fundamental angular frequency, and ω_2 its second harmonic.

$$\omega_1^2 = \frac{1}{L_1 C_1} \qquad (1)$$

At ω_2, the impedance, Z_1, of L_1 and C_1 in series is

$$Z_1 = \frac{1 - \left(\frac{\omega_2}{\omega_1}\right)^2}{j\,\omega_2 C_1} \qquad (2)$$

which corresponds to an admittance Y_1

$$Y_1 = \frac{j\,\omega_2 C_1}{-3} \qquad (3)$$

Combining Y_1 with the admittance of C_2, the total admittance, Y_a, is

$$Y_a = j\,\omega_2 \left[C_2 - \frac{C_1}{3}\right] \qquad (4)$$

Equation *(4)* indicates that the network $L_1 - C_1 - C_2$ appears, at ω_2, to be a capacitance C_a, where

$$C_a = C_2 - \frac{C_1}{3} \qquad (5)$$

(*Continued on page* 33)

Figure 1
Low tank Q characteristic plate-voltage wave with alternate cycles of unequal height.

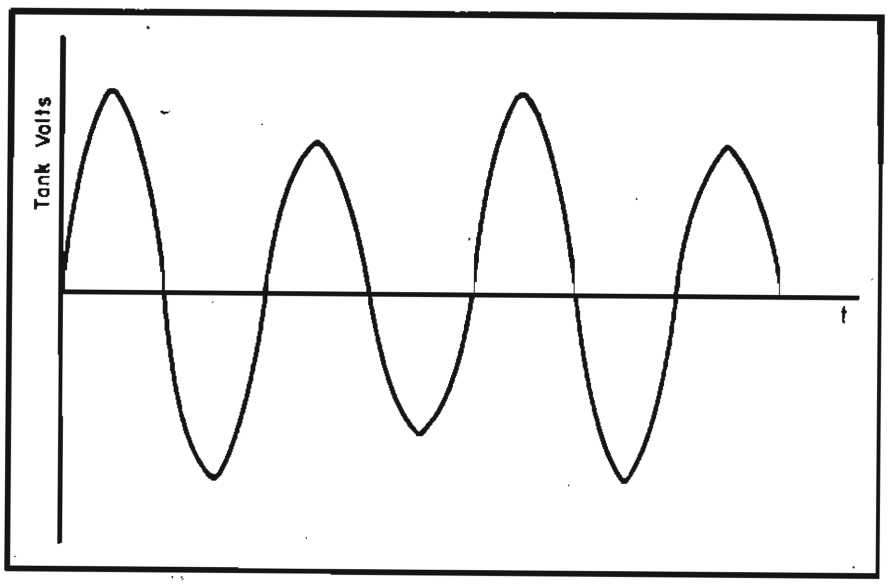
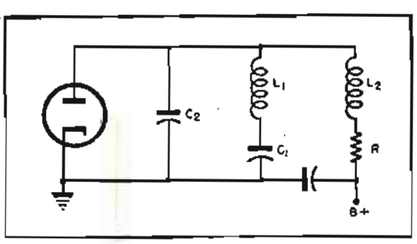


Figure 2
Circuit in which the tank is shunted with a series-resonant circuit tuned to the fundamental.



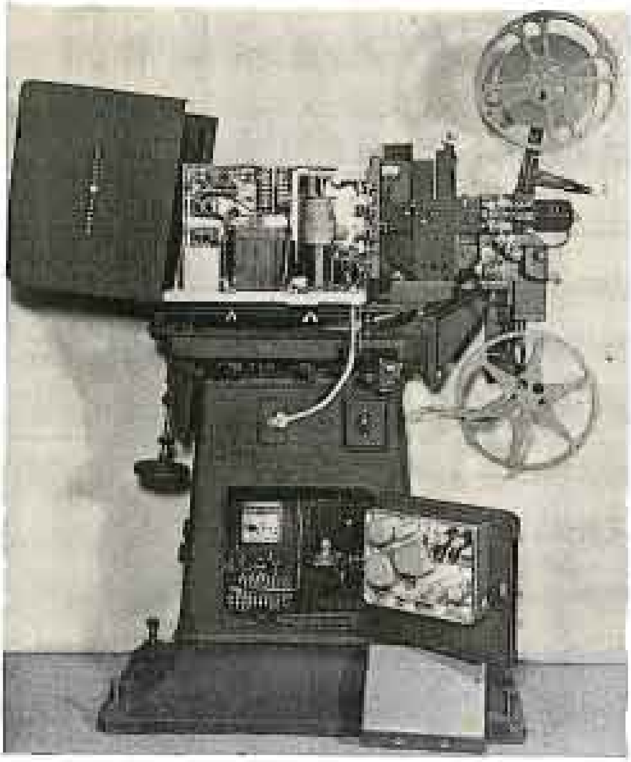


Figure 1
The pulsed-light projector.

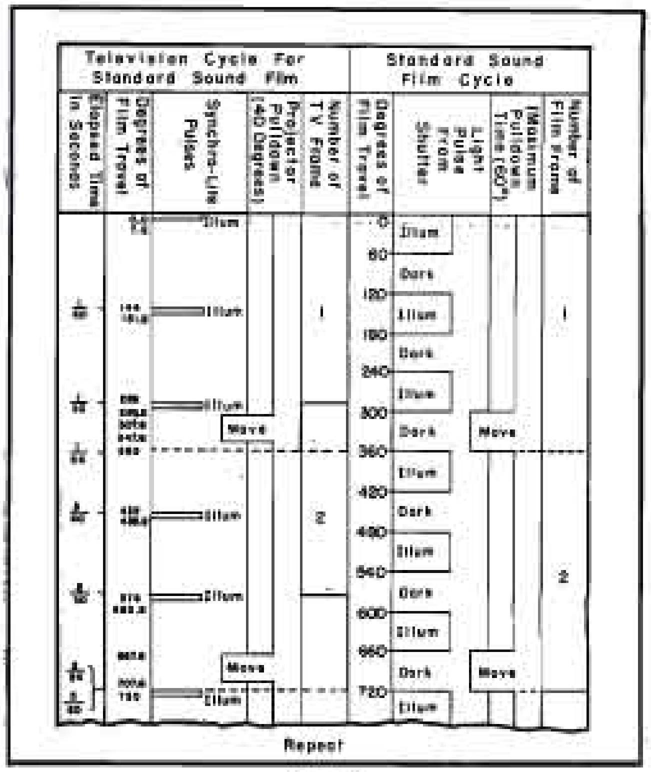


Figure 2
Time cycle of the 16-mm projector.

*TV 16-mm Pulsed-Light Projector**

The 16-mm motion-picture projector and its associated film camera has become the backbone of most TV station layouts. For all stations, 16-mm film consisting of features, newsreels and commercials, account for a large part of the program time and for those stations without direct network facilities, video transcriptions on 16-mm film has become one of the major program sources. In fact, a recent survey shows that about 50% of the program time is accounted for by film transmissions.

In TV service, requiring intermittent motion film projectors the standard sound motion picture film with 24 frames per second must be converted to the 30 frames per second TV standard. In addition, it is desirable to illuminate only during the vertical blanking period of the TV signal and thus the film must be stationary in the gate at this time. An examination of the 16-mm projector time cycle shows the conditions which must be met for illumination time and pull down time. The vertical blanking is set at 5% to 8% of 1/60 of a second so that the illumination time cannot exceed 5% of 1/60 of a second or 830 microseconds. In developing a projector for standard 16-mm motion picture sound film, provision has to be made for the transporting of 24 frames per second intermittently past the aperture. The TV system with its 60 fields per second has 1/2.5 times the 24 frame motion-picture rate. In practice, this ½ frame differential is taken care of by illuminating one frame three times and the next one twice. This imposes restrictions on the maximum pull down time of 7 milliseconds. Fortunately, there are standard 16-mm projectors that have better than 7 milliseconds pull down so that if the projector mechanism is synchronized with the vertical pulse from the sync generator, no special intermittent, such as required for 35-mm projectors, is needed.

As indicated the illumination of the film must be timed to synchronize with the TV sync generator. This can be accomplished either by using a rotating shutter to interrupt a continuous light source such as an arc or incandescent projection lamp or by a system we found very effective, illumination of the film from a pulsed light source[1] timed from the sync generator.

Illumination Requirements

High-intensity illumination has been found necessary to obtain satisfactory reproduction with present film pickup tubes. The short light pulse (830 microsec) for TV is only ⅙ as long as the 50% pulse in a conventional motion picture projector. Thus the light output must be very high to give adequate intensity through a dense film onto the camera tube mosaic. It was found that the pulsed light-source system affords this high intensity illumination without requiring either excessive power or forced cooling.

In operation, the arc in the flash tube strikes between the two tungsten alloy tips, about 6,000 to 7,000 volts being required to break down the gap. The tube is filled with Krypton gas at a pressure of two atmospheres which gives a bluish-white light pulse.

There are three functions a satisfactory pulsed light system must fulfill:

(*1*) Gas between the electrodes must be ionized.

**From a paper presented at the Third Annual NAB Broadcast Engineering Conference.*

Shutterless Projector Uses Pulsed Light from a Krypton Flash Lamp, Controlled by the Sync Generator. Hi-Fidelity Audio Provided, With Frequency Response Equalized and Hum and Microphonics Minimized.

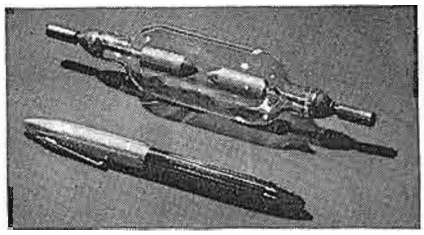


Figure 3
Flash-tube size comparison.

by H. B. FANCHER

Head, TV Transmitter Division
General Electric Company

(*2*) Energy for the light pulse supplied to the lamp.

(*3*) Light pulse cut off at the proper time.

Circuit Elements Required For 3 Functions

In Figure 4 appears a circuit of the pulsed-light system. In the setup a vertical synchronizing pulse from the sync generator is fed through a buffer amplifier and used to trigger the multivibrator which in turn fires a blocking oscillator and thyratron. An *RC* circuit, in the grid of the pulse amplifier tube, is used to filter sharp spikes from the sync line, and to make the circuit insensitive to disturbance on the sync line such as might be caused by power line hash in the ground system. The pulse, developed by the blocking oscillator, is used to drive a 715B high-voltage pulser tube. High voltage for this pulser is supplied by a conventional half-wave rectifier. The output of the 715B is an oscillatory wave having a peak-to-peak value of 15,000 volts with a 1 microsecond period. This voltage appears across the gap of the lamp and performs the first function of ionizing the gas.

Selenium Rectifier System

A much lower voltage, at high current, is required to maintain the arc in the flash tube during the light impulse. This is provided by a three-phase selenium rectifier with an output of approximately 135 volts at approximately 2 amperes, in conjunction with two resonant circuits. In the circuit, L_1 and *C* make up a resonant charging circuit which charges the capacitors to a peak of 600 volts just before the high voltage pulse is applied to the lamp. This charging circuit operates in conjunction with a resonant discharge circuit consisting of L_2, *C*, the flash tube and the thyratron. The duration of the flash and the shape of the light pulse is controlled by this resonant discharge circuit which is so designed that the light pulse will be 4½ to 5% of the 1/60 of a second field rate. This insures that the light pulse will be equal to or less than the lower limit of the vertical blanking period.

Resonant Waveforms

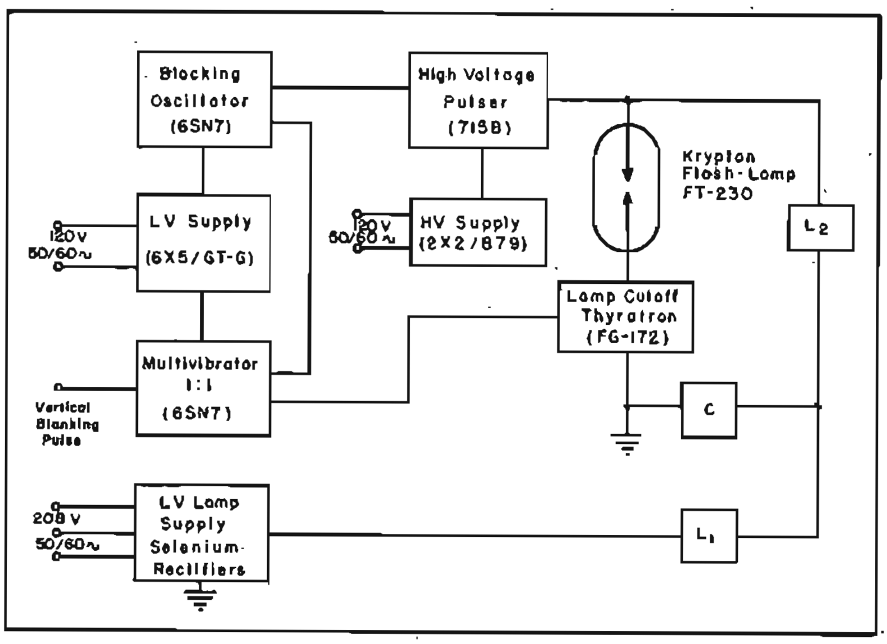
The thyratron carries the full flash lamp current and acts as a diode to cut off the light pulse during the negative swing of the resonant discharge cycle. The peak current, through the lamp, is approximately 70 amperes and the light pulse is a half sine wave which reduces the transient generated in the camera pickup tube over that from a rectangular light pulse. (The unit is fully enclosed with safety interlocks for protection of personnel and with the necessary power switches on the front panel. No adjustable controls other than these power switches to control the high voltage and low voltage power supplies are required.)

Tests have revealed that with average film, the pulse-light system delivers 20% more video signal from an iconoscope film chain than the same film in a system using a 1,000-watt projection lamp and a rotating shutter. From an operating standpoint, the system permits stopping a single frame in the gate, illuminated at full intensity without danger of burning or blistering the film. This allows a channel to be readied for switching on the line with shading, back light, and level adjustments preset and gives the program director a clear image for preview of his available channel.

Lamp House

The optical system, except for the projection lens, consists of a separate

Figure 4
Circuit of the *synchro-lite* system.



[1]Synchro-Lite, using a Krypton filled flash tube (type FT-230) made by the G. E. lamp department.

lamp house with provision for precision mounting and control for the flash lamp, reflector, and condensing lens system.

The condensing lens system is designed to uniformly illuminate the film in the aperture and is so designed with its reflector mirror to eliminate any flicker in the projected picture from arc wander in the flash tube. This is done by allowing sufficient overlap of the aperture by the light beam and by properly positioning the reflected image with respect to the direct image. Both rotation and elevation of the flash lamp is provided to position properly the light source with respect to the optical system. The projection lens itself, completes the optical system. It consists of a 3" f2 *In-crelite* coated lens[1] which projects the correct size picture at a distance of 40" from the projection lens.

The projector head itself is a modified Filmo-arc projector[2] with a standard double-claw type intermittent with a pull down of 4.6 milliseconds. The intermittent movement is driven by a 1,800 rpm, 1/75 *hp* synchronous motor. Since no mechanical shutter is required, the drive motor can be small and consequently, the starting and stopping time is greatly reduced, since there are no heavy elements to add inertia to the system. A starting time of three seconds and a stopping time of two seconds is thus attained. A separate takeup mechanism and motor are included which are also used to provide rewind facilities. Synchronization of the intermittent movement of the film with the TV sync generator is assured since the synchronous motor drive and the TV sync generator are both locked to the power system. Phasing the projector is accomplished by mechanically changing the position between the motor shaft and the intermittent drive shaft with a set-screw coupling. Once the projector is properly phased with the sync generator and other projectors in the same system, there is no need for further adjustment. Since the pulsed-light system properly times the light pulse with the sync generator, no *dc* field on the driving motor is required and the projector will always come up with the proper phase. Complete freedom from the power line frequency can be obtained by synchronizing the projector driving motor directly from the sync generator. This eliminates any pro-

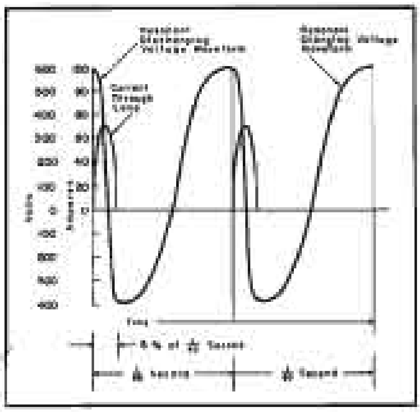
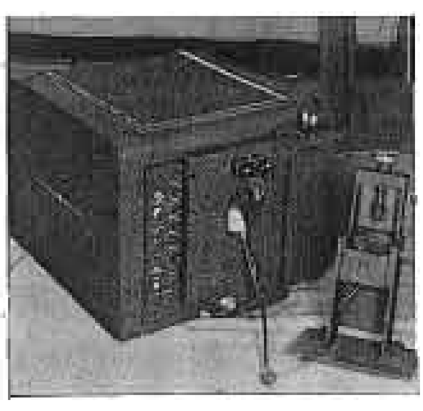


Figure 5
Current and voltage waveforms. The time scale has been distorted to illustrate more effectively the discharging and current waveforms.

jector phasing requirement and permits the station sync generator to be phased with remote or network signal to meet the suggested RMA recommendation concerning continuity of vertical synchronization. A framing device[3] is provided in the projector head to permit exact placement of the film frame in the aperture.

The sound system consists of a conventional exciter lamp, lens, slit, with a photocell pickup. The exciter lamp filament is lighted by a high-frequency (50 kc) supply to eliminate ac hum. A light shield is provided to exclude extraneous light from the room from entering the photocell. After the film leaves the picture aperture, the intermittent motion is largely removed by a continuously moving second sprocket and a third continuously moving sprocket which draws the film at a constant speed from the sound aperture. Vibration removing or damping devices are used. These, known as the sound filter, consist of a weighted rotating flywheel rigidly mounted to the shaft of the roller which carries the

Figure 6
Rear view of the lamp house.



film past the sound aperture. In addition, a device called an oscillatory stabilizer is used to neutralize irregularities in the rate of film travel by transmitting a forward motion of the film on the take-up side of the sound aperture back to the portion of the film that has not yet reached the sound aperture as a backward impulse. This acts so that any change from a constant rate in the travel of the film is made to neutralize itself. Finally, a constant tension take-up mechanism provides a steadily increasing torque, as the wheel becomes loaded with film, and protects against vibration and jerks inherent in a take-up driven by a spring belt with a clip clutch to adjust for differences due to changes in the amount of film on the take-up reel.

Audio System

The audio system has a *pe* cell,[4] which along with a preamplifier, makes up the sound head for the projector. Since the photocell is a low level, high impedance device, the location of the amplifier next to the phototube reduces hum and noise pickup and provides a high-level lower impedance signal which can be passed through a cable to the amplifier in the projector base.

Amplifier, a two-tube affair, has a self-contained power supply and an equalization network to compensate for the film sound track deficiencies. The amplifier itself has a frequency response between 50 and 10,000 cycles within $\pm 1\frac{1}{2}$ db and a noise level 60 db below −20 dbm which is the normal output signal level fed from the unit into a 600/150 ohm line.

The equalization provided will give the system a flat response from 80 to 6,000 cycles from a standard multifrequency test film. Old noisy film may dictate a somewhat reduced frequency range which can be obtained by controls in the equalization network.

The system noise level is made up principally of the random noise from the photocell and first amplifier and microphonics from the projector mechanism. With the projector stopped and a 25% neutral filter in the gate, the noise level is 55 db and with the projector running, the total signal-to-noise ratio is 50 db.

Credits

The writer wishes to acknowledge the work of L. C. Downes and E. H. Lederer of the transmitter engineering division, who contributed to the design of the pulsed-light system.

[2]Bell and Howell.

[3]4,000' reel arms are provided with the projector so that up to 110 minutes of continuous film can be provided with the projector. The intermittent movement and driving mechanism is designed for 1,000 hr life.

[4]Type 918.

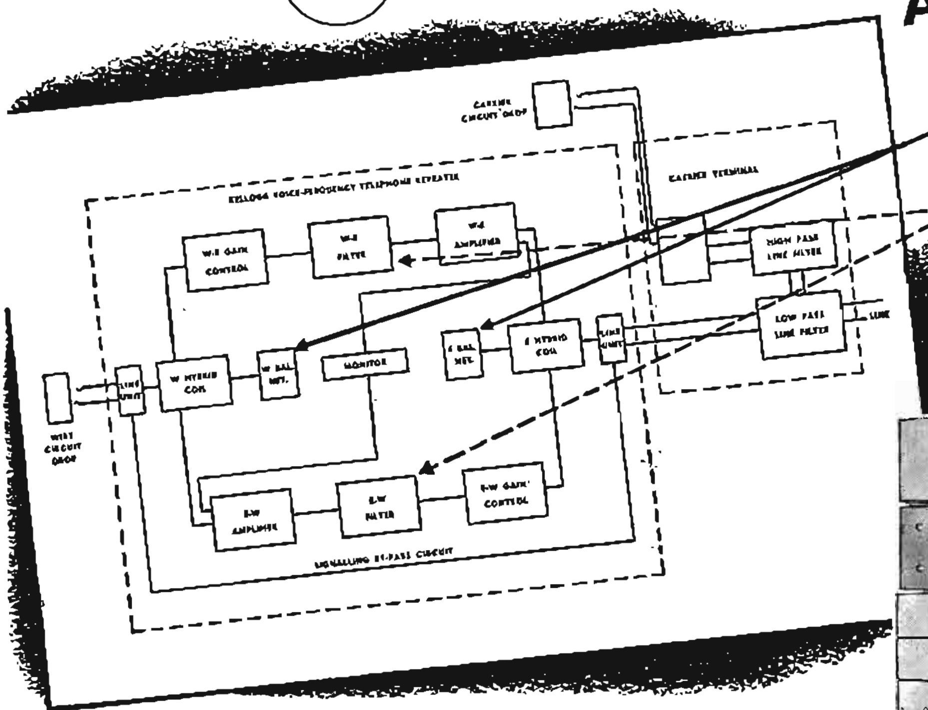
Here's a Question

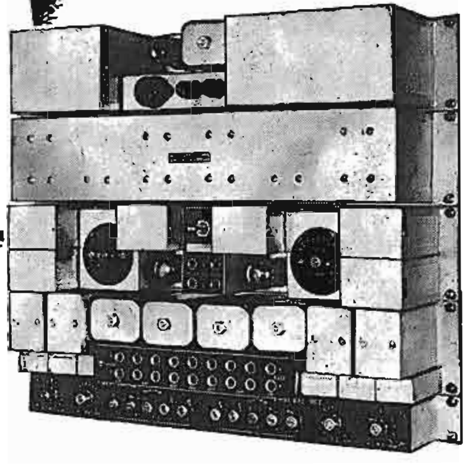
—with an unexpected answer!

Q: Can a reasonable gain be realized from a telephone repeater installed on a wire line over which a carrier system is operating *without* using a special balance network?

A: Yes—if a *Kellogg* Voice Frequency Telephone Repeater is used. The Kellogg Repeater with the standard No. 1 balance network will compensate for the low-pass line filter in the carrier terminal.

This is possible because of the skillfully engineered and manufactured No. 204-2 Filter Unit, which consists of two sharp cut-off, straight-walled, 300-2700 CPS band-pass filters.





By limiting the band of frequencies to be passed and amplified, the No. 204-2 Filter allows maintaining a high degree of balance with a relatively simple network. It thus permits maximum repeater gain on circuits upon which a carrier system is superimposed and on heavily-loaded cable lines. The No. 204-2 Filter also produces a quiet circuit. Its use greatly attenuates any noise voltages outside of the pass-band, eliminates carrier leak and cross-talk and 60-cy. hum induced by adjacent power lines.

Stable balance is easily obtained with maximum ease in the Kellogg Repeater with continuously variable potentiometers and a series of small capacity steps. An ordinary screwdriver quickly makes all adjustments, with no need for strapping. Gain adjustments are accurately calibrated in 1-db steps so gain is always known without necessity for measurement.

"Unit" construction facilitates adaptation to various circuit requirements, while a variety of line units may be obtained for different circuit or signalling functions. Kellogg Repeaters are available for operation from 24V or 48V battery or from a 105-125V 60-cy. AC power source.

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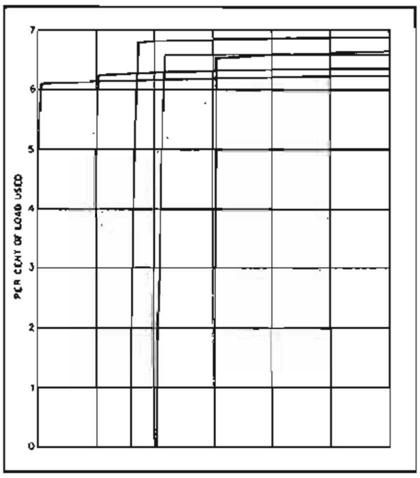
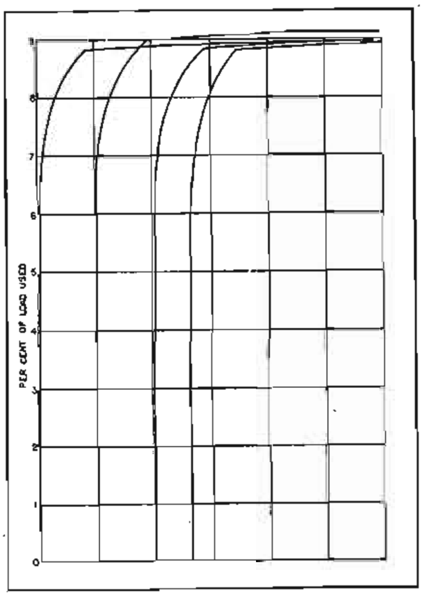
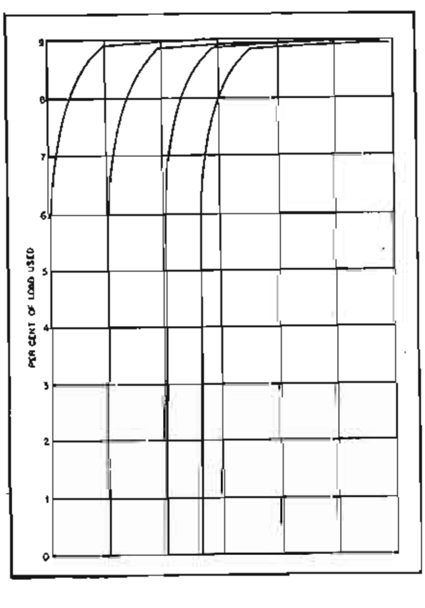
Corrosion In Multiple







Figures 1, 2, and 3 (top to bottom)
Curves shown here are based on electrolytic corrosion tests which indicate the difference between a material that will corrode and one that will not. These are stress-strain curves on small diameter copper wire, before and after the corrosion tests, tests being made on backings of pressure-sensitive papers. A sample showing no corrosion had a cellulose acetate backing, while the sample which corroded used a paper backing. (See COMMUNICATIONS, January, 1949, for detailed analysis of curves.)

IN THE analysis of electrolytic corrosion in coils, in part 1* it was pointed out that leakage paths may be established over the surface of the coils from terminal to terminal, or through insulation from one conductor to another where potential gradients exist, or between conductor and frame through the insulation. Many corrosion failures have been located deep in a coil structure, far from outside surfaces, where a leakage path had formed between the copper of the conductor and ground.

In order to have current flow between wires or between wire and ground or terminal in a coil, it is necessary that the insulating film on the magnet wire be broken to the extent that it is no longer a barrier to the potential impressed on it.

Electrolytic corrosion is frequently caused by minute nicks, or cracks in the film of the wire. This explains why many *opens* in coils, resulting from this type of corrosion, appear as a broken wire. Microscopic examination, however, will reveal greening on the end of the wire.

It must be noted that these factors for producing electrolytic corrosion are essentially the same as those producing chemical corrosion, namely, impurities in the construction, material and moisture—with the flow of *dc* in leakage paths added. This flow of current causing the action described, accounts for the spread of electrolytic corrosion.

In 1937 the theory of electrochemical oxidation of cellulose as a cause of electrolytic corrosion was introduced.[1] Many tests seem to substantiate this as a fact. Electrolytic corrosion will take place in a coil, making use of the purest forms of cellulose insulation, if a *dc* potential and moisture are present.

This corrosion is the result of electrochemical oxidation. Cellulose such as paper or cotton will oxidize at the particular spot, where they contact minute areas of bare copper wire that carry a positive potential in respect to other wires in the coil.

The oxidation products will combine with the moisture to form complicated organic acids, which are good electrolytes. These organic acids migrate within the coil and are readily ionizable. Once these organic acids are present, electrolytic action can take place as previously mentioned. It might well be that the organic acids are corrosive in themselves and also attack the copper chemically.

Galvanic Corrosion

Galvanic corrosion is in the overall corrosion picture in a very mild way. Few open circuits occur from this source, but increased resistance between terminals of coils is often due to galvanic action, which takes place when two dissimilar metals are joined.

The degree of action depends on the relative position of one of the metals to the other in the electromotive force series of the metals. Any metal in this series is negative or cathodic to those below it. Whenever dissimilar metals are joined by amalgamation, contact potentials are set up within the amalgam itself and ion migration takes place within the joint. However, this ion migration inside the joint proper has no bearing on the corrosion problem and is a subject of its own.

The Problem of Moisture

Moisture is again a factor in galvanic corrosion. The *emf* established by the two different metals in conjunction with the moisture forms many galvanic cells or minute batteries at the surface of the metals, the water becoming an electrolyte to complete the circuit. Any or all of the reactions which take place in a battery, such as evolution of hydrogen, dissolving of metals, and plating actions, can take place in the many galvanic cells at the surface of the bi-metal joint. It is these actions which attack the metal, form corrosion, and reduce cross section area to the point where resistances are affected.

Up to this point, the fundamental causes of corrosion in multiple layer coils have been described. These reactions take place in one form or another, regardless of whether the coil makes use of layer insulation or is ran-

[1] Dr. H. N. Stephens and Mr. Gehrenbeck at Minnesota Mining and Manufacturing Company.

* COMMUNICATIONS, JANUARY, 1949.

Layer Wound Coils

Part II* of Report on Progress Achieved In Overcoming Electrolytic Corrosion In Multiple Layer Coils; Tests Used To Determine Characteristics of Corrosion.

by HOWARD ORR

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dom wound without insulation between the layers. The big question is the control of corrosion in a coil.

Multiple Layer Coil Corrosion Control

As mentioned previously, chemical corrosion takes place while the coil is at rest and not energized. Its control can only be effectively maintained by carefully checking the purity of all materials entering into the coil construction. Paper and cotton materials should have a neutral acid number or *ph* if safety from chemical corrosion is to be assured.

This control can be accomplished by extracting or leaching the material under question in distilled water, running a hydrogen-ion concentration check on the extract with a *ph* meter, or titrating the extracted solution against a standardized acid or alkaline solution, depending upon the circumstances.

If the coils are varnish treated, the characteristics of the varnish film after aging must be known, and assurance established that any acids or soaps formed will not be corrosive. As pointed out, ingress of moisture plays a most important part and any treatment, potting in compound, or sealing up that can be done on a coil will help guard against ehemical corrosion. Air-borne impurities, such as CO_2, acid, or alkali, and other fumes in small quantities which combine with moisture to form corrosive solutions should be shielded out by treatment or potting whenever it is possible to do so.

The problems of heat transfer and economics should be given careful consideration in deciding whether or not a coil should be potted or sealed in a can. Last but not least, all flux remaining at soldered or brazed connections should be removed.

Electrolytic Corrosion Control

Control of electrolytic corrosion has been a problem for years and while there is still no control technique universally recognized definite progress is being made in that direction. Due to the magnitude of the problem, many people having a responsibility in the control of materials entering into multiple layer coils, have a method or technique for evaluating electrolytic corrosion. They have established their own technique, whether they are manufacturers of coils or suppliers of materials used in coil structures.

One point definitely certain is that not all materials are subject to electrolytic corrosion and that materials produce electrolytic corrosion in varying degrees. These facts seem to be borne out by all the methods used in evaluating electrolytic corrosion. At the present time, it seems evident that materials which are not subject to electrochemical oxidation and are not ionizable are not subject to electrolytic corrosion.

Some of the materials that do not produce electrolytic corrosion are cellulose acetate, methylamathaculate, polysterene, polyethylene, acetate butyrate and Nylon. Materials which do produce this type of corrosion are kraft paper, rag paper, cotton cloth, tapes, and sleevings, phenolic compounds and animal glues. In the case of paper and cloth, varnish treatments do not guarantee against corrosion of the electrolytic type, and a neutral *ph* is not a guarantee against electrolytic corrosion.

It is well established that in order to have electrolytic corrosion moisture must be present; therefore, one of the first requirements is the conditions under which tests[2] are to be made. Temperature and humidity are especially important. In order that accelerated tests mean anything they must be significant to the service conditions in which coils are placed. Recommended temperatures range from 75° to 125° *F* and humidity from 85 to 100 per cent plus dew. There is little difference of opinion existing on the temperatures within the range given. If salts are used for obtaining a definite humidity according to the *International Critical Tables* the temperature will be fixed by the humidity. Opinion, however, is divided on the proper relative humidity for testing purposes.

One school of thought advances 98 to 100 per cent plus periodie cycles of dew, the theory being that much electrolyte will be produced quickly, current flows will be heavy, answers would be fast and the test would represent the worst condition coils could be subjected to. The disadvantages are, that due to the severity of the test many materials which are entirely adequate for their purpose might be rejected. The condensation or dew precipitated on the material may dissolve a large amount of airborne impurities to form electrolytes which are not produced by the material under test. Of minor importance would be the rapid deterioration of the test fixtures.

The second school of thought on test conditions makes use of humidity between 90 and 95 per cent. Under this condition, the electrolyte formed, which is all produced within, and by the material under test, will show the degree of corrosion, thereby allowing closer eontrol in separation and classification of materials. The formation of heavy current carrying electrolytes on the surface of the material being tested is minimized.

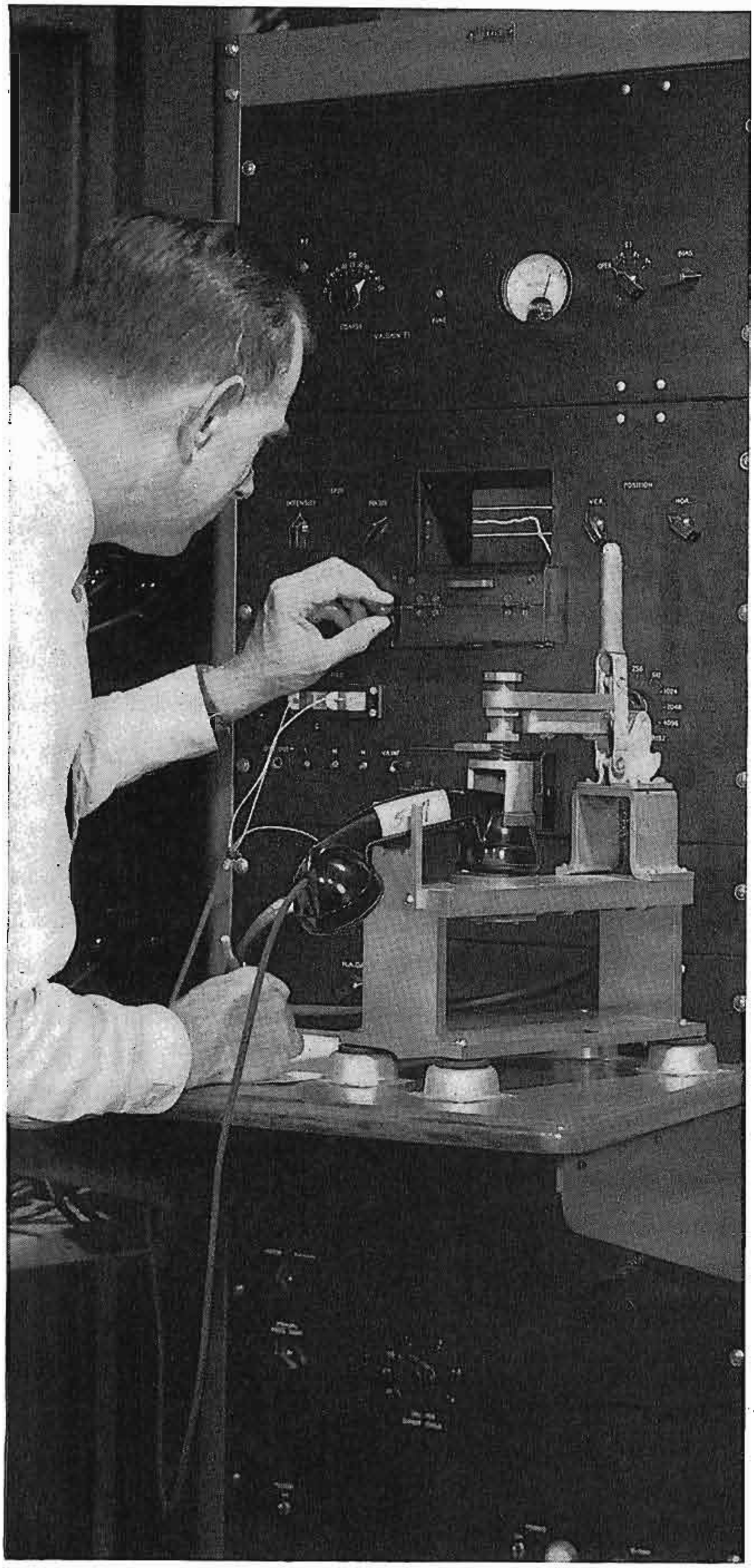
The disadvantages of these lower relative humidities are that some materials may be pronounced non-corrosive, which on a very long time test would produce some corrosion. In acceptance test work, material will be withheld from production for a longer period of time if the lower humidities are used.

[To Be Continued]

[2]In June, 1945, the American Society for Testing Materials established Sub-Committee 7 Section E of Committee D-9. It is the duty of this committee to establish test methods, acceptable to industry, for the evaluation of pressure sensitive tape. One of the properties of pressure sensitive tape requiring evaluation is its electrolytic corrosion factor. It was in this committee that the many individual methods for evaluating corrosion were brought to light.

Each method presented, of course, carries mueh weight and merit. Industry engaged in the manufacturing of coils and also those engaged in the manufacture and supply of coil construction materials have representation on Sub-Committee 7. The work of this committee is pertinent and important to the problem of electrolytic corrosion, because any test methods established for the evaluation of electrolytic corrosion of pressure sensitive tapes will be applicable, with only slight modification, to the other insulating materials.

Evaluation of materials for electrolytic corrosion is of course a big problem. Inasmuch as no method of accelerated test has yet been adopted by ASTM no attempt has been made in this paper to eatalog or place values on the various methods.



TUBE *Engineering News*

The increased use of the *vhf* bands have prompted the production of quite a variety of tubes for fixed and mobile service.

One tube, recently announced, the 5763,[1] a 9-pin miniature *vhf* beam power amplifier, has been designed for use in low-power, mobile transmitters and in the low-power stages of higher-power, fixed-station transmitters. It has a maximum plate dissipation of 12 watts and can be operated with full input up to 175 mc.

In class *C* service at 50 mc, this amplifier can deliver a useful power output of about 7 watts (*ccs*) with a plate voltage of 300 and a driving power of 0.35 watt. With a driving power of 0.6 watt, the tube affords a useful power output of about 2.1 watts as a doubler and 1.3 watts as a tripler.

Features of the 5763 Miniature Beam Power Amplifier, 4-65A Power Tetrode and 811-A Power Triode VHF Tubes Designed for Fixed and Mobile Service.

5763 Installation and Application

The *base pins* of the 5763 fit the noval 9-pin socket, and if used in aircraft transmitters at high altitudes, it is recommended that the socket clip of pin *2* be removed. Removal of this clip will help to insulate the plate (pin *1*), from grid *3* (pin *3*) and thus prevent any flashover.

The *bulb* becomes hot during continuous operation and, therefore, free circulation of air around the tube must be provided. If a tube shield is used, it has been found advisable to paint the inside and outside surface of the shield a matte black, and to provide ventilation slots to prevent the temperature at the hottest point on the bulb surface from exceeding 250° C.

Grid *1* of the tube has been designed with heavy support rods, and has two pin connections (pins *8* and *9*) to permit cooler grid operation. In operation, it is essential that both grid No. *1* pins be connected into the circuit.

In class *C* FM service the 5763 should be operated with grid bias obtained from a fixed supply or from a grid resistor. The use of a grid resistor is preferred because the bias is automatically adjusted as the load on the circuit varies. Because of the high amplification factor of the tube, a small cathode resistor of 68 ohms can furnish sufficient voltage to protect the tube in the event of excitation failure and resultant loss in developed bias. A cathode bias of 3 volts, required for protection, is sufficiently small to make the *dc* plate power loss an unimportant factor.

In class *C* service, the grid current and driving power required to obtain the desired power output will vary with the plate loading. If the plate circuit presents a relatively low resistance to the tube, the desired output can be obtained with relatively low grid current and driving power, but plate-circuit efficiency is sacrificed. Conversely, if the tube operates into a relatively high load resistance, relatively high grid current and driving power are required to obtain the desired output and the plate-circuit efficiency will be high. In practice, a compromise must be made between these extremes.

As stated earlier, the tube can be operated at full input up to 175 fc. However, it is recommended that it be used as a frequency multiplier rather than as a straight-through amplifier at frequencies above 135 mc, to avoid excessive driving power due to *hf* input loading.

Because of the relatively large *hf* currents carried by the grid and plate terminals, heavy conductors must be used to make the circuit connections.

When two or more tubes are used in the circuit, precautions should be taken so that the plate current drawn by each tube is the same.

When more *rf* power is required than can be obtained from a single tube, push-pull or parallel circuit arrangements may be used. Two tubes in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive the tube. With either connection, the driving power required is approximately twice that for a single tube

The 4-65A

Another recently announced *vhf* tube, the 4-65A,[1] a power tetrode, has a maximum plate dissipation of 65 watts and was developed for modulator, power amplifier, and oscillator service. Can be used with full input at frequencies up to 50 mc and with reduced input up to 250 mc.

The 811-A

A third *vhf* tube, for higher power application, the 811-A[1] power triode, has also become available. A pair of these tubes in class *B af* service, with a plate input of 470 watts (*icas*) requires a driving power of 4.4 watts and can modulate 100 per cent an *rf* amplifier having an input of 680 watts.

In unmodulated class *C* service under *icas* conditions, two 811-As operated with a plate input of 520 watts require a driving power at the tubes of about 14 watts. Operation with maximum ratings is permissible up to 30 mc, and with reduced ratings to 100 mc.

In class *B* modulator or *af* service, the 811-A should have an input transformer designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the class B stage when the signal input is small. It should also be designed to handle the required input power for a strong signal. The output transformer should be designed so that the resistance load presented by the modulated class *C* stage is reflected as the recommended plate-to-plate load in the class *B* stage.

In this type of service the tube requires no grid bias at plate voltages up to and including 1,250, but above this value, a small amount of grid bias is required. In *icas* operation of the tube with 1,500 volts on the plate, it is necessary to use a grid bias of –4.5 volts with reference to midpoint of filament operated on *ac*, or about –1.4 volts with reference to the negative end of the filament operated on *dc*.

[Data based on copyrighted information prepared by the Tube Department of RCA.]

[1]RCA.

L-Section Low-Pass

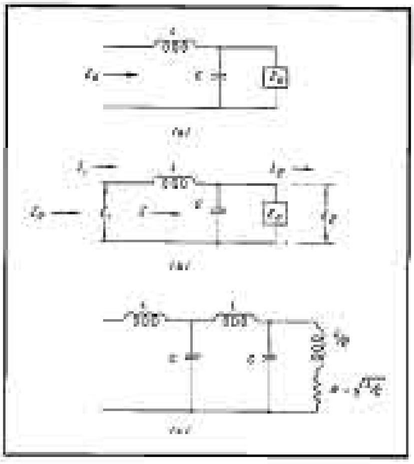


Figure 1
Elementary low-pass filters

Probe of Theory and Design of Low-Pass Filters Based on L-Sections, Commonly Used for Decoupling Purposes and for Smoothing the Output of *DC* Power Supplies Discloses Other Applications Where Some Variation in Transfer Throughout the Pass-Band Can Be Tolerated. Chart Developed to Facilitate Design Work.

by PETER G. SULZER

Research Assistant
Department of Electrical Engineering
The Pennsylvania State College

FILTERS are conveniently specified in terms of Z_o, the characteristic impedance, and f_c, the cut-off frequency. A single-section filter of the type under consideration, terminated in Z_o, is shown in Figure 1(*a*). Defined in the usual way, Z_o is the input impedance of the filter section when it is terminated in that same impedance. Thus,

$$Z_o = j\omega L + \frac{\dfrac{Z_o}{j\omega C}}{Z_o + \dfrac{1}{j\omega C}}$$

Solving for Z_o,

$$Z_o = \frac{j\omega L}{2} + \sqrt{\frac{L}{C} - \frac{\omega^2 L^2}{4}} \qquad (1)$$

As ω approaches o,

$$Z_o \cong \sqrt{\frac{L}{C}} \qquad (2)$$

a pure resistance.

If the filter is always terminated in its characteristic impedance, a source of power connected to the filter will always see that impedance as a load. Cut-off will occur when the source sees a pure reactance, since then no power will be absorbed by the load. This takes place when the square root term in (*1*) disappears. Thus,

$$\frac{L}{C} - \frac{\omega_c^2 L^2}{4} = O$$

and

$$\omega_c = \frac{2}{\sqrt{LC}} \qquad (3)$$

where ω_c is the cut-off angular frequency. Then,

$$f_c = \frac{1}{\pi\sqrt{LC}} \qquad (4)$$

where f_c is the cut-off frequency. It should be noted that the resonant frequency of a series LC circuit is $\frac{1}{2\pi\sqrt{LC}}$. Therefore the cut-off frequency is twice the resonant frequency.

In some applications it is necessary to know the phase shift and time delay through the filter. Referring to Figure 1(*b*),

$$I_1 = \frac{E_1}{Z_o}$$

$$E_2 = I_1 Z = \frac{E_1}{Z_o} \cdot \frac{\dfrac{Z_o}{j\omega C}}{Z_o + \dfrac{1}{j\omega C}}$$

Solving for the ratio $\frac{E_2}{E_1}$,

$$\frac{E_2}{E_1} = \frac{1}{1 + j\omega C Z_o}$$

At low frequencies, (*2*) can be substituted for Z_o, and therefore

$$\frac{E_2}{E_1} = \frac{1}{1 + j\omega\sqrt{LC}} = \frac{1}{\sqrt{1 + \omega^2 LC}} \angle \theta \qquad (5)$$

where $\theta = \tan^{-1}(-\omega\sqrt{LC})$. If the phase angle θ is small, $\theta = \tan\theta = -\omega\sqrt{LC}$, indicating, as might be expected, a lag through the filter. Since

$$t = \frac{\theta}{\omega},$$

$$t = \sqrt{LC} \qquad (6)$$

where t is the delay time through the filter. By combining (*4*) and (*6*) it is possible to obtain the relation that

$$t = \frac{1}{\pi f_c} \qquad (7)$$

The expressions derived so far apply to a filter with any number of sections, since a perfect match is assumed, each section properly terminating the one before it. Z_o and f_c are independent of the number of sections, while the expressions for θ and t must be multiplied by the number of sections.

Effects of Termination

Unfortunately, in practice it is impossible to terminate the filter in the value of Z_o given by (*1*), since this impedance becomes entirely lossless at the cut-off frequency. It is usually necessary, therefore, to use the low-frequency value, given by (*2*), as an approximation. Comparison of (*1*) and (*2*) shows that a somewhat better approximation can be obtained by using $\frac{L}{2}$ in series with a resistance equal to $\frac{L}{C}$ as a termination.

Calculation of the transfer characteristic of the filter is best carried out with the aid of matrix algebra.[1] In using this method, a pair of equations is obtained in the form

$$\begin{aligned} E_1 &= A\,E_2 + B\,I_2 \\ I_1 &= C\,E_2 + D\,I_2 \end{aligned} \qquad (8)$$

where A, B, C, and D are coefficients associated with the network, and I_1 and I_2 are the currents respectively entering the network at the left-hand side and leaving at the right-hand

FILTER DESIGN

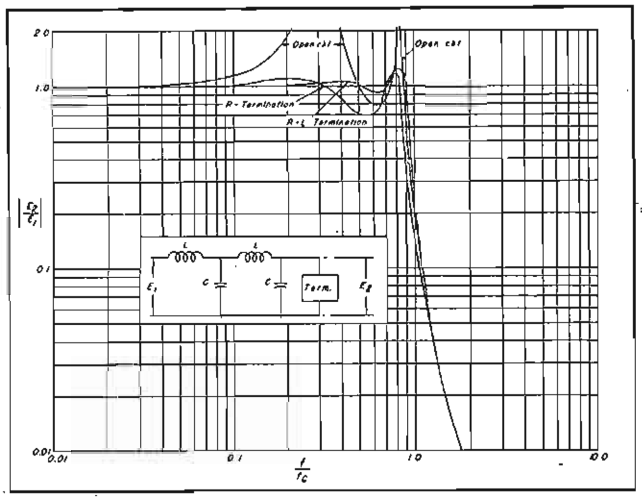


Figure 2
Voltage-transfer characteristics of two-section filters with various terminations.

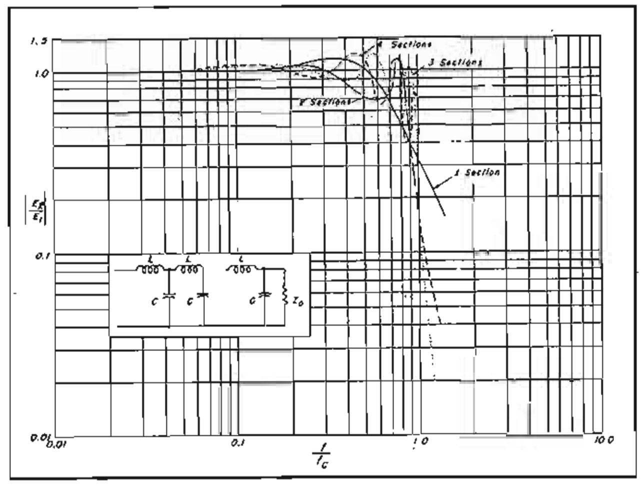


Figure 3
Voltage-transfer characteristics of resistance-terminated filters with various numbers of sections.

side. If the terminating impedance is included as part of the network, the composite network made up of the filter and its termination will see an open circuit, and therefore $I_2 = O$. Then,

$$E_1 = A\,E_2, \text{ or } \frac{E_2}{E_1} = \frac{1}{A} \qquad (9)$$

where $\frac{E_2}{E_1}$ is defined as the voltage transfer characteristic of the filter.

The coefficients A, B, C, and D are the elements of the over-all transfer matrix for the network, which is obtained as follows:

Referring to Figure 1(c), it can be seen that the network is easily divided into series and shunt elements. The transfer matrix for a series element, Z, is

$$\begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & J\omega L \\ 0 & 1 \end{bmatrix}$$

in this case, while the transfer matrix for a shunt element, Z, is

$$\begin{bmatrix} 1 & 0 \\ \frac{1}{Z} & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ J\omega C & 1 \end{bmatrix}$$

To find the transfer matrix for these two sections in cascade, the product of the individual matrices is taken, in order:

$$\begin{bmatrix} 1 & J\omega L \\ 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 \\ J\omega C & 1 \end{bmatrix} = \begin{bmatrix} 1-\omega L C & J\omega L \\ J\omega C & 1 \end{bmatrix}$$

It will be noted that the product has the same number of elements as each of the original matrices (for the square matrices being considered here). Each element of the product is formed by multiplying the corresponding row of the first matrix by the corresponding column of the second. The elements of the row and column are multiplied in order. Thus, for the product formed above, A = (top row of first) $\times$ (left-hand column of second) $= 1 \times 1 + J\,\omega\,L \times J\,\omega\,C = 1 - \omega^2\,LC$.

In analyzing the circuit of Figure 1(c), it is convenient to assign unity values to L and C. The overall transfer matrix is then given by the product of the matrices

$$\begin{bmatrix} 1 & J\omega \\ 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 \\ J\omega & 1 \end{bmatrix} \times \begin{bmatrix} 1 & J\omega \\ 1 & 0 \end{bmatrix} \times \begin{bmatrix} 1 & 0 \\ J\omega & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 \\ \dfrac{1}{1+\dfrac{J\omega}{2}} & 1 \end{bmatrix}$$

from which

$$A = 1 - 3\,\omega^2 + \omega^4 + \frac{J\,(2\,\omega - \omega^3)}{1 + \dfrac{J\,\omega}{2}}$$

Rationalizing, and applying (9), it is found that

$$\left|\frac{E_2}{E_1}\right| = \sqrt{\frac{4 + \omega^2}{4 + \omega^2 - 6\,\omega^4 + 11\,\omega^6 - 6\,\omega^8 + \omega^{10}}} \qquad (10)$$

which is the voltage-transfer characteristic of the two-section filter with $R - L$ termination. In a similar way the characteristics of filters with different numbers of sections and various terminations can be found.

Figure 2 shows $\frac{E_2}{E_1}$ versus $\frac{f}{f_c}$ for two-section filters with various types of terminations. Since the parameters are dimensionless ratios, they can be applied to any filter of the type under consideration. The circuit elements are assumed to be lossless. It can be seen that a very uneven characteristic is obtained below cut-off when the filter is open-circuited. With an R termination a much flatter characteristic is obtained, while the best results are had with the $R - L$ termination.

The different types of termination have very little effect above cut-off. Therefore, when filters of this type are used for decoupling purposes, with the applied frequencies well above cut-off, the type of termination is of no consequence.

Effect of Number of Sections

Figure 3 shows the voltage transfer characteristics of filters with *1*, *2*, *3*, and *4* sections, with resistive termination. It will be noted that the number of maxima is equal to the number of sections. It will also be noted that the attenuation beyond cut-off increases as the number of sections is increased. Table I lists three of the voltage transfer characteristics used in plotting Figure *3*. These characteristics refer to filters with unity values of L and C. For any other filter, ω can be replaced by $2\,\frac{\omega}{\omega_c}$ or $2\,\frac{f}{f_c}$, since for the unity-valued filter $\omega_c = 2$. Therefore,

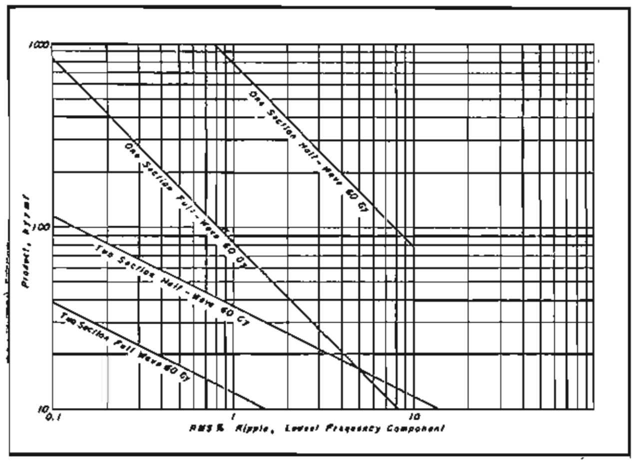


Figure 4
Design chart for power supply filters.

Number of Sections	$\left\|\frac{E_2}{E_1}\right\|$, R termination
1	$\frac{1}{\sqrt{1-\omega^2+\omega^6}}$
2	$\frac{1}{\sqrt{1-2\omega^2+7\omega^4-5\omega^6+\omega^8}}$
3	$\frac{1}{\sqrt{1-12\omega^2+46\omega^4-62\omega^6+37\omega^8-10\omega^{10}+\omega^{12}}}$

Number of Sections	$\left\|\frac{E_2}{E_1}\right\|;\frac{f}{f_c}$ 1.5	$\left\|\frac{E_2}{E_1}\right\|;\frac{f}{f_c}$ 2.0	$\left\|\frac{E_2}{E_1}\right\|;\frac{f}{f_c}$ 2.5	$\left\|\frac{E_2}{E_1}\right\|;\frac{f}{f_c}$ 3.0
1	$\frac{1}{8.55}$	$\frac{1}{15.5}$	$\frac{1}{24.5}$	$\frac{1}{35.5}$
2	$\frac{1}{58.8}$	$\frac{1}{218}$	$\frac{1}{556}$	$\frac{1}{1200}$
3	$\frac{1}{377}$	$\frac{1}{2910}$	$\frac{1}{12,600}$	$\frac{1}{39,800}$

Table I
Values calculated for a resistive termination; they can also be applied to open-circuit termination with reasonable accuracy.

as $2\frac{f}{f_o}$ becomes mueh greater than unity,

$$\left|\frac{E_2}{E_1}\right| \cong \frac{1}{\left(2\frac{f}{f_c}\right)^{2n}} \qquad (11)$$

where n is the number of sections. This is a useful relation, because it gives the attenuation through the filter in compact form. Since this relation applies only to filters operated well beyond cut-off, it will hold under open-circuit conditions, and can also be applied with fair accuracy to any termination likely to be found in practice.

Table I also lists $\frac{E_2}{E_1}$ for various values of $\frac{f}{f_c}$.

Applications

Power-Supply Filters: By employing *(11)* it is possible to obtain a simple relation between the *rms%* ripple (*rms* value of lowest-frequeney ripple component/*dc* output voltage, times 100) and the *LC* product of the filter section. By substituting *(4)* in *(11)* it is found that

$$\left|\frac{E_2}{E_1}\right| = \frac{1}{\omega^2 LC}$$

for one section. Considering a full-wave rectifier operated at 60 cps, the lowest ripple frequency is 120 cps; *(11)* then becomes

$$\left|\frac{E_2}{E_1}\right| = \frac{1.76}{LC}$$

With this type of rectifier the peak value of the 120-cycle ripple is $\frac{2}{3} \times dc$ output voltage.[2] The per cent ripple is then given by

$$rms\,\%\text{ ripple} = \frac{\frac{2}{3}\times\frac{1}{2}\times dc \times 1.76 \times 100}{LC \times dc} = \frac{83}{LC}$$

Similar results can be obtained for other types of rectifiers and different numbers of sections. Figure 4 shows $L \times C$ versus *rms%* ripple for half-wave and full-wave rectifiers operating at 60 cps with one-section and two-section filters. With two sections the LC product refers to each section alone. The seetions are assumed to be equal, which is the most economical design.[8]

Considering an example, suppose it is desired to design a full-wave 60-cycle power supply with 0.1% *rms* ripple. Referring to Figure 4, a one-section filter will require an *LC* product of 840, while two sections will require an *LC* product of 38. Thus, with one section a capacity of 80 mfd could be used with an inductance of 10.5 henrys; while with two sections, two 40-mfd capacitors could be used with two 1-henry ehokes. The second design is much more economical.

Decoupling Filters: Decoupling filters are commonly used to block a *hf* signal, while passing *dc*, or some low frequency. The variables for purposes of design are L, C, and Z_o. To find the relations between the three variables, *(2)* and *(3)* can be solved simultaneously for L and C. Thus,

$$L = \frac{Z_o}{\pi f_c} \qquad (12)$$

$$C = \frac{1}{Z_o \pi f_c} = \frac{L}{Z_o^2} \qquad (13)$$

Figure 5 is a plot of L and C versus f_c, with Z_o as a parameter. In drawing this chart, an attempt was made to cover the maximum possible frequency range consistent with a reasonable percentage accuracy. Therefore, it is not necessary to refer to auxiliary charts in order to interpolate between decades. The frequency range is from 1,000 cycles to 100 mc, while the characteristic impedance range is from 1 ohm to 100,000 ohms. Use of the chart is best illustrated by the following example:

An *if* amplifier was designed with a voltage gain of 10 per stage, a bandwidth of 5 mc, and a center frequency of 30 mc. Because of the low plate-supply voltage available it was necessary to use LC decoupling filters in the plate supply between stages instead of the usual RC filters. To minimize regeneration it was desirable to have an attenuation $\left(\frac{E_2}{E_1}\right)$ of at least 25, with only one section. Referring to Table I, it can be seen that the desired ratio $\frac{f}{f_c}$ is 2.5. Thus a cut-off frequency of 12 mc was chosen. The largest plate-bypass capacitors available were .001 mfd ceramicons. Referring to Figure 5, the intersection of 12 mc and .001 mfd gives a Z_o of 27 ohms. It will be noted that capacity is read downward on the right-hand side of the chart, and that the lines slanting upward to the right indicate the capacity for different values of Z_o. Referring to the left-hand side of the ehart, and using the lines that slant downward to the right for Z_o, the required inductance is 0.7 microhenry. The inductance was measured by resonance at 6 mc with a .001 mfd capacitor; see *(4)*.

It was desired to place another such filter between the detector and the video amplifier of the same *if* strip. The maximum video frequency to be passed was 5 mc. However, to preserve the phase response of the system, it was decided to make the cut-off frequency of the filter 10 mc. Thus $\frac{f}{f_c}$

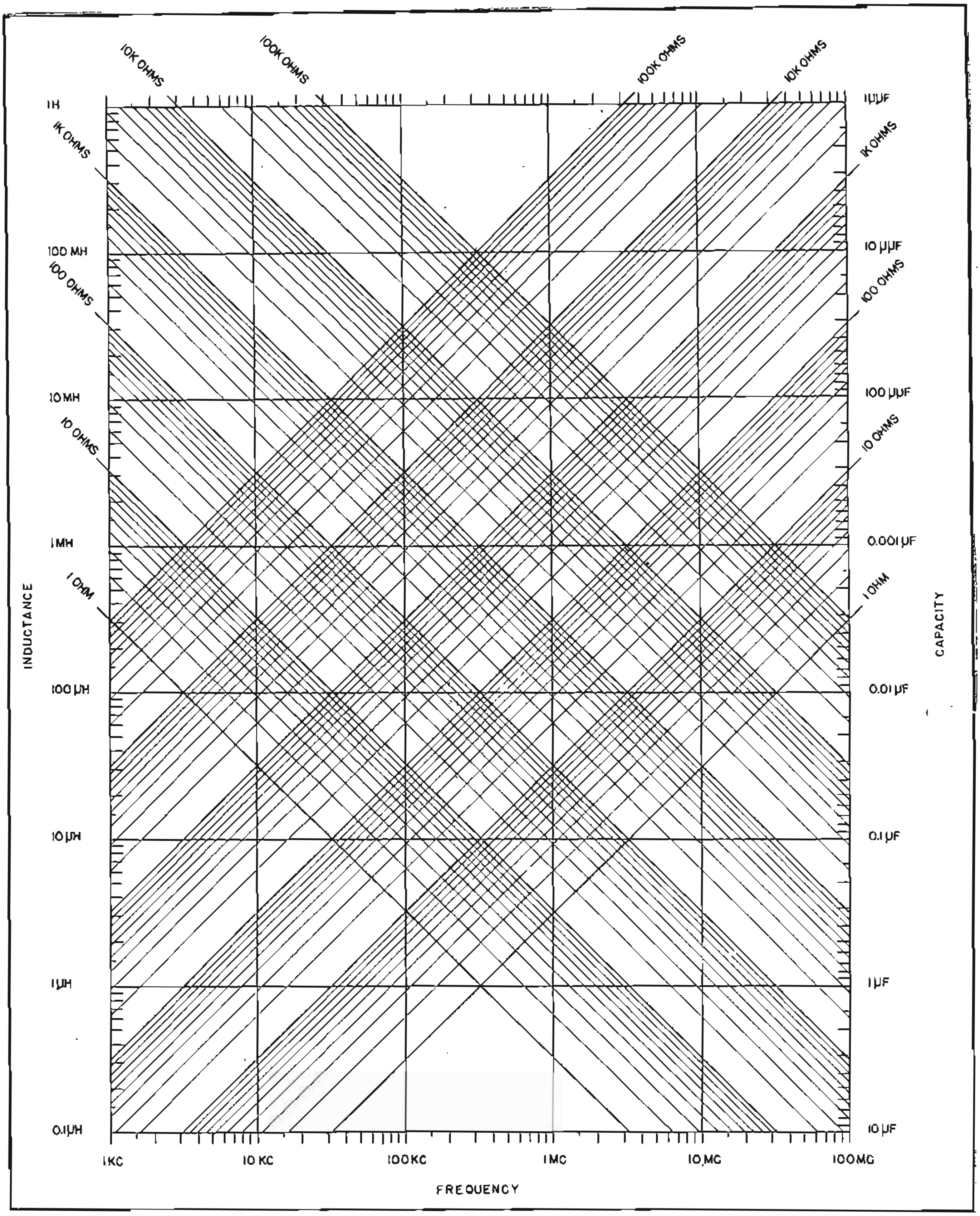


Figure 5
Design chart for decoupling filters.

became 3. The input capacity of the video amplifier, including a connector and short cable, was 20 mmfd. Knowing f_c and C, it is possible to find Z_o and L from Figure 5. These values are $Z_o = 1{,}600$ ohms, and $L = 51$ microhenrys. The required attenuation through the filter was 1/10,000, which was necessary to prevent *if* regeneration with the poor shielding used. Referring to Table I, it can be seen that three sections were required. Since this filter delayed the video signals, the magnitude of the delay was of interest. With the aid of (7), t was found to be .0318 microsecond per section, or a total of .095 microsecond. In a radar set this would cause a range

(*Continued on page 32*)

AIRBORNE ELECTRONIC

In planning the mock-up of the fuselage, the use of the solid material and the double-shielded approach was considered. After considerable investigation it was decided to use 4 x 4 mesh hardware cloth in the construction of the mock-up fuselage. This material when carefully soldered at all overlapping and mating surfaces proved to be fully as adequate, electrically and mechanically, as solid metal for simulating the skin of the aircraft. Also the mesh of this material was coarse enough to allow sufficient passage of air and light to eliminate a ventilating and lighting problem within the fuselage. This material is rigid enough to be partially self-supporting, easily soldered and readily formed into any shape.

Fuselage Design

The simulated aircraft fuselage was constructed on a wooden frame which provided the necessary rigidity; flooring, bulkheads and shelves were made of plywood covered with hardware mesh cloth which was carefully soldered (bonded) at all joints. The mock-up was made full scale; the dimensions, location of shelves, bulkheads, position of equipment, routing of cables, and locations of antennas obtained from drawings of the aircraft.

Antenna Patterns

It was not considered feasible to obtain antenna patterns on a full scale mock-up in a shielded room. However, any interaction, interference or mal-functioning of equipments produced by antenna coupling on a mock-up compares favorably with an actual aircraft installation.

Power Considerations

Power for the electronic equipment is obtained from the generator specified for the particular aircraft under investigation. The aircraft engine-driven generator is operated by a vari-drive generator test stand located in a screened room adjacent to the screened room containing the mock-up. The vari-drive is capable of driving the aircraft generator under its normal load and speed conditions. The power regulators, cutout and aircraft battery are located either near the generator or in the fuselage depending upon the aircraft installation. Power and other connections between generator and mock-up are routed through a conduit between the two rooms.

Systems Analysis Procedure

The system analysis begins with a careful check of each equipment prior to installation in the mock-up to make sure that equipments being used are functioning normally in every respect. The equipment is then installed in the mock-up placing the components as close as possible to the location designated for each equipment in the production aircraft. Interconnecting cables are fabricated using unshielded wires in the initial installation except for coax cables and other wires that are known to require shielding. The interconnecting cables are also located in the mock-up as near as possible to the position specified on the production aircraft drawing. The various equipments are interconnected in compliance with the requirements and specifications set up for the aircraft, i.e., all radio receiver audio and transmitter side tone circuits are connected to the intercommunication system.

Checkups

At the completion of the installation, including all power and electronic equipments for the aircraft, each equipment is carefully checked in every respect to determine if it is functioning normally. Equipments that do not function normally are checked to determine the cause, and corrective action is taken. Then all equipments are turned on simultaneously and each is carefully checked to determine if any other equipment in the aircraft, when operated in a normal manner, causes any malfunctioning or otherwise interferes with the equipment being checked.

Mock-Up Results

Briefly some of the causes of airborne system malfunctioning, experienced in these mock-ups, are:

(*a*) Reduction in output or sensitivity due to mis-matched impedances or parallel operation of antennas, phones, etc.

(*b*) Electrical interference or interaction between controls; i.e., audio level at one position affects level at another station.

(*c*) Insufficient adjustment of individual equipments to allow composite aircraft system to function as required.

(*d*) Voltage regulation of power equipment poor with sudden changes in load from no-load to full-load.

(*e*) Overloading of wiring, fuses, circuit breakers, and power generating and control equipment.

(*f*) Lack of protection for some circuits.

(*g*) Power equipment frequency variation adversely affecting equipments; i.e., causing overheating, excessive ripple, abnormal voltages, etc.

Interference Problems

Electrical interference between units is another serious trouble encountered in a composite system. Equipments which may be interference-free when operated independently may cause enough interference to render all other equipment in the aircraft inoperable. The major sources of interference found in the system covered at this activity have been found to be:

(*a*) Interference from rotating machinery; dynamotors, inverters, *dc* motors and generators.

(*b*) Interference produced by interrupted sources; vibrators, relay contacts, finger type voltage regulators and many other devices of a similar nature.

(*c*) Pulse-type interference produced by radar modulators, multivibrator circuits, sweep circuits, marker pulses and spark tubes.

(*d*) *Rf* oscillator leakage produced by crystal, beat, master and local oscillators.

(*e*) Spurious signals produced by buffers, harmonic amplifiers and transmitter, final amplifier, fundamental and harmonic frequencies.

(*f*) *Hash* type interference produced by video signals.

Systems Analysis in the Lab

Part II . . . Constructional Features of Full-Scale Mock-Ups Used to Check Characteristics of Antennas and Their Patterns, Power Systems, etc. Procedures Used in Systems Analysis to Determine Features and Faults in Projected Airborne Setups.

by J. J. MacGREGOR and K. L. HUNTLEY

Senior Electronic Engineer — Electronic Engineer

Naval Research Laboratory

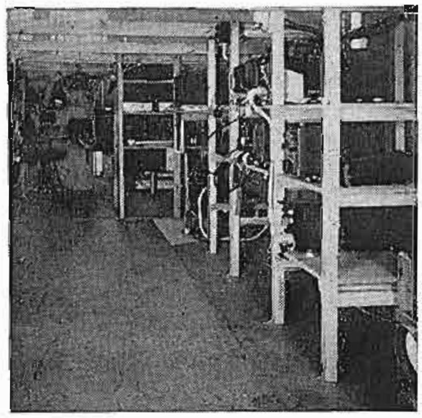


Figure 1
A forward view of the operator's position in the mock-up.

In the analysis of electrical interference it is usually imperative to determine: (*a*) the source of interference, and (*b*) various paths by which it is being conducted to the affected equipment, that is; line conducted interference, radiated interference or a combination of both. Receivers which cover the interference frequency range and are equipped with a loop probe are essential for this phase of the investigation.

After the previously mentioned interference information is determined corrective action can be taken. Usually this is done at the source of interference and consists of adding a properly designed filter, shielding, isolation, bonding, etc. However, in some cases it may be necessary to apply the corrective measures on the equipment which is experiencing the interference. No definite instructions can be given for any particular interference or equipment, but careful analysis of all pertinent information together with technical and practical knowledge of filters and interference will enable one to correct the most severe cases of interference.

Systems-Analysis Value

This *systems-analysis* activity proved that the logical place for such work is in a laboratory where all necessary test facilities and a wealth of technical information are available. Practically all of the malfunctioning, interaction and interference problems which had been arising in the field were eliminated as a result of this activity. To expedite the providing of usable systems to the service groups it was often necessary to incorporate corrective measures which were applicable to that particular system in a particular type of aircraft. In all cases where the correctives were made at the source of the trouble they were adequate for any installation. The reason this was not always possible was that it would require a major modification to production equipment with a resultant delay in delivery . The wartime urgency made temporary correctives mandatory. With peacetime removal of this urgency and closer cooperation between military agencies and manufacturers, many if not all of the difficulties revealed by system analysis can be eliminated.

Group's Expansion

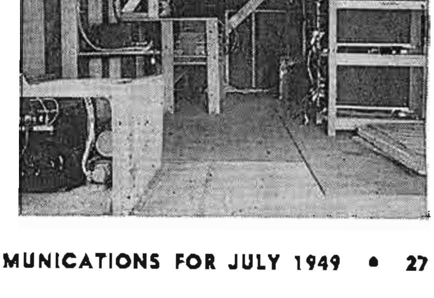
The *system analysis* group worked on approximately 60 systems none of which were entirely adequate and many not usable in the original form. This is no reflection on any individual's ability to work up a system, as in all cases discrepancies were entirely unpredictable. Actually the originators of the system did amazingly well.

In its early stages this activity consisted of two radio engineers, two Naval chief radiomen and one screened room with which it was possible to conduct work on but one system at a time. However, the results of this work so conclusively established its importance that the Bureau of Aeronautics immediately authorized expansion of the project. Accordingly it soon reached its peak performance with a group of 22 engineers and facilities for conducting an analysis of five systems simultaneously. This condition obtained substantially the same throughout the war. While it is no longer being conducted at NRL the project has been set up on a permanent basis by BuAer at other Naval agencies. The techniques and facilities developed at NRL are still largely used and personnel trained there are responsible for the work at some of these agencies.

Credits

The writers wish to acknowledge the aid of persons in the Bureau of Aeronautics, especially Captain L. V. Berkner, whose foresight and cooperation made this project possible; also members of the Airborne Electronic System Analysis group at the Naval Research Laboratory who contributed much toward making this a successful project.

Figure 2
A forward view of the patrol aircraft navigator's position.



The Industry Offers

CLARKE INSTRUMENT PHASE METER

A *phase meter*, model 108-C, has been announced by Clarke Instrument Corporation, 910 King Street, Silver Spring, Md. Phase indication is displayed on a meter marked in two-degree intervals. Normally supplied for operation in the standard broadcast band. Adaptable to other frequency ranges on special order.

* * *

C-D TRANSMITTER MICAS

A line of transmitter mica capacitors with universal mountings, for use in low power transmitters for plate or grid coupling, filament, and plate bypass applications, has been announced by the Cornell-Dubilier Electric Corp., South Plainfield, N. J. This line, the Faradon NF series, is similar to type 9 except for different case style and mounting arrangement.

The dimensions of these capacitors are 1 13/16" x 9/16" x 1 7/16" over-all, with a choice of a vertical mounting with insulated mounting holes tapped for a 6-32 screw, or a horizontal mounting with brass terminal bushings tapped for a 6-32 screw. The latter type has insulated slotted mounting holes and insulated spacer feet to permit assembly against a chassis. Solder lug terminals and brass terminal bushings tapped for 6-32 screws provide an optional method of making electrical connections. The rating range is from .00005 mfd with 2,500 *dc* working volts to .03 mfd with 600 *dc* working volts.

* * *

G.E. PLUG-IN AUDIO AMPLIFIERS

AM, FM and TV plug-in audio amplifiers have been announced by the transmitter division of G. E.

The amplifiers plug into Cannon receptacles mounted at the rear of trays, which fit into a shelf which can be mounted in any standard 19" cabinet or relay rack. A hinged front panel on the shelf permits replacement of amplifiers and tube check from the front of the rack. A special extractor tool attached to the rear of the front panel makes it possible to slide out any desired amplifier for maintenance in a matter of seconds.

* * *

COMPTON CAPACI-RING

A *Capaci-Ring* designed to simplify the problem of socket terminal *rf* bypassing, which combines, in one compact shielded unit, four separate mica capacitors isolated from one another, has been announced by the Compton Company, Bethesda, Maryland.

Sections are provided for heater, screen and cathode with the lead from each section properly located adjacent to the appropriate socket terminal.

The standard *Capaci-Ring*, type 8 MA, is designed for application to the 7-pin miniature tube socket.

The unit is designed to operate at 500 volts, *dc*.

* * *

FTL 50 MC-WIDE BAND VIDEO 'SCOPE

A 'scope, FTL-32A, which is said to enable the observation of waveforms having frequency components as high as 50 mc and as low as 10 cps, has been announced by Federal Telecommunication Laboratories, Inc., 500 Washington Ave., Nutley 10, N. J. Response is said to be obtained with sufficient amplification to provide deflection sensitivity of 0.1 peak-to-peak volts per inch. The horizontal amplifier has a bandwidth of 10 cps to 10 mc.

Two probes are provided; one to minimize the loading on circuits under test, the other for direct connection to vertical amplifier, where maximum sensitivity is required.

Both repetitive and triggered sweeps are incorporated with time durations consistent with the 50 mc bandwidth. Synchronization from either an internal or external source is independent of the synchronizing signal amplitude, provided a minimum of 0.1 volt is exceeded.

SHALLCROSS RHOMBIC ANTENNA RESISTOR

A rhombic antenna terminating resistor, No. 9079, has been introduced by the Shallcross Manufacturing Company, Collingdale, Penna. Consists of two non-inductive Ayrton-Perry wound 362.5 ohm resistors enclosed in a glazed ceramic insulating shell and sealed under a dry vacuum method.

Leads are brought out to terminal eyes which are designed for seven-strand No. 16 antenna wire. Resistors are rated at 25 watts dissipation and are designed to operate between —20 and +120° F.

Unit measures 6 11/16" long x 2½" diameter overall or 5¾" long x 1⅞" diameter exclusive of the eyelets.

* * *

PREMAX ANTENNA

A mobile antenna to cover the 75-meter band, featuring a base-loading coil and a graduated or tapering whip of about six feet in length, giving a total overall length of about 88", has been developed by Premax Products, Niagara Falls, N. Y.

It is said that this type of antenna shows about a 6 db gain over the conventional whip types.

* * *

HICKOK MICROVOLT SIGNAL GENERATOR

A microvolt generator, model 292X, designed to cover both upper channel TV and mobile band frequencies on fundamentals, has been announced by The Hickok Electrical Instrument Co., 10521 Dupont Ave., Cleveland 8, Ohio.

Measures both input and output of units under test; modulated and unmodulated output from 1 to 100,000 microvolts. May be externally modulated from 15 to 10,000 cps. Self-contained crystal oscillator circuit.

For complete information write H. D. Johnson.

BENDIX DC MOTOR

A speed-controlled *dc* motor has been introduced by the Red Bank Division of the Bendix Aviation Corporation, Red Bank, N. J.

Designed for special airborne recording equipment, this motor, a continuous-duty type, has an input of 28 *v dc* and is rated at .018 hp. Its normal speed is 3,600 rpm. Has a centrifugal governor which also acts as a fan.

The motor diameter is 2¾", length 4⅞", and weight 2 pounds, 6 ounces.

* * *

CAMBRIDGE THERMIONIC MINIATURE CERAMIC COIL FORM

A miniature ceramic coil form has been announced by the Cambridge Thermionic Corporation, 445 Concord Avenue, Cambridge 38, Mass.

Designated LST, the form is constructed of silicone impregnated ceramic (grade L-5, JAN-1-10). Measuring 19/32" in height (mounted), the form has a diameter of 3/16" and mounts in a single No. 18 hole. The mounting bushing has an 8-32 thread.

Mounting bushings and ring type adjustable terminals are of brass, the bushings being cadmium plated and the terminals silver plated.

* * *

CLIPPARD CAPACITANCE COMPARATOR

An automatic capacitance comparator that is said to allow an unskilled operator to grade, sort or check as many as 8,000 capacitors a day has been developed by the Clippard Instrument Laboratory, Inc., 1125 Bank Street, Cincinnati, Ohio. Instrument, model PC-4, tests all types of capacitors, paper, mica, oil filled, ceramic and electrolytic.

Meter is a large-faced, square, *dc* D'Arsonval type (4" Weston make) inclined for easiest vision with minimum parallax. Meter scale reads in per cent. Range is from 10 mmfd to 1,000 mfd. There are three scales on the meter in ranges of —5% to +5%, —25% to +30% and —50% to +100%.

* * *

ACME ELECTRIC VOLTAGE REGULATOR

A portable voltage-regulating instrument, the *Voltrol*, has been developed by Acme Electric Corporation, Cuba, N. Y. The unit has windings that are individually tapped at each turn, which is said to provide a full range of stepless control from 70 to 130 volts.

According to the manufacturer, the *Voltrol* regulation is accurate to 4/10 volt adjustment and the output voltage is practically independent of the load.

Supplied with indicating voltmeter, 10' cord and plug and carrying handle. Size 10¾" x 6¾" x 5¼".

* * *

RADIART VIBRATOR-CONVERTERS

A *Vipower* line for *dc* to *ac* power conversion, to furnish 110-volt 60-cycle *ac* from 6, 12, 32, or 110-volt *dc* sources, has been announced by the Radiart Corp., Cleveland, Ohio.

Models will handle power requirements ranging from 50 to 350 watts. Some of the units feature a *Phantomswitch* that allows for set control through the radio switch, eliminating turning the *Vipower* on and off each time the set itself is turned on or off. Another feature is a variable frequency vibrator control that allows for setting frequency to prevent wave-like picture distortion in TV set reception.

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

At the annual dinner-cruise of the Chicago Chapter, left to right: Howard Dodge, Walter Marsh, George Martin, Les Gorder, Bill Halligan, Tommy Rowe (chairman), Royal Higgins (standing), Tom Moore (guest speaker, *Chicago Rocket Society*), Louis Baer, and Harold Safford.

Personals

LEROY BREMMER, when not at home in Los Angeles, is either radio engineering KRSC-TV in Seattle, or making a summer trip to Alaska where he is supervisor of the radio stations of the Nakat Packing Corp., of Seattle. . . . Wm. A. Breniman, who likes Illinois so much that he still lives in La Grange, writes that he would like to see more about some of the lower brass of VWOA in the annual yearbook, instead of so much about the higher level brass. Regardless, though, he thinks VWOA is okeh. Back in '19 he published the *Trans-Pacific Wireless Operators Handbook*. He is now chief of the Communications Operations Division, third Region CAA, which means he supervises about 550 *Communicators*. . . . Packanack, N. J., is now the home of Alfred Dowd. . . . H. J. Buckley, Elmwood Park, Ill., writes to say that he is with WGN in the engineering department, a post he has held since '37. He started back in '14 as a ham, and has worked aboard ship, in broadcasting at WLS and WBBM, and with Northwest Airlines. . . . One of the talented technical writers now with FTR is none other than F. E. Felton. Larry, as many know him, also operates W2BS. He has served as an operator at WNY, WSH, Eastern Air Lines, CAA in Hackensack, N. J., and the N.Y. Merchant Marine. . . . F. J. Gommo, one of the outstanding installation engineers of Tropical Radio, has been doing a bang-up job in Central America, outfitting many of Tropical's stations with new transmitters and receivers. . . . After a long absence we've received a note from C. P. Gruetzke, wishing everyone best 73s. CP is now living in San Pedro, Calif. . . . H. D. Hayes is with the FCC in Chicago with the title of Engineer in Charge. Hayes has been with the government in radio since '23 and for a while in '16-'17, having worked in San Francisco and Seattle, Washington. . . . Earle E. Hill, one of TRT's oldest (in service), is now working at their new station at OJUS, Fla. . . . V. A. Kamin writes that he is now living in Elgin, Ill. . . . Ye secretary, Bill Simon, has purchased a gleaming new car and left with part of his family for a tour of Kentucky, revisiting his old home town, Frankfort, and other familiar sites in Louisville. He'll also be stopping off at Chattanooga, Tenn. . . . From oldtimer C. D. Guthrie has come an absorbing report of his experiences as a naval radio op, a career which began at eighteen as a student at the Pennsylvania Nautical School, with training aboard the U. S. S. Saratoga, a sloop of war built in 1842. It was aboard this famous ship that Admiral Dewey, Farragut and others served. In '04 Guthrie enlisted in the U. S. Navy as an Electrician, third class and was posted aboard the U. S. S. Lancaster, another oldtimer which roamed the seas during the Civil War. While serving aboard the battleship Kentucky, as an Electrician, second class, in the dynamo room, Guthrie received his first opportunity at the wireless business, when he was assigned for duty in the wireless room. These were the early Telefunken days and were quite thrilling, notes Guthrie. The range then, using a coherer, was 150 miles maximum. The coherer was praised and criticized, and surveys by the experts finally indicated that other methods should be used. As a result, Guthrie discloses that the mercury turbine interruptor was changed from

(*Continued on page* 31)

The Ad Hoc Report

(Continued from page 9)

noise figure to give an effective noise figure. The effective noise figure, together with an appropriate value for an acceptable signal-to-noise ratio, can be combined to give the minimum required signal power at the input to the receiver for the several TV channels. The appropriate values of minimum required field intensity can then be determined by using appropriate values for the receiver antenna capture area and transmission line loss, both of which may be expected to be variable with frequency. These values of required field would appear to be appropriate for rural areas. Since the noise figure and gain will be variable among the various receivers available to the public, a determination of the appropriate noise figure to use in this connection may involve a statistical study, as well as the subjective determination of acceptable signal-to-noise ratios.

The second problem concerns interfering signals originating outside of the receiver from nearby sources such as oscillator radiation from other receivers, spurious emissions, and ignition interference.

The Commission, in its present television rules, specifies a value for the field intensity required for service in urban areas in addition to a value required for rural areas. In urban areas where noise and interference external to the receiver are of sufficient intensity to determine the minimum usable field, it should be noted that if the interfering field intensities enter the receiver through the antenna, the differences in the effective lengths of the antenna and in the line losses at different frequencies cease to be factors in the determination of the minimum required signal for satisfactory service. Secondary effects may be present because of the greater tendency of some presently used television antennas to have a more distorted field pattern on channels 7-13, which may produce a directional discrimination in favor of randomly located interfering sources. Furthermore, the presence of multipath transmission, producing ghost images, will tend to degrade the service below that indicated by field intensity measurements above. None of these effects has been evaluated for lack of time and data. There is a serious question as to whether they should be taken into account either in this case or in the case of interfering television signals, on the assumption that the set owner should be expected to provide himself with a suitable antenna.

The interrelation between the minimum signals required in the presence or absence of noise and interference external to the receiver, as functions of frequency, are discussed at some length in a report by K. A. Norton.* The values used were accepted by the committee as illustrative only, but the tendency can be noted for the minimum value of signal at which external noise becomes controlling to increase with frequency. There was some opinion among committee members that the 5 millivolts per meter (54 db above one microvolt per meter) now specified as the median field intensity for acceptable urban service, while apparently adequate to overcome both receiver noise and external noise and interference at an acceptable percentage of locations for channels 2-6, is not sufficient to overcome receiver noise on channels 7-13. If this is true, it is the consensus of the committee that the effect is not due primarily to the differences in the calculable effects of antenna length, line losses, and available receiver noise figures, but must be to a large extent due to the unknown differences in the range of signal variation in urban areas and to the effects of the antenna pattern. The committee had insufficient data on the variation of field intensities in urban areas at close distances from the transmitter and at locations away from the main arteries of travel on which much of the presently available field intensity data have been measured, to make a recommendation on the magnitude of the differential which may be required. However, the problem exists and it is recommended that a continuing study be made looking toward a definite answer.

The third problem involves an interfering signal which originates from another station operating on the same or adjacent channel.

In this case, since both the desired and undesired fields will be variable with time and location, it is necessary to take both of these variations into account with appropriate allowance for any effects of correlation.

Where there are two or more stations interfering with the desired station is another extremely important factor.

It is self-evident that the interference which is caused by a plurality of stations will add in some manner so that a net increase in interference, above that caused by one station, will result. This problem has received a considerable study, and several approaches to it have been made by various members of the committee. At the present time, however, there is no generally acceptable solution available. Moreover, certain aspects of the subjective effects of adding interferences require laboratory investigation, particularly with regard to the interference from adjacent channels. This problem will be studied further by the committee and it is hoped that a practical answer will be available before the conclusion of the television rule making proceedings.

As to the question of correlation of the terrain correction factor variations between the desired and undesired signals, the committee did not have available measurements which have been analyzed to evaluate the correlation quantitatively, and it was considered likely that it would not be negligible. However, for the solution of the immediate problems, and until experimental data are available, the committee recommended that the effects of this correlation be neglected. The effect of assuming a correlation coefficient of zero will be to over-estimate the percentage of receiving locations, L, free from interference for a specified percentage of the time when $L < 50\%$, and to underestimate L when $L > 50\%$ but will have no effect when $L = 50\%$.

In combining the effects of irregular terrain and of tropospheric propagation, it was the feeling of the committee that the tropospheric variations would be independent of the terrain variations. In other words, the tropospheric fading range will be the same at both good and poor locations. There are no direct measurements which prove this relation, but the inference may be drawn from a consideration of the data in the report* by E. W. Allen, Jr., W. C. Boese and Harry Fine of the FCC. This is considered to apply to both the desired and undesired signals.

In the matter of the correlation between the time variations of the desired and undesired signals, it was recommended that zero correlation should be assumed when applying the curves to allocation problems.

The report was endorsed by eleven members of the committee: E. W. Allen of the FCC, who served as chairman; W. C. Boese, FCC; Harry Fine, FCC; F. G. Kear, consulting engineer; S. L. Bailey, consulting engineer and IRE prexy; R. M. Wilmotte, consulting engineer; A. F. Murray, consulting engineer; R. P. Wakeman, DuMont Labs; J. W. Wright, CBS; G. H. Brown, RCA Laboratory Division; and R. N. Harmon, Westinghouse.

*See editorial.

Remote-Control Switching

(*Continued from page 12*)

common motor while still retaining independent control. Three or four control heads are commonly used in aircraft radio applications to tune the equipment to the selected frequency channel.

Credits

While our broadcast engineering department accomplished the system engineering on this switching unit, the system of control and wire-saving scheme was the work of the mechanical department. We are particularly indebted to H. M. Schweighofer for his efforts in devising the fifty-position control switch and positioner assembly; Mr. Schweighofer is one of the inventors of the remote device and is largely responsible for its development.

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VWOA News

(*Continued from page 29*)

two segments, providing about a 25-cycle note, to a four- and then six-segment resulting in a 500-cycle note or higher. (The 500 cycle later became the Navy standard.) From then on Guthrie says they were able to cover distance. When 800 miles from Culebra in the Virgin Islands, Guthrie reveals that he heard the Flagship Maine and when he informed the captain that he had been in touch with the Flagship, the captain remarked: "My God, man, do you know where we are?" A message to the Flagship convinced the captain that contact had been established. Confirmation was definitely established a month later when a newspaper clipping captioned "Wonderful Feat of U. S. Warship" was received. The report cited the great distance worked. GDG says that he believes Ben Wolf on the Maine was the one who received the message. CDG's classmate Bob Woolverton, who was in charge of the wireless room, was quite a resourceful fellow, constructing all types of new gadgets. Those days, reports Guthrie, proved the need for ingenuity, for many of items they needed, were never available and had to be made. When CDG's Navy enlistment expired, he sailed out of New York for the United Wireless Co., serving on the Royal Steam Packet ships, the *Togus, Trent, Nile* and

(*Continued on page 33*)

Low-Pass Filter Design

(*Continued from page 25*)

error of .0089 mile, or 47 feet, which was not considered excessive.

Transmission-Type Filters: Transmission-type filters, in which the attenuation both below and above cut-off are of interest, can be designed with the aid of Figures 2, 3, and 5. The variation in transfer throughout the pass-band and the attenuation beyond cut-off are indicated in Figures 2 and 3, while circuit values can be obtained from Figure 5. As before, an example is useful to indicate the method:

A filter was to be placed between the modulator and class-*C* amplifier of a low-powered radio transmitter. The purpose of the filter was to reduce the sideband spread caused by a speech-clipping circuit. The maximum allowable variation in transmission was 2 db up to 2,500 cycles. The transmission was to be down 20 db at 3,000 cycles. The load impedance presented by the class-*C* amplifier was 2,500 ohms. From Figure 3 it can be seen that a two-section filter with *RL* termination would be satisfactory. A cut-off frequency of 2,700 cycles was chosen. From Figure 5, $L = 0.29$ henry, and $C = .047$ mfd.

Conclusion

It has been shown that L-section low-pass filters are easily designed, and are particularly suitable for decoupling and filtering. Although it has not been stressed in this paper, the theory presented is also useful for the design of artificial transmission lines.

References

[1]E. A. Guillemin, *Communication Networks*, page 145, volume II, Wiley, 1935.
[2]F. E. Terman, *Radio Engineers' Handbook*, page 23, McGraw-Hill, 1943.
[3]L. B. Hallman, Jr., *A Note on the Simple Two-Element Low-Pass Filter of Two and Three Sections*, Proc IRE; November, 1933.

The Industry Offers

(*Continued from page 28*)

PHILCO FM COMMUNICATION EQUIPMENT

FM equipment to be used for point-to-point communications in the 72-76 mc band by the Public Safety, Transportation and Industrial services, has been developed by the Industrial Division of Philco, Philadelphia 34, Pa.

Included are a 50-watt transmitter and a companion receiver, which is available for both fixed station and automatic repeater applications. The transmitter and receiver can be supplied in housings for wall or desk mounting or in standard enclosed relay rack cabinets for floor mounting.

* * *

ADC TRANSFORMERS

A line of transformers, the Yeoman line, has been put into production by Audio Development Company, 2833 13th Ave., S., Minneapolis, Minn.

Transformers are said to be lightweight, compact, with open frame construction and ten-inch leads.

Line includes impedance matching, input, output and power transformers.

* * *

WESTINGHOUSE 50-KW AM TRANSMITTER

A high-level AM transmitter with a nominal power output of 50 kw, type 50-HG-2, has been announced by Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa.

Uses metal rectifiers in all power supplies.

Features a supervisory control system, coordinated with a sequential interlock system and with an overload and safety protection system.

* * *

TRIPLETT TV-FM SWEEP GENERATOR

A TV-FM sweep signal generator, model 3435, which provides continuous range coverage to 240 mc for all TV carrier and if frequencies, has been announced by the Triplett Electrical Instrument Co., Bluffton, Ohio.

Continuously variable sweep width, effective from 500 kc to 12 mc, with off position. Phase controlled sweep voltage for 'scope horizontal input. Standby switch for temporary silencing of generator during other work on equipment under test.

AUTOMATIC ELECTRIC HERMETICALLY SEALED RELAYS

A line of hermetically sealed relays has been announced by Automatic Electric Company, 1033 W. Van Buren St., Chicago 7, Ill.

Sealed in a controlled atmosphere of dry, inert gas.

Relays available will accommodate operating potentials from a fraction of a volt to several hundred volts. Contact ratings can vary from a few milliwatts to several hundred watts. Operate times can vary from 1 to 100 milliseconds, and release times from 1 to 500 milliseconds.

* * *

TRIAD MINIATURE AF TRANSFORMERS

Two hermetically sealed mounting types for audio transformers to be known as *Trifets*, have been announced by Triad Transformer Mfg. Co., 421 N. Western Ave., Los Angeles, Calif.

One type, JO, is 15/16" in diameter, 1 13/32" in height, and weighs 1¼ ounces. Another type, JOA, is 15/16" in diameter, 1 25/32" in height and weighs 1½ ounces. Both types are mounted by 2-56 studs on 9/16" centers.

* * *

DUMONT OSCILLOGRAPHIC PROJECTION LENS

An oscillographic projection lens, type 2842, a two-element, symmetrical, objective unit having a relative aperture of f/3.5 and a focal length of 7.7 inches, has been announced by the Allen B. DuMont Laboratories, Inc., Instrument Division, 2000 Main Avenue, Clifton, N. J.

The lens projects an oscillographic pattern of an area up to 3-inches square to distances from 8' to 30', resulting in a picture size that may be as large as 12-feet square. The axial light transmission of this lens system is approximately 85%.

The lens may be mounted on a 5" 'scope.

* * *

PRESTO RECORDER

A recorder, the 86-G, designed for both standard and microgroove recording, has been announced by the Presto Recording Corporation, Paramus, N. J. Said to combine the features of Presto's dual motor gear drive with the overhead mechanism and turntable of the Presto 6-N recorder. The cutting head is the Presto 1-D.

VWOA News

(Continued from page 31)

Clyde, which ran as far as Porto Columbia in South America. From there, these vessels carrying no radio ops went to England. Even if there had been operators aboard, the Marconi stations could not hear these vessels because they were not fitted with Marconi apparatus. This sorry condition was remedied after the Titanic tragedy in 1912. In '09, Guthrie joined the Massie Company, and was assigned by C. J. Pannill to the S. S. Providence running to Fall River. (*This interesting report from one of radio's real old-timers will be continued next month.*)

•

Frequency Doublers

(Continued from page 13)

L_2 can be obtained from

$$\omega_2 = \frac{1}{C_o L_2} \qquad (6)$$

and

$$\frac{\omega_2^2 L_2}{R} = Q \qquad (7)$$

This system has been applied to several doublers and has proved to be quite satisfactory.

•

KAAR MOBILE EQUIPMENT

Mobile radiotelephone equipment for the 152-162 mc band, which is said to feature low standby battery drain, has been announced by the Kaar Engineering Company, Middlefield Road, Palo Alto, Calif. The instant-heating transmitter consumes no power from the battery during standby periods; the receiver uses 4 amperes. In combination, the equipment consumes a total of 4 amps during standby operation.

FM receiver (FM-47X) and 15-watt (FM-177X) or 50-watt (FM-179X) transmitter is available for the mobile service.

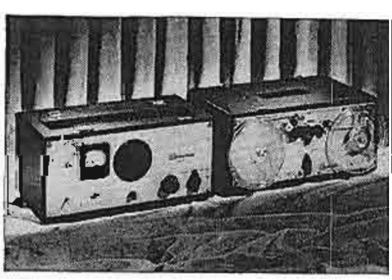
• • •

MAGNECORD PORTABLE TAPE EQUIPMENT

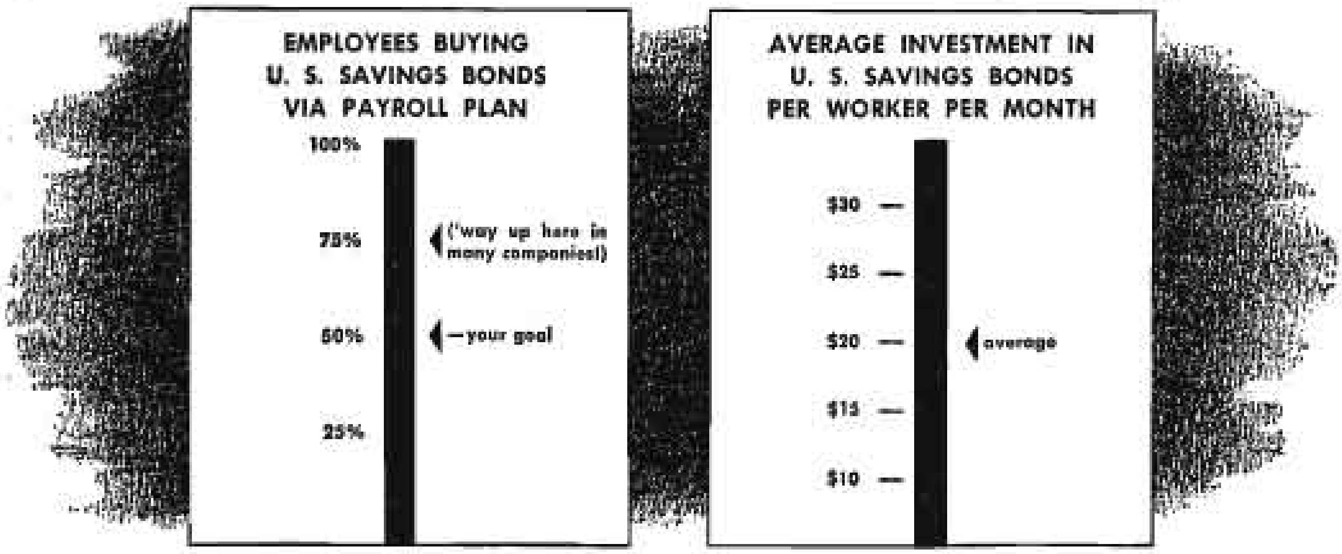
A one-channel, two-case portable magnetic-tape unit (PT6-JA) has been announced by Magnecord, Inc., Chicago 1, Ill.

Has single low-impedance microphone input, with gain control, high level input, monitor speaker, zero level output terminal, a vu type meter and a 10-watt monitor amplifier and associate jack for use with an external speaker. Features high speed forward and rewind and either 7½" or 15" tape speeds.

Unit is said to conform to NAB specifications and has a frequency response of 50 to 15,000 cps ±2db with less than 2% harmonic distortion at full modulation.



How is YOUR company doing in this "EVERYBODY-BENEFITS" plan?



Compare your employee participation with others who have Payroll Savings

If the figures for your company fall below those shown above, you're missing your share of benefits of the Payroll Savings Plan! These benefits are described below. Nation-wide experience proves that when top management puts the "OK" on the Plan, its benefits rise sharply.

BENEFITS TO *EMPLOYEES*: Every $3 invested in Savings Bonds pay $4 at maturity. Workers gain a 33⅓% return on their money—enabling them in the future to buy more of the things they will want—plus the peace of mind that goes with regular saving.

BENEFITS TO *EMPLOYERS*: The feeling of security that goes with participation in Payroll Savings makes workers more contented. Worrying less, they work better. Among the more than 20,000 large companies with Payroll Savings, records show that—following installation of the Plan—production increased, absenteeism and accidents decreased!

BENEFITS TO THE *NATION*: The Payroll Savings Plan is a powerful deterrent to inflationary forces. Every Savings Bond dollar built up in the Treasury withdraws a dollar from the swollen spending stream. The Plan thus contributes to national security—which affects *your* security!

WHAT CAN YOU DO? If your company has the Payroll Savings Plan, make sure it's being adequately promoted—backed by your top executives—to bring your company its full measure of benefits. If you haven't yet installed the Plan, why pass up its benefits any longer? All the help you need is available from your State Director, Savings Bonds Division, U. S. Treasury Department. He is listed in your telephone book. Call him now!

Do You Realize...?

Over $75,000,000,000 worth of Savings Bonds have been bought since 1941.

•

More than ⅔ of this volume—over $50,000,000,000—is still held by the purchasers.

•

During 3 months of 1948, 1,500 additional large firms installed the Payroll Savings Plan.

•

Via this plan, 7,500,000 workers are each investing on the average of $20 per month of their pay—more than $150,000,000 per month—in Bonds.

The Treasury Department acknowledges with appreciation the publication of this message by

COMMUNICATIONS

This is an official U. S. Treasury advertisement prepared under the auspices of the Treasury Department and the Advertising Council.

News Briefs

PERSONALS

Dr. Vladimir K. Zworykin, vice president and technical consultant of the RCA Laboratories Division, received the Lamme Medal recently from the AIEE.

Dr. Zworykin was awarded the medal "for his outstanding contribution to the concept and design of electronic apparatus basic to modern television."

Dr. Allen B. DuMont, president of Allen B. DuMont Laboratories, Inc., received recently an honorary degree of Doctor of Engineering from the Polytechnic Institute of Brooklyn. The degree citation read in part: "Your achievements in the science, the art and the industrial management of television have been widely recognized by members of professional societies and trade associations, and by the ultimate beneficiaries of your genius, the American people."

Dr. Victor J. Andrew was honored recently by the College of Wooster, with an award of an honorary degree of Doctor of Science. Dr. Andrew was graduated in '26 from the College of Wooster, and in '32 received the degree of Doctor of Philosophy from the University of Chicago.

James H. Jewell, manager of apparatus sales, and **John M. McKibbin,** assistant to vice president and manager of advertising and sales promotion, have been elected vice presidents of Westinghouse Electric.

John J. Eibye has been appointed manager of magnetic component sales of the Raytheon Manufacturing Co., Waltham, Mass. Eibye will be responsible for the promotion and sale of voltage stabilizers, transformers and rectichargers and rectifilters.

Wilfred L. Kelley, formerly equipment engineer for Western Electric, has joined the distributor sales department of the radio division of Sylvania Electric Products, Inc., and will operate out of the Chicago office at 20 North Wacker Drive.

Daniel R. Donovan, formerly vice president and sales manager of Callite Tungsten Corp., has been appointed sales manager on Elmet and Fine Wire products of the North American Philips Company, Inc. He will be located at Lewiston, Maine.

G. O. Wanvig, president of Globe-Union, Inc., since 1927, has been elected chairman of the board. **Wyeth Allen,** executive vice president for the past year and Globe management consultant for the past twenty years, has been named president.

Milton J. Streble has been appointed assistant sales manager of replacement tubes for the tube divisions of G. E.

Elmer William Engstrom, vice president in charge of research for RCA, received recently the honorary degree of Doctor of Science from New York University.

Chancellor Harry Woodburn Chase conferred the degree with the following remarks:

"Elmer William Engstrom: The advancement of life in America owes much to that small band of men who, like yourself, lead the way in the vast field of industrial research. To you, with our gratitude and thanks, we give today our honorary doctorate of science."

LITERATURE

Chicago Transformer Division, Essex Wire Corp., 3501 W. Addison St., Chicago 18, Ill., have released a 16-page catalog of new equipment transformers. Included are mounting and construction details, dimensional drawings, frequency response curves for many of the audio units, and a table of *power-vu-db* relationships.

A line of Chicago hermetically sealed transformers is described in a new four-page illustrated folder. Included are power transformers, bias transformers, filament transformers, and filter reactors, all of which are constructed to meet Grade I, Class A, JAN-T-27 specifications.

Aerovox Corp., New Bedford, Mass., have published a *Duranite* decoder chart, which shows the RMA color band coding for molded tubular paper capacitors, with corresponding numerical values of capacitance, tolerance and voltage.

Last Minute Reports . . .

The world's first public demonstration of 625-line TV was presented recently at the British Industries Fair, Castle Bromwich, Birmingham, England. From Great Britain has also come the report that the BBC will soon place in operation a new TV station at Sutton Coldfield near Birmingham, England, to operate on a video frequency of 61.75 mc, with a power output of 35 kw, the audio transmitter operating at 58.25 mc with a power output of 12 kw. . . . WPIX in New York recently installed three new studio cameras, according to Thomas E. Howard, chief engineer, who also reported that the station now has a total of eight field cameras in operation. . . . Harry F. Dart, office manager of Westinghouse Electronics Engineering Department, Bloomfield, New Jersey, has been named chairman for the New York section of the IRE. . . . Virgil M. Graham has announced that the Rochester Fall Meeting will hereafter be known as the Radio Fall Meeting and will be held this year at the Hotel Syracuse, Syracuse, New York, on October 31 and November 1 and 2. . . . On or about September 1, the Oswego County Broadcasting Company, Fulton, New York, will go on the air with a G. E. 1 kw AM transmitter. . . . H. W. Pfeffer, of Struthers-Dunn, Inc., has been elected president of the National Association of Relay Manufacturers. . . . A three-month graduate training program in electronics is now being held at the Camden plant of RCA Victor, in cooperation with the Moore School of Electrical Engineering of the University of Pennsylvania. Twelve student officers of the United States Army Ground Forces are taking the course. . . . The Tenth Annual Summer Seminar of the Emporium section of the IRE will be held on August 19 and 20. Guest speakers will include H. G. Clavier, who will discuss long distance communications and microwaves; Allen A. Barco, covering TV deflection and high voltage supplies; Michael Landis, discussing orthicon camera chains, etc. . . . A 48-page handbook covering miniature selenium rectifiers has been published by the Federal Telephone and Radio Corporation, 900 Passaic Avenue, East Newark, New Jersey. Priced at twenty-five cents per copy. . . . George L. Downs is now in charge of the transformer operation at Raytheon, at Waltham, Mass. . . . John F. Rider Publisher, Inc., will publish Milton Kaufman's *Commercial Radio Operators' Q&A Manual*, a 576-page book, which is expected to appear in August. . . .

ADVERTISERS IN THIS ISSUE

COMMUNICATIONS INDEX

JULY, 1949

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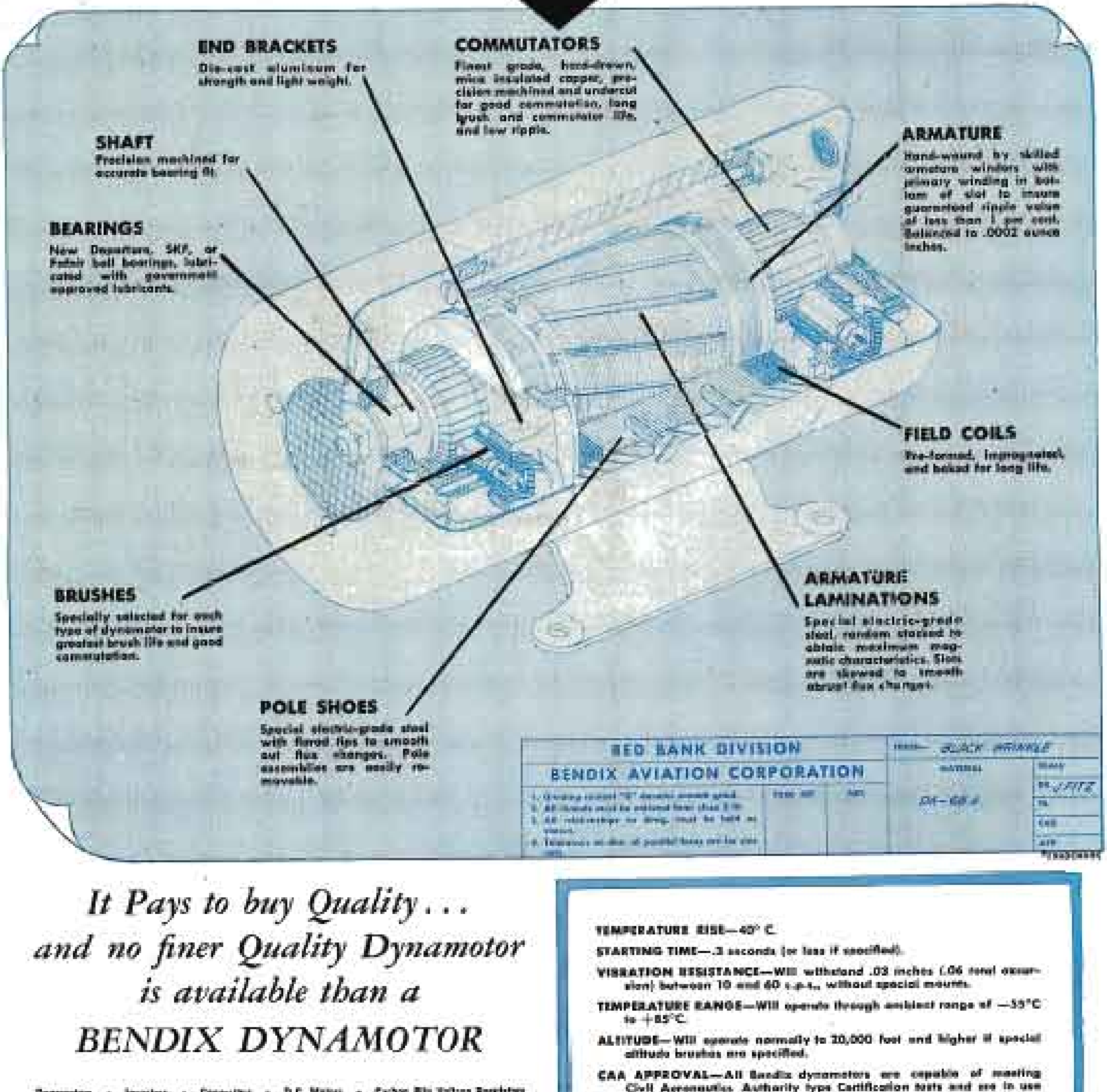

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VIBRATION RESISTANCE—Will withstand .03 inches (.06 total excursion) between 10 and 60 c.p.s., without special mounts.

TEMPERATURE RANGE—Will operate through ambient range of −55°C to +85°C.

ALTITUDE—Will operate normally to 20,000 feet and higher if special altitude brushes are specified.

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INSPECTION AND TEST—All Bendix Dynamotors are carefully inspected in every step of production. Every unit receives a six to twelve hour run-in, depending on type, to insure proper brush seating.