CONTENTS

Cover Design ............................................. From a Design by Harvey Hopkins Dunn 330
Frontispiece ................................................. Where Radio Progress Begins 330
Television—Its Progress To-day ...................... Howard E. Rhodes 331
A Nine-Tube Screen-Grid Super ....................... Robert Burnham 334
The March of Radio ...................................... An Editorial Interpretation 337
The Low-Power Stations Plead Their Case ........ Here and There
Regulations for Television and Picture Transmis-

The "Hi-Q 29"—A Receiver with a Band-pass R.F. Amplifier D. K. Oram 341
A Short-Wave Transmitter for 1929 ...................... Robert S. Kruse 344
"Strays" from the Laboratory ........................... Kenney Henmy 347
Two Interesting Patents ................................... Engineers at Selmilen 348
Radio as a Signal Generator ......................... Testing for Soft Tubes 349
A Screen-Grid Mystery ................................. Short-Wave Reception 350
Mortality Among the A.C. Tubes ....................... The Remler A.F. Amplifying System 351
A Two-Tube A.C. Screen-Grid Tuner ................. James Millen 349
As the Broadcaster Sees It ............................... Carl Dreher 352
The Sargent-Rayment Seven Receiver ................. Lord Rayleigh on Sound 354
"Radio Broadcast's" Home Study Sheets .......... 377
The 222 Tube as an R.F. Amplifier (Part II) ....... Glenn H. Browning 359
Book Review ............................................... Carl Dreher 360
Coupling Methods for the R.F. Amplifier ......... Bert E. Smith 361
"Our Readers Suggest" ................................... 364
A Power Unit Voltage Divider ......................... Dynamic Speaker Field Supplied from B-Power Unit 364
Obtaining Screen-Grid Bias .............................. A Single Audio Channel Equalizer 365
Tuning for Soft Tubes ................................. A.C. Tube to Reduce Microphonic 365
Matching Condensers and Coils in Tandem ........ An Antenna Booster for Loop 366
Tuned Circuits ............................................ An Output Filter Without a Condenser 366
An Amplifier Kit .......................................... 366
The "Vivitone 29" Receiver ............................... R. F. Goodwin 366
"Radio Broadcast's" Service Data Sheets on Manufactured Receivers 369
No. 0. The Bosch Model 38 Receiver ................. No. 10. The Splodin "Inherently Electric" Receiver 369
Practical 5-Meter Hints .................................. Robert S. Kruse 371
New Apparatus ............................................. 372
Useful Information on New Products ......... 372
Radio Helps in the Coast Survey ....................... D. L. Parkhurst 374
Manufacturers' Booklets .................................. 376
"Radio Broadcast's" Laboratory Information Sheets 378
No. 351. Calculating Grid Bias for A.C. Tubes .... No. 350. The Telephone Transmission Unit 378
No. 355. Grid Bias Circuits for A.C. Tubes....... No. 355. Filters 379
No. 358. The Dynamic Loud Speaker ................. No. 355. The Voltmeter 379
Photo Broadcasting in England ......................... William J. Brittain 384
Letters from Readers ..................................... 386

The contents of this magazine is indexed in The Readers' Guide to Periodical Literature, which is on sale as public libraries.

AMONG OTHER THINGS...

Readers who did not see our announcement in this space last month with respect to the change in our publication date and who failed to see our October issue when they expected may be somewhat confused. Effective with this number, Radio Broadcast is on sale at all good newstands on the first of the month. That is early enough.

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A few of our readers who carefully classify the contents of each issue feel that each article should be classified according to the Dewey decimal system when published. At one time our excellent British contemporary, Experimental Wireless, classified their articles this way, but has since discontinued the practice. Radio Broadcast is quite willing to serve its readers, but we feel that this classification would appeal to all too few. The editor would be glad to hear from those who favor the scheme—and from those who prefer the status quo.

And here we group many miscellaneous matters: read the last box you were probably aware of! The complete set of "R. B. Lab. Data Sheets" in book form—No. 1-190—is now available at $1 per copy from the Circulation Department of this company... We shall soon start a special department, along lines similar to "Our Readers Suggest," to be made up of practical contributions from radio service men and professional set builders. Quite a few interesting contributions are already in the office and readers who desire to submit any ideas that seems to them worth while passing on are invited to do so. The same general rules hold for these contributions as for the "Readers Suggest" department... How many readers are interested in the problems of series filament connection for a.c. operation? We should like to hear from readers who have done some work along this line, or from those who would like an article devoted to the subject... In the past few weeks, our mail has contained a number of simple questions about radio which we are thinking of answering in a short article composed simply of the questions and their answers. We invite the submission of short and particularly troublesome questions which readers would like to see treated in this way... A radio house in Sao Paulo, Brazil, informs us that they are expanding and desire exclusive American agencies for radio apparatus in Brazil. Manufacturers who wish to get in touch with this house may write to the editor... Our request in the August "Strays" for methods of testing for hard and soft tubes has brought two answers. One may be found in this number on page 348, in the "Strays" department, and the other on page 364 in the department, "Our Readers Suggest."...

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—Willis Kingsley Wing.

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Lowest Wholesale Prices

**Set Builders**

Set Builders and experimenters will welcome an association here where tremendous stocks of practically all of the nationally advertised lines are carried—coupled with an organization trained to serve. Immediate shipments are assured. Silver-Marshall—Hammarlund—Roberts—Aero—Tyrman and practically all of the latest kits and parts are available. Your orders, large or small, will be handled with a promptness and dispatch that should prove a revelation to you in Radio Service.

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Allied Radio Corporation is composed of a large corps of trained men who have had years and years of experience in radio. They know how to get results. Their great fund of experience is now available for your benefit. They know the newest improvements, the up-to-the-minute demands of the trade and are ready to give you personal, helpful service.

**50,000 FEET OF RADIO**

50,000 square feet of floor space in a large modern building is devoted exclusively to radio. Floor after floor is filled with a tremendous stock of every variety that is exceptionally complete in kits, parts and sets of every description. Here are found the latest improved designs and styles in radio equipment.

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**IMMEDIATE SHIPMENTS**

The Allied organization is trained to service. Real team work from executives and department managers to stock clerks and office boys—all animated by a desire to serve—to make Allied service Radio's most dependable service.

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Wholesale Radio Distributors

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These views in the laboratory of the Arcturus Radio Company give a graphic picture of the organized experimentation that goes on before a technical advance is announced to the radio public. At the top is the testing room, where every characteristic of a radio receiver or vacuum tube may be accurately measured. Precision condensers, oscillators, resistance and inductance standards, and gain measuring equipment fill this experimenters’ paradise. The circle inset shows a corner of the chemical laboratory, where experiments are carried on with the gases and metals that make up a vacuum tube. At the bottom is a complete tube factory in miniature, where the engineers can build any tube they want at a moment’s notice. The man at the left is bending over a vacuum tube pump for exhausting experimental tubes. At the extreme left are racks in which tubes are given life tests. Such scenes as this may be duplicated in the laboratory of any wide-awake radio manufacturer.
Television—Its Progress To-day

By HOWARD E. RHODES
Radio Broadcast Laboratory

LIKE the search of the ancient philosophers for the elixir of life, television has been for years an inspiring dream of man. Although its first fruits in experimental demonstrations have been shown only in the past few years, the principles on which these demonstrations have been built have been work of several generations of scientific endeavor. The scanning disc, for example, which is an essential part of all the systems being utilized in this country to-day, is the invention of Nipkow, and dates back to 1884. To a considerable extent the problems which it was necessary to solve to make the recent demonstrations possible have been associated with the applications of already known principles, but the future development of the art will be the result of research—the systematic pursuit of knowledge—or the result of some new television tool, and it seems likely, to the writer, that such is necessary to make television really practical.

Enough has already been done in television, however, to excite the interest of everyone. Some stations are now on the air with television, and some are getting ready to go on, so that dyed-in-the-wool experimenters will find it hard to resist the temptation to set up apparatus to receive the broadcasts—even though their quality and program interest is negligible. For the benefit of these experimenters, and also for those interested only in the thrill of "looking in," we here report the progress of television in this country to date. The questions that immediately pop into one's mind—how good are the results, what stations are transmitting, how much does the receiving apparatus cost—are answered as fully as possible. In order that the article might be written with a background of experience, the past few weeks have been spent collecting data and personally seeing several demonstrations.

TELEVISION DEMONSTRATIONS

THE first television demonstration seen by the writer which showed promise of being applicable to home use was the demonstration by Dr. E. F. W. Alexanderson at the Schenectady plant of the General Electric Company. This company through three of its stations is now transmitting television signals in accordance with the schedule given in Table i. The receiver in this demonstration consisted of a scanning disc with a neon tube back of it, the disc being turned by a motor and manually synchronized by varying the resistance of a rheostat.

Essentially similar apparatus was used for part of the American Telephone & Telegraph Company's demonstration, with the difference that synchronization in the latter case was accomplished by means of synchronous motors—a more scientific method of holding the receiver in step with the transmitter, but also much more expensive. To the Telephone Company television constitutes a method of communication complementary to the telephone, and its interest is to develop a system giving quality reproduction. Therefore it cannot consider any system in which synchronization is not positive and automatic. In the same classification fall the more recent tests of this company in which actual outdoor events were televised. The apparatus used was entirely beyond the scope of the experimenter. The experimenter must depend upon other sources for television signals—and who knows but that some interesting results might come from his work. Even the greatest are sometimes caught napping.

More recently we saw a demonstration at the laboratory of the Daven Company, which has employed Mr. P. H. Kober, a former associate of Doctor Alexanderson, to develop television apparatus for them. In the Daven laboratory, a complete television transmitter and receiver have been constructed, similar in operation and results, so far as the writer can see, to that demonstrated at the General Electric Laboratories. Synchronization of the receiver with the transmitter is accomplished by means of a rheostat in series with the motor, across which a push-button switch is placed. The resistor is adjusted so that the motor tends to turn at slightly below the correct speed; pressing the...
TABLE 1: WHO IS ON THE AIR WITH TELEVISION SIGNALS

<table>
<thead>
<tr>
<th>Call Letters</th>
<th>Location</th>
<th>Wave-length Meters</th>
<th>No. of Holes in Disc</th>
<th>Speed of Disk (R. P. M.)</th>
<th>No. of Pictures Per Second</th>
<th>Schedule of Transmissions (E. S. T.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WOG</td>
<td>Schenectady, N. Y.</td>
<td>379</td>
<td>24</td>
<td>1260</td>
<td>21</td>
<td>Every day 10:15-10:30 M. M. Tues., Thurs., Fri. 1:00-2:00 P. M.</td>
</tr>
<tr>
<td>2XAP</td>
<td>Schenectady, N. Y.</td>
<td>31.4</td>
<td>32</td>
<td>1260</td>
<td>21</td>
<td>Every day 9:00-10:00 A. M. Wed., Fri. 9:00-10:00 P. M.</td>
</tr>
<tr>
<td>2XAP</td>
<td>Schenectady, N. Y.</td>
<td>22</td>
<td>32</td>
<td>1260</td>
<td>21</td>
<td>Every day 6:00-8:00 A. M. Sat. 11:00-12:00 P. M.</td>
</tr>
<tr>
<td>5XX</td>
<td>Washington, D. C.</td>
<td>46.7</td>
<td>48</td>
<td>900</td>
<td>15</td>
<td>Every day 10:00-11:00 P. M.</td>
</tr>
<tr>
<td>WNYT</td>
<td>New York City</td>
<td>325</td>
<td>48</td>
<td>450</td>
<td>7.5</td>
<td>Every day 6:30-7:30 P. M.</td>
</tr>
<tr>
<td>2XAL</td>
<td>New York City</td>
<td>32</td>
<td>48</td>
<td>450</td>
<td>7.5</td>
<td>Every day 6:30-7:30 P. M.</td>
</tr>
<tr>
<td>2XAA</td>
<td>Chicago, Ill.</td>
<td>61</td>
<td>48</td>
<td>900</td>
<td>15</td>
<td>Every day 10:00-11:00 P. M.</td>
</tr>
<tr>
<td>WMAC</td>
<td>Chicago, Ill.</td>
<td>447</td>
<td>45</td>
<td>900</td>
<td>15</td>
<td>Every day 10:00-11:00 P. M.</td>
</tr>
<tr>
<td>4KA</td>
<td>Memphis, Tenn.</td>
<td>24</td>
<td>90</td>
<td>1500</td>
<td>7.5</td>
<td>Every day 10:00-11:00 P. M.</td>
</tr>
<tr>
<td>2XAV</td>
<td>Lexington, Mass.</td>
<td>62</td>
<td>48</td>
<td>900</td>
<td>15</td>
<td>Every day 10:00-11:00 P. M.</td>
</tr>
<tr>
<td>8XAV</td>
<td>Pittsburgh, Pa.</td>
<td>62.5</td>
<td>60</td>
<td>900</td>
<td>16</td>
<td>Every day 10:00-11:00 P. M.</td>
</tr>
</tbody>
</table>

The method of synchronizing is interesting and we found it quite easy to hold the picture stationary. The arrangement used is indicated in Fig. 1. The scanning disc, D, is mounted on a shaft which revolves in the bearing, B. The motor, M, is mounted on a block of wood at a small angle to the disc as indicated, and the mounting block fitted with a slider, fitting into a groove on the baseboard. The screw, S, enables the operator to move the motor to the left or right, parallel to the disc. The end of the motor shaft is fitted with two flanges, F, about 3/4" in diameter with a rubber disc, R, clamped between them. This rubber disc may be made by cutting a 3/4" or 3/4" diameter disc from an old automobile inner tube. The motor is so located that the rubber disc bears against the scanning disc at a point about 3/4" from the center of the scanning disc. The motor may be any type, a.c. or d.c., is connected to the line without the use of a resistor and the speed of the disc is adjusted by turning the screw, S, thereby moving the motor assembly forward or backward thereby moving the scanning disc. With this arrangement the motor runs constantly at normal speed; at least, it runs much more uniformly than when synchronizing by means of a resistor in the motor circuit—the method mentioned previously. We recommend flat scanning disc experiment, start off with this method—although since we are experimenting everyone has a perfect right to try any and every method he can think of to obtain easy synchronizing.

Jenkins at present transmits silhouettes, although he expects to transmit transparent pictures. Silhouettes were used at first so as to keep the side band frequencies within a limit of about plus or minus 500 cycles. The short-wave channels now being licensed for experimental television are 25 kc. wide, and in a band of this width it is possible to transmit the wide band of frequencies essential for transmitting high quality half-tone pictures. To date, Jenkins has always sent out the same program—a little girl bouncing on a chair. The reception of the ball was heard clearly under the pink background of the neon glow.

A trip was made to Boston a few days later and at this point we succeeded in receiving 3XX, Jenkins' station, and getting recognizable images on a television receiver constructed by James Middlebrooke, Boston. Static was very bad, but apparently had less effect on television reception than on ordinary broadcast reception which was very poor at the time. At this time we used a large disc made by the National Company and a Raytheon Kino-Lamp, from which combination pictures can be obtained.

This test at Mr. Millen's home was made on a Friday between the hours of 8 and 9 P.M. E. S. T. during one of Jenkins' regular transmission periods. Static was very bad, and during the latter half of the demonstration there was thunder and lightning. In spite of this, however, satisfactory results were obtained. The transmission started off with an announcement in both code and phone telling what the program consisted of, after which the transmission began. The incoming signals contained a large number of side bands, and the frequencies in the audio band, but the characteristic note in the loud speaker seemed to be about 2000 cycles, probably because the ear is most sensitive to this frequency.

At various points the television waves, especially during those moments when the signal was strong, the silhouettes of our little girl with the bouncing ball could be easily recognized. The station produced a lot of black spots and lines on the picture but did not prevent one from recognizing the image. In this test a 'short-wave' tuner followed by a three-stage high-quality transformer-coupled amplifier was used. Theoretically, results would have been better with a resistance-coupled amplifier but the improvement would not be noticeable unless good strong signals were received. The last point of interest for it gives one some idea of what can be expected, and it also indicates the perhaps obvious but obvious fact that television reception will be satisfactory at any point at which a good loudspeaker signal can be received.

Jenkins' scanning apparatus shows the scanning disc, neon lamp, and driving motor. The screw at the left controls the speed of the disc by moving the friction drive motor along its surface.
TELEVISION—ITS PROGRESS TO-DAY

Station WNYW of New York has installed a television transmitter and are transmitting programs through their regular broadcasting station and their short-wave station, as indicated in Table 1. According to a recent release from the Westinghouse Electric and Manufacturing Company, the experimenter will soon be able to look to the station this company operates for programs of radio movies—it will be noted from Table 1 that this company has obtained an experimental license. A demonstration of radio movies was held in Pittsburgh on August 8th—a demonstration which we, unfortunately, did not see. The system used was in one respect at least, unusual: a mercury arc lamp, magnetically controlled by the incoming signals, we understand, was used in place of the neon tube, the advantage being that much more light can be obtained from the arc than can be obtained from the neon tube so that brighter images are possible. The neon tube doesn’t give any too much light. On the other hand, it seems likely that the arc will be more expensive than the neon tube.

Incidentally, the statement in the Westinghouse release is another statement that during research in television, “a strip of motion picture film was projected from a standard machine upon a photoelectric cell. The moving picture of the film was then re-created for an observer by receiving equipment involving a suitable neon tube and a scanning disc.” Whether first or last the Westinghouse tests are of interest to experimenters as another possible source of television signals.

APPARATUS FOR RECEPTION

Table 1 sums up the situation with a complete list as could be obtained of those who expect to transmit television signals. The table also gives the data one must have in order to receive the programs. In this connection the important facts are the number of holes required in the scanning disc and the speed of the disc. The column headed number of pictures per second is equal to the speed of the disc in r.p.m. divided by 60. The table shows, among other things, lack of cooperation for as many as five different sets of scanning discs (50 holes in one set, 45 holes in the other set, 48 holes in the other set, 40 holes in the other set, 45 holes in the other set, 48 holes in the other set, and 50 holes in the other set). It would be required to receive all of the stations. A complete television receiver consists of a tuner, which may be any ordinary broadcast band or short-wave set depending upon whether the signals to be received are being transmitted on the broadcast or short-wave bands. Strong signals are required for the operation of the neon tube. As a basis of comparison we might say that the signals should preferably be strong enough to load up a 1714 tube with 180 volts on the plate and a 50-microvolt C bias. If a transformer-coupled amplifier is used, three stages instead of two may be necessary unless the signals are good and loud. A three-stage resistance-coupled amplifier is preferable, however, especially as quality improves. An amplifier of this type properly constructed will pass the higher frequencies which would be cut off by a transformer-coupled amplifier.

The cost of a television receiver disc neon lamp and motor will vary, depending upon the parts used. Forty or fifty dollars should cover it in all cases. Table 2 shows the companies which are at present manufacturing apparatus for use in television reception.

Complete details for the construction and operation of a television receiver are not given here, but will be the subject of a future article. In these pages we have aimed merely to make clear for the readers of this magazine the present status of experimental television.

CONCLUSIONS

In RESULTS, none of the demonstrations which we have seen, possibly with the exception of those by the American Telephone and Telegraph Company, first held on April 2, 1927, produce pictures which hold one’s interest for any length of time. The present appeal of the art is not one of receiving good pictures, but is to do at home—all by oneself—which is demonstrated in the laboratories of a large corporation with the aid of a thousand engineers, and a million dollars worth of apparatus. When one sees such a demonstration, its greatest appeal—of doing it oneself—is lost, and there remains nothing but comparatively poor reception of the image of a person, made pink-faced because of the characteristic glow of the neon tube in the receiver.

Television, then, is still the province of the experimenter, the man who likes to do his own pioneering. And to the experimenter it should be among the most fascinating of all the fields of modern scientific advance—because its possibilities are so vast, its perfection so tenuous in the future, and its technique so amenable to new ideas and new ways of doing things. And what does the experimenter, the scientific enthusiast, get out of it? To the world at large, perhaps, pep and a hearty laugh are the attributes of the stock promoter, a fish-tail handshake and absent-mindedness the constants of the scientific outlook. Such views, however, must be held by persons who have never been on the inside. The scientist and experimenter get as much fun out of peeping through a spectrophotometer (a device for measuring the intensity and color of light) as does the baseball fan when he catches the ball that Babe Ruth knocks into the stands. They merely get their joy out of life in different ways. C. Francis Jenkins is a shining example in the field of television of the man who is carried on by the sheer joy of being on the inside of a great development. He is sixty years old, and has been working some twenty-five years on photo broadcasting, television and a host of other things, yet he still retains an enthusiasm which seems to charge his whole staff. Jenkins’ attitude, that of getting a thrill out of working with something new, and putting together stuff that frequently utilizes some gadgets from the junk box, is that of a born experimenter. Do you want to experiment with television? Then answer this question: Can you get a kick from twirling dials and rheostats for a couple of hours to get finally some fleeting, perhaps hardly recognizable image in the viewing window of a scanning disc? Or do you have to see the previously mentioned Babe Ruth knock a homer to get a thrill?

Although the cases aren’t exactly synonymous, think of the thrill Galileo got out of looking through his glass—the first telescope. As a young lad, Galileo used to watch the candlebra in the cathedral swing slowly to and fro; he timed its motion by the pulse beat in his wrist, and thought of using such a device for the measurement of time. In later life he invented the telescope, and with it saw thousands of stars never seen before by man. In 1610 he wrote to Kepler: ‘Oh, my dear Kepler, how I wish that we could have one hearty laugh together! Here, at Padua, is the principal professor of philosophy, whom I have repeatedly and urgently requested to look through the magnifying glass and I, with my glass, which he pernickety refuses to do. Why are you not here? What shouts of laughter we should have at this glorious folly! And to hear the professor of philosophy at Pisa laboring before the Grand Duke with logical arguments as if with magical incantations to charm the new planets of the sky.’ Some joy is surely to be derived from doing what hasn’t been done a thousand times before.

TABLE II: WHO IS MAKING TELEVISION APPARATUS

<table>
<thead>
<tr>
<th>Name of Manufacturer</th>
<th>Apparatus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daven Corp.</td>
<td>Motors, scanning discs (either 24, 36, or 48 holes), neon tubes, rheostats for controlling motor speed, completely assembled resistance-coupled amplifiers. Complete set for about $52.50.</td>
</tr>
<tr>
<td>Idealine Corp. of America</td>
<td>Complete kit listing $52.50, containing scanning disc with either 24, 36, or 48 holes, motor and control apparatus, magnifying lenses (to make the picture appear larger), hardware.</td>
</tr>
<tr>
<td>National Co.</td>
<td>16-hole scanning disc. Price: $15.00</td>
</tr>
<tr>
<td>Raytheon Mfg. Co.</td>
<td>High-tension lamp, $11.00 for use in television receivers. Price: $12.50</td>
</tr>
</tbody>
</table>
WITH the steady increase in the number of broadcasting stations operating in the frequency band of 350 to 1500 kc., that has taken place in the last several years, the efficacy of the super-heterodyne system of reception has gradually dwindled, for the characteristics of the typical super are such that the effective selectivity of the oscillator dial is practically halved due to the basic principle of the system. This and the accompanying fact that the average super-heterodyne, besides repeating stations at two or more points on one of the two tuning dials, will bring in a multiplicity of heterodyne squeals, has militated against the advantages of this system, such as the high amplification possible, until to-day it is quite safe to say that a good 6-tube screen-grid t.r.f. receiver will outdistance an ordinary 7 or 8-tube super-heterodyne in the matter of actual distance reception, primarily due to the greater selectivity of a t.r.f. set. The usual method of obviating repeat points upon a super-heterodyne is to use an intermediate frequency so high that the separation upon the antenna tuning dial of two stations which may be heterodyned by a single given oscillator adjustment is so great that the repeat point is either beyond the required oscillator range (for the majority of signals) or so far separated as to impose no undue selectivity requirement upon the antenna circuit. This system in a measure vitiates the principal advantage of the super-heterodyne which is the higher amplification, obtainable at low radio frequencies, than may be had at such high intermediate frequencies as are encountered in the r.f. amplifier of a t.r.f. set or as are necessary in the I.F. amplifier of a successful one-spot super. This factor makes some one-spot super-heterodynes actually inferior to a good t.r.f. set of two less tubes!

Bearing in mind that a low intermediate frequency is necessary to realize the full amplification possibilities of the super-heterodyne system and that the frequency changing feature of the super-heterodyne must in no way be relied upon to provide adequate selectivity under present broadcast conditions, the receiver pictured and described herewith was developed. As it has been developed, this receiver does not depend upon the selectivity usually obtained in the intermediate-frequency amplifier at the expense of tone quality, or upon the apparent selectivity resulting from the frequency changing action. To provide a high degree of selectivity, the input to the first detector has instead been designed to provide in itself practically all of the selectivity required for this rather unusually sensitive set. This end is attained through the use of a 3-stage radio-frequency amplifier, tuned by a 3-gang condenser to any desired wavelength. This amplifier is sufficiently selective in itself to provide effective effect of heterodyne squeals has been practically done away with, even when the receiver is operated in such congested centers as New York and Chicago.

THE DESIGN OF THE RECEIVER

IN FIGURE 1, the receiver is seen with the cabinet removed, and with all parts labeled as in the parts list. In Figure 2 is the schematic circuit diagram of the receiver, while Figure 3 shows the set with tubes in place but shields removed. The receiver consists essentially of a three-stage broadcast band t.r.f. amplifier employing three screen-grid tubes and a screen-grid first detector. Coupled into the screen lead of the first detector is the oscillator, which is of conventional type. Following the first detector is the two-stage 6-kc. intermediate amplifier and the second detector. All of these circuits are individually shielded in small copper cans with removable sides and tops for easy access. Following the second detector is a single stage of audio amplification utilizing the new Clough system. The receiver is intended to operate with an external power amplifier in order to provide a high degree of tone quality. Because of the desirability of a 210 or 250 type output tube to prevent overloading it has been thought best to omit this last stage tube from the receiver assembly. Despite the apparent complication of the r.f. amplifiers involved, the control of the receiver is simplicity itself, for the 3-gang t.r.f. amplifier condenser is controlled by the left-hand drum dial of Figure 1, while the oscillator condenser is controlled by the right-hand dial. Sensitivity of the t.r.f. amplifier is controlled by the small knob at the lower left of the control panel escutcheon. Rb. This adjustment takes the form of a potentiometer which varies the screen-grid potential of the

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**A Nine-Tube Screen-Grid Super**

By ROBERT BURNHAM

FIG. 1. THE RECEIVER WITHOUT THE CABINET

Compact construction makes this nine-tube super-heterodyne occupy a smaller space than most receivers of the same number of tubes. All the tubes except the antenna input and audio tubes are housed in the shield cans in the rear.

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**THE EDITOR.**

Many of us have probably operated a super-heterodyne which would tune in a single powerful local station at four and sometimes six or more points on the dial. This condition is due to two factors: (a) insufficient selectivity in the tuned circuits preceding the first detector, and (b) the generation of harmonics by the oscillator. There are two methods of overcoming these difficulties. One of these methods is to raise the frequency at which the intermediate amplifier is designed to operate to a value such that the second point (and the harmonics) of the oscillator cannot, for practically all dial settings, beat with any station except the one desired to produce the proper frequency to be amplified by the intermediate amplifier. This method was used in the receiver described by Mr. W. H. Hollister in the September issue.

The second method of making fool-proof the operation of a super, uses one or more stages of ordinary r.f. amplification ahead of the first detector, so that practically all the required selectivity (as well as some gain) is obtained in this amplifier; the intermediate amplifier then functions to amplify greatly the signal without being also called upon to supply all of the necessary selectivity. The receiver described in this article employs this second method.
A nine-tube screen-grid super

FIG. 2. THE SCHEMATIC DIAGRAM

If the plate lead of the detector tube, $S_6$, is removed from the P post of the first intermediate-frequency transformer and instead is connected to post No. 2 of the first-stage audio transformer, that the i.f. receiver resulting will provide very satisfactory distance reception over a range of several hundred to one thousand miles or more, and selectivity which in itself is considerably greater than that obtained from many ready-made receivers. This arrangement may be resorted to for preliminary testing of the receiver. (While a screen-grid detector tube would not work into an ordinary audio transformer at all satisfactorily, the characteristics of the Clough audio system are such that a screen-grid detector may feed directly into a transformer of this type with a quite satisfactory resultant frequency characteristic.)

The oscillator coil, $L_4$, has a grid winding equivalent to the r.f. transformer secondaries and in addition a coupling coil consisting of 35 turns of No. 34 d.c.c. wire on a 1/8" tube and a tickler coil wound in a slot at the bottom of the form consisting of 35 turns of No. 34 d.c.c. wire. The grid winding of the oscillator is shunted by the 0.0005-mfd. condenser, $C_{25}$, controlled by drum dial $D_5$. A small r.f. choke coil, $L_5$, is placed directly under the oscillator coil base with its axis at a right angle to the axis of the oscillator coil. (The oscillator and r.f. coils are wound upon moulded S-M plug-in forms which fit any standard 5-prong tube socket.)

In working upon the intermediate amplifier, a number of different transformer designs were evolved and tested, and in the course of this work the possibilities of standard i.f. transformers now on the market were investigated. The S-M 310 transformers which are normally broad-band iron core types were found to give excellent results with screen-grid tubes and due to their comparatively small primaries, functioned as rather sharply tuned transformers, giving an amplification of 65 per stage at 65 kc. and a band width of about 10 kc. at forty per cent. of maximum amplification—a quite satisfactory characteristic for an intermediate amplifier.

The intermediate amplifier tubes are $S_5$ and $S_6$, the second detector $S_4$, and the three i.f. transformers are $T_1, T_2, T_3$. The second detector employs a grid condenser and leak for rectification, while the first detector has really no means provided to effect rectification. While this may seem peculiar, it was observed in operating tests that due to the effect of the impressed oscillator voltage, very satisfactory detection was obtained even though none of the usual precautions were employed in the circuit to insure it. This being the case, it was thought best to take advantage of this propitious condition and discard the usual adjuncts to rectification, such as grid condenser and leak or C battery, which seemed only likely to add complications without any resulting gain to the receiver.

In actual operation this 9-tube super-heterodyne operating into a power amplifier stage has allowed reception of weak out-of-town stations within 10 kc. of any Chicago local station when the receiver was operated in residential districts. In comparative tests against other receivers, it was found that this super-heterodyne would in every case show a considerably higher noise level.
when adjusted to maximum sensitivity. This condition was thought to indicate a very satisfactory degree of sensitivity indeed—a value so high that it could not be utilized in the warm, summer weather due to the high noise level. During preliminary tests small 50 and 100-watt stations 1000 or more miles away were received with loud speaker volume, and the more powerful stations on the Atlantic and Pacific coasts, and in fact in all parts of the country, were received with excellent volume whenever the noise level was low enough to let these stations be separated from the noise.

**CONSTRUCTION AND OPERATION**

THE construction of the receiver itself is quite simple. The parts employed in the model described herewith are listed at the end of this article, the listings being accompanied by the designating letters seen in the various illustrations and in the circuit diagram. Despite the apparent complexity of the circuit, the receiver is very simple to put together for it is built up upon a very ingenious pierced steel chassis which is available in the open market. On this chassis, which incidentally is suited to the mounting of a number of different types of receivers, all necessary wiring and mounting holes are pierced so that to assemble the set it becomes necessary merely to put the various parts in the different stage shields as seen in the photographs and then to bolt these stage pans to the chassis itself, along with a few other parts. The wiring is quite easily handled, as all leads are short and direct and use of the metal chassis as the A minus, B minus and C plus common circuit return eliminates a large number of connecting wires. The only parts mounted beneath the chassis are the three 1-mf. bypass condensers, C1a, C1b, C1c, the antenna resistance, Rn, and the rheostat, Rg (the adjusting screw of which is visible in Figure 4). The connecting cable used simplifies the battery connection to the receiver and eliminates the multiplicity of binding posts ordinarily used for this purpose.

The testing and operation of the receiver is most simple, it being necessary after it has been assembled, wired, and checked, merely to connect the necessary A and C batteries (or light-socket power units) to the battery cable and then to connect the proper leads of the cable to the B-voltage binding posts of a single-stage power amplifier and B supply. (The receiver may not be operated satisfactorily from dry B batteries, since the current drain on the 45-volt circuit is approximately 30 milliamperes—though the total current drain of the whole receiver is only 40 mA). A good standard B-power supply should be used for the set if a power amplifier is not employed, though the latter is distinctly desirable since it is never wise in the interests of good tone quality to operate a loud speaker directly out of a single audio stage following a detector tube. Nevertheless, this may be done for test purposes and until the builder can afford an amplifier, for the receiver will give very good loud speaker volume without the use of a power output stage (which should preferably be a 210 or 250 push-pull stage).

In operation, stations are tuned in upon the Selector I and Selector II dials, and volume and stability is adjusted by means of the two small knobs on potentiometers R1 and R2, the set is turned off by turning R5 to the off position. The stations will be received at only one point upon the left-hand dial and at two points upon the right-hand dial. This condition, however, is no disadvantage, for the selectivity of the r.f. amplifier is so great that there is never any possibility of two stations, for which a single oscillator setting will serve, coming through the receiver at one time—the short wave-t.r.f. amplifier absolutely prevents this usual source of trouble. This receiver cannot be operated at maximum amplification adjustments except in locations having a most unusually low noise level and under the best of weather conditions, for the sensitivity of the receiver is such that in ordinary residential districts noises not heard on most receivers can be brought in with ear-splitting volume and of course many weak stations ordinarily not heard come in with them. This, however, is no disadvantage, for by turning down the gain controls of the receiver local programs can be received with quietness, freedom from interference, and satisfying tone quality obtainable from few other radio sets.

**FIG. 4. THE RECEIVER SEEN FROM ABOVE**

**LIST OF PARTS**

THE substitution of electrically and mechanically equivalent parts may be made in the list below, at the builder's choice. The apparatus in kit form, with all the necessary hardware, is obtainable from several mail order houses, at about $96.00 list price.

B-1 S-M 701 universal pierced chassis
BP-1. BP-2 moulded binding posts, consisting of 1⁄2 screw, nut, and moulded top
C1 to C3—2-0.025-mfd. midget bypass condensers
C4—2 0.0005-mfd. grid condenser with clips
C5—0.002-mfd. bypass condenser
C6, C7—5-1-mfd. bypass condensers
D1—1 S-M 806L (left) vernier drum dial
D2—1 S-M 806R (right) vernier drum dial
E—1 S-M 809 dual control escutcheon
J—2 Yaxley 420 insulated tip jacks
L1, L2, L3—S. M. 112B plug-in t.r.f. transformers
L4—1 S-M 132C plug-in oscillator
L5—1 S-M 273 choke
R1 to R6—Carter RU10 10-ohm resistors
R7—1 2-megohm grid leak
R8, R9—1 Carter A3 3-ohm sub-base rheostat
R10—1 Carter H3 3-ohm resistor
R11—1 Durham 1,000,000-ohm resistor
S1 to S8—8 S-M 111 tube sockets
S9—1 Naald 481XS cushioned tube socket
SH1 to SH3—5 M. S. 638 copper stage shields
SW—1 Yaxley 500 switch attachment
T1, T2, T3—S-M 210 long-wave transformers
T1—1 S-M 255 first-stage a.f. transformer
T3, T6, TC6—1 S-M 323 3-gang condenser
TC8—1 S-M 321R 0.00033-mfd. Universal condenser
4 S-M 512 5-prong tube sockets
1 S-M 708 10-std. 5-foot connection cable
2 S-M 818 hook-up wire (25 ft. to carton)
1 Set Hardware (furnished by Set Builders Supply Co.)
To make the set operative, the following accessories are necessary:
6 cx-322 tubes
2 cx-1124 tubes
1 cx-2014 tube
Power amplifier (210 or 250 push-pull preferable)
B-power unit (135 volts maximum)
Source of A and C voltage
A THE recent series of hearings before the Federal Radio Commission, a hundred stations were averted to show cause why they should be allowed to continue in operation. The evidence proved to be a most comprehensive presentation of the case of the smaller broadcasting station. So eloquently did some of the owners of the independent stations present their story that many a hard hearted enemy of broadcasting congestion felt that means must be devised to take care of as many worthy local stations as possible. Not only must the rights of listeners to good reception be considered but also that of communities to broadcast.

The whole question is: To what degree shall good reception for the greatest number and the widest areas be sacrificed to the self-interested wish of a minority of communities to broadcast? No one would oppose extension of broadcasting facilities to any community, however small, did not such a policy inevitably restrict enjoyable listening to that limited number within the high grade service area of a local station. But even disregarding the listener's rights entirely, how many of the insatiable host of radio advertising stations, most of them parading before the commission as altruistic local service stations, could be accommodated were the entire broadcasting band devoted to their exclusive use?

In spite of the obvious local sentiment for the continuance of some of these community stations, the statement remains unrefuted that no great number of them can be taken care of without making high-power broadcasting impossible. From the engineering standpoint, the capacity of the ether is strictly limited to a definite number of stations of a given power per channel, separated by a definite minimum distance. As early as March 24, 1927, a member of the staff of Radio Broadcasting presented to the Federal Radio Commission a comprehensive plan for broadcast station allocation which definitely appraised the station capacity of the broadcast band and provided for equitable distribution of channels by areas. The plan proposed that the United States be divided into areas 500 miles square, and laid out a definite quota of high-power, regional and local stations of various powers which could be accommodated for simultaneous operation in each area. It pointed out that the Commission's first task was to appraise the capacity of our 85 broadcast channels and then allot their facilities equally to specific areas. Only now is the Commission beginning to do all of these things.

With respect to local service stations, the plan pointed out that 50-watt stations, providing "high grade" service for three miles and "satisfactory" service for five miles, were adequate to meet the requirements of local communities broadcasting for the benefit of a particular city and its environs and would make it possible to provide such facilities for the greatest possible number of cities. Several stations of that power can be assigned to the same channel, if separated by a minimum of 300 miles. Were all of our 85 channels assigned to this service exclusively, there would be a maximum of 157 local service stations. The maximum area receiving satisfactory service would be 1,839,650 square miles, or approximately half the area of the United States. Assuming equal geographic spacing, there would be a carrier on every dial setting of the receiver, but a program of satisfactory strength could be received in half the area of the country on but one dial setting. The other half of the country would have no "satisfactory" service whatever. No allotment would be made to higher powers on this basis, so that the listener, tiring of his one local station, could not take advantage of high grade regional stations.

The other extreme which could be adopted would be to give virtually no consideration to the rights of communities by assigning all channels to super-power stations endowed with exclusive channels. This would provide a maximum of 90 stations of 50,000 or 100,000 watts. A station of 50,000-watt power has a "high grade" service range of 90 miles and a "satisfactory" service range of 350 miles. The total area receiving "satisfactory" service coverage from 89 such stations would be 36,236,350 square miles. Therefore, were these stations spaced equidistantly, there would be twelve 50,000-watt stations within 300 miles of every point in the United States. The high-grade service coverage would be 13,747,350 square miles. In other words, the listener would have a choice of four stations within high grade service range and twelve within satisfactory service range, no matter where he was located. With 1157 50-watt stations, only 8800 square miles of the United States would have high grade service.

Any plan of allocation is a compromise between these extremes. Either few communities will have stations as a medium of expression, while the listener, no matter where he is located, will have a considerable choice of powerful stations, or else many communities will have opportunity to place themselves on the air for local service while the actual area getting high grade service would be significantly reduced.

The table on this page, taken from Using Radio in Sales Promotion, gives the average number of stations per channel, their minimum separation and their service ranges and areas. The average of one and a half stations per channel of 5000 watts is based on the fact that two stations of such power may be placed at diagonal extremes of the United States, while in any other location the 5000-watt station must have an exclusive channel. The table shows that there is no gain in frequency space by reducing the maximum power from 100,000 to 10,000 watts, or any other such figure, as is often suggested, because a 10,000-watt station takes as much ether space as a 100,000-watt station.

The most important argument against the high-power station is that the total number of radio broadcasting stations in the United States is reduced in proportion to the number of high-power stations permitted. A few large stations naturally tend toward the centralization of broadcasting in a few organizations, because high-power stations are unprofitable unless they draw upon the finest possible program sources and the most fruitful revenue producing programs. The other extreme is in the establishment of many community stations of low power and necessarily of low program merit. It is our opinion that the low-power station should be encouraged in sparsely populated sections where there is no reasonably good service from high grade stations, but that in populous areas, with many independent broadcasting sta,

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JUST BEFORE MAKING RADIO HISTORY
At Signal Hill, Newfoundland, Senator Marconi, in the center, Mr. G.S. Kemp (left) and Mr. P. Page (right) are pictured with a basket containing a balloon that they hope will carry an antenna on which to receive radio signals from Poldhu, England, Time: December, 1901. The balloon was carried away in a gale, but a kite was used, and the historic letter "S" came through from England—the first transatlantic radio signal ever received.
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or direct advertising. Picture broadcasting is a general service of pictures into the home. For the present, this is a service principally to expand the horizons of the public—those who initiated the broadcast boom in 1928—and it is unfair to pass special regulations restricting the service to that growing group.

However, in one sense, the desired objective of the Commission to restrict picture signals to hours such that the public, seeking musical entertainment, shall not be too frequently disturbed by picture signals, has already been attained. Ninety per cent. of all picture transmissions take place during daylight hours when the stations involved have heretofore been customarily silent. No program director is prepared to force picture signals upon an audience pre-dominantly interested in tone reception, especially between the hours of eight and eleven in the evening, and the maximum weekly schedule of the stations now broadcasting pictures through out the United States involves less than twenty minutes of actual picture signal per week. This is certainly not too great a concession to the experimenter who looks forward to the day that illustrated radio programs will be received in every broadcast listener’s home. In spite of the doubtful validity of a regulation applying program restrictions, there is really no opposition to the Commission’s proposed course in limiting the number of picture transmissions permissible.

Here and There

The Army Air Corps, according to F. Truube Davison, Assistant Secretary of War for Air, will install radio beacons at Mitchell Field, N. Y., San Francisco, Calif., San Antonio, Texas, Uniontown, Pa., Dayton, Ohio, and Washington, D. C. Experiments prove that the range of these beacons may be extended up to 2000 miles, if required.

Chief Radio Supervisor W. D. Terrell has issued an order to amateurs and experimental stations, effective October 1, that they use the intermediate “w,” if located in continental United States, and “k,” if in our territories or insular possessions, in accordance with the plan adopted by the International Radio Telegraph Convention.

A studio is being installed in the new administration building of the Board of Education of Pittsburgh, Pa., in order that educational programs may originate there for transmission by kko. Practically every school in Pittsburgh has been equipped with a receiving set and, at specified times, lessons on a particular subject will be broadcast to all pupils of all schools of a certain grade. Educational work of this nature has been carried on in England for several years. More than 150 schools in London and Daventry are equipped to receive programs radiated through the British Broadcasting network.

Another experiment along educational lines was conducted for a period of six weeks last season by west of Boston, and will soon be resumed on a more elaborate scale. From one to thirty o’clock on Tuesday and Thursday afternoons, the students of the S. A. Day Junior High School of Newtonville held classes in the assembly hall before the local station. The success of the project was so marked that many schools were equipped with radio receivers during the summer. The subjects taught last season were French, poetry, music, science, history, and geology.

Contributions ranging from fifty cents to two dollars were received by Tex Rickard as expressions of thanks from members of the radio audience for making possible the broadcasting of the Tunney-Heeney fight. Rickard, upon receipt of these donations, expressed the opinion that they were evidence that the broadcasting companies have been receiving something good for practically nothing for a long time. His contract with the N. B. C. soon expires and the probabilities are that Rickard’s peace conferences will not be broadcast for some time to come. Eventually, however, a commercial sponsor will probably be found for them.

The Columbia Broadcasting System has concluded arrangements with Station WRC, operated for some years by A. H. Grebe & Company, to become its alternate New York key station on the evenings that WOR is not available. Columbia chain programs have thereby become nightly affairs. WOR has also relinquished Sunday afternoons and evenings in favor of WRC.

Advertisers are spending from ten to twelve million dollars yearly in presenting good will programs through radio, according to Frank A. Arnold of the National Broadcasting Company. This, it seems to us, is greatly underestimated, since it does not take into account the money spent on local stations for advertising announcements.

The number of stations deleted from the list of broadcasters as a direct result of the notification to show cause, served on 264 stations, amounted to but 36. All but 57 of the cited stations appeared at the hearings with witnesses and affidavits, and 21 stations filed affidavits by mail.

Captain S. C. Hooper has been made Director of Naval Communications to succeed Rear Admiral Craven, who has been made commandant of the naval training station at Great Lakes, Ill. Captain Hooper has been temporarily assigned to the Federal Radio Commission as short-wave expert.

A list of frequency assignments for special services on short waves was announced by Captain Hooper, just prior to his appointment as Director of Naval Communications. Six channels were reserved for communication between airplane and ground stations; five channels for communication between ships, ship-to-ship and coastal stations by radio telephony; one channel for police departments; three marine calling frequencies; two groups of frequencies comprising eleven channels for experimental purposes; five for geo-physical purposes; six for railway communication between engine and cabooses; four for scientific expeditions and yachts, in addition to their usual calling frequencies; three for portable stations and twenty for power line control. This latter generous allocation should certainly satisfy the power companies.

 Appearing before the Federal Radio Commission on May 14, 1928, to request a great number of 100-kilowatt channels for television purposes, Dr. Alfred N. Goldsmith of the Radio Corporation of America stated: “Radio television is at a stage where it is prepared to leave the scission of the research laboratory and to enter into the daily affairs and uses of men. Intensive development work of an experimental nature has already been carried on and transmission of television material is at hand through confidential experiments and transmissions carried on at Schenectady, Pittsburgh, and New York. In other words, television is not a vague and remote project, but, while still experimental, it is an imminent and plausible possibility.

After pointing out that unformed television broadcasters would transmit an endless series of unsatisfactory pictures which would benefit only oculists in the proportion that they would ruin the eyesight of the public, Dr. Goldsmith continued: “In the interests of saving both the

How It’s Done in Japan

Nipponese broadcasters use Western apparatus (in this case a Marconi ro-kilowatt transmitter), but they manage to create the atmosphere of a Japanese print room in so mechanic a background as this. The photograph shows the modulator and amplifier panels of Station JOBK at Osaka, one of Japan’s leading broadcasting stations.
RADIO BROADCAST

OCTOBER, 1928

vision and the television of the public, only an experienced and responsible organization, such as the Radio Corporation of America, should be granted license to broadcast television material, for only such organizations can be depended upon to uphold high ideals of service. If these statements are universally accepted, all but the R. C. A. will quit the television field.

Among the suggestions made for increasing the number of local communities which may be represented in the ether by broadcasting effusions, came one from Senator Edwards of New Jersey to the effect that 25 channels be set aside for stations of 5000 watts power or more, leaving 52 channels for 500-watt stations and 12 channels for stations of 350 watts power shared with Canada. The average number of 500-watt stations which can be accommodated on a single channel is not higher than three, although there is a theoretical maximum of six, so that the Senator's plan provides for about 150 500-watt stations and for 25 to 50 stations of greater power. The seemingly liberal plan therefore represents an even more drastic cut than that proposed by the engineers.

In the appointment of Louis G. Caldwell of Chicago as Chief Counsel for the Federal Radio Commission, and Dr. J. H. Dellinger, former Chief of the Radio Division of the Bureau of Standards, as Chief Engineer, the Commission has recruited to its ranks two of the most eminent and competent men in their respective lines. Caldwell, who is in no way related to his namesake, the Commissioner for the first district, has made a most exhaustive study of radio law and has represented important broadcasting interests. Dr. Dellinger's reputation as a scientist requires no rehearsal to any radio enthusiast. He has been a public servant for many years and, unlike most of those few qualified to act in an advisory capacity on technical matters to the Commission, has no former association which might be deemed a disqualification by radical persons.

The Bell Telephone Laboratories demonstrated, on July 12, a new photoelectric cell which is considerably more sensitive than any similar device so far shown publicly. The original television transmitter and receiver, demonstrated a year ago, were used in the newer demonstration, and by application of the more sensitive photoelectric cell, a full-size figure in motion was successfully televised. The new cell greatly increases the range of vision of the eye of television and places even greater emphasis on the still unsolved problem of conserving the frequency or channel space required to transmit a television image of sufficient detail to have real entertainment value.

A new Japanese broadcasting station has been opened at Kumanoto of 10 kilowatts power, operating on 380 meters. The call letters are J00K.

Our commercial attaché in London reports that an American radio receiver is being delivered at London at a cost of forty-five dollars, must then pay royalties of fifteen dollars to the Marconi Wire-

less Telegraph Company. These royalties tend to curtail American radio exports to England. American exports in 1926 to that country amounted to $55,375 in sets and $34,089 in tubes.

Improvement in the naval communication system is indicated by the fact that the average time of messages between the Pacific Coast and the Philippines has been reduced to one and fourteen minutes in May, 1926, as compared with seven hours and five minutes, the average obtaining in June, 1926.

The Radio Communications Board of the Philippines decided to issue licenses only to short-wave telegraph stations for remote districts where the services thereby established will not compete with that offered by the Bureau of Posts. Seven stations will soon be placed in operation by that body.

Recognition of radio broadcasting as an agency for political propaganda has been accorded by the major political parties through the appointment of Joseph Israel II as radio director for the Democratic National Committee and O. P. Gascoigne to a similar office for the Republican National Committee.

Beginning with a single installation in June, 1925, the Lighthouse Service now has in operation twenty radio beacons along the shores of the Great Lakes. In fair weather, these stations transmit signals four times daily for a half hour, permitting the taking of compass readings. During heavy weather, they maintain a continuous compass service. A company has been formed in Sydney to take over the control of two local broadcasting stations which were suffering from lack of program variety and tendency to duplicate features. This is the first step in merging all Class A stations in a single system. It is said that only the state-controlled station at Queensland will remain outside the pale, if the plan of the new company is successful.

The International News Service expects to exchange press reports with Europe from a station to be located at 59th Street in New York City. Receptor has the cooperation of friend, and, where re-transmission to all parts of Europe is possible. The United Press will not attempt to use radio in competition with existing communication systems, but will utilize its station at Garden City for expeditions, important broadcasts and similar special services.

At a meeting of the International Circulation Managers Association, it was brought out that radio summaries of news features helped newspaper circulation, but that radio has cut the sales of extra and similar scheduled events, such as prizefights and baseball games.

One million shares of Baird Television, Ltd., at five shillings a share, were subscribed to by the English public recently. These shares have risen in value upon circulation of a rumor that the American rights to Baird Television had been purchased. This public support of the issue appears surprising in the absence of any regular broadcasting of television images, and in the face of the hostile attitude of the British trade press, which issued an unanswered challenge to Baird to make a public demonstration of television by radio, posting a prize of five thousand dollars.

A Delaware charter has been filed by the American Baird Television Corporation with a capital stock of a million shares of no par value. No doubt the public will soon be invited to participate in this enterprise, possibly in advance of any demonstration of Baird equipment.

Licensed broadcast listeners in Germany on April 1, 1928, totaled 8,234,732, as compared with 1,130,000 on February 1, 1924. The license fee paid by these numerous listeners amounts to fifty cents a month each and the government budget for the support of the nine broadcasting stations maintained in that country amounts to $12,500,000.

The British Broadcasting Corporation showed a total income of $4,508,130 for 1927, of which about four million was from licenses and the balance from publications and other sources. Of this revenue, $2,438,640 was spent for program material. The system was on the air during the year for a total of 68,000 hours. There were 20 hours of break down. The number of listeners amounted to 2,395,174, an increase of 217,000 over the previous year. Apparently, the numbers of listeners in England and Germany are about equal, but three times as much money was spent in winning the German system as the British.

What's doing on the Potomac

This open-air laboratory is part of the Bureau of Standards equipment for testing the field strengths of broadcast transmissions, in an effort to help in unraveling the present station allocationuddle. The transmitter is two miles to the south, across the Potomac near Washington, and the engineer is making a record of the field strength of various broadcasts.

-E. H. F.
The "Hi-Q 29"—A Receiver with a Band-pass R. F. Amplifier

By D. K. ORAM
Hammond Mfg. Co.

In the design of a modern broadcast receiver it is conceded that quality of reproduction and selectivity are of prime importance. Also, in most cases, a high degree of radio-frequency amplification is a distinct asset, if it can be secured without loss of stability and without affecting the preceding qualifications. A high-gain r.f. amplifier preceding the detector circuit increases the sensitivity of the receiver as a whole. Great sensitivity is highly desirable from two standpoints. First, it enables the set owner to receive programs from very distant stations when he feels so inclined, and second, it makes possible quite satisfactory reception from local and moderately distant stations on a very short indoor antenna even in unfavorable locations.

Unfortunately, these three prime requisites of a fine receiver, quality of reproduction, selectivity, and sensitivity, are by no means independent of each other. For example, the modern high-quality audio transformers now available make possible the construction of a practically perfect audio amplifying system. If a power tube is used in the last stage of such an amplifier and its output fed into one of the better type speakers, the audio amplifying and reproducing system leaves little to be desired. However, this system can only amplify and reproduce what is fed into it by the detector tube, which in turn receives the signal from the radio-frequency amplifier. Hence it is evident that even a perfect audio system cannot provide a high quality output from the loud speaker if distortion is introduced in the r.f. amplifier due, let us say, to excessively sharp tuning, technically known as "side band cutting."

In the same way selectivity and sensitivity are incompatible. One of the reasons for this condition is not generally understood, and is even more seldom taken into consideration. The average receiver owner or experimenter bases his judgment almost entirely on the "apparent" selectivity. This is quite natural, in view of the fact that the actual selectivity of a receiver can only be determined by a series of very careful measurements. The apparent selectivity of the ordinary radio set decreases as its sensitivity increases. Therefore, of two receivers having exactly similar "actual" selectivity and one having, say, three times the sensitivity of the other, the set having the higher sensitivity (or amplification) will invariably seem broader or less selective. This principle is very clearly shown in Fig. 1. Curve A is the response curve of the less sensitive receiver when tuned to 600 kc. Assuming that no 6oo-kec. station is on the air at the time no sound will be heard from the loud speaker, as the sensitivity of the set is not great enough to bring the 580-kec. station (which is assumed to be on the air at the time) above audibility. Curve B represents the response characteristic of the more sensitive receiver, and under the above mentioned conditions the 580-kec. station will now be heard, since the increased amplification of the more sensitive receiver is sufficient to bring the signals above audibility. Thus it is quite easy to understand why the more sensitive of the two sets will appear to be less selective, although in reality one is equally as selective as the other.

The Advantage of the Screen-grid Tube

The new 222 type screen-grid tube with its high amplification factor and extremely low plate-to-grid capacity would at first glance seem to be ideal for use in r.f. amplifiers. The manufacturers of these tubes state that a voltage step-up of forty or more per stage is obtainable at broadcast frequencies. In addition the plate-to-grid capacity is said to be of the order of one-fortieth of a micromicrofarad or about one-fourth of a hundredth as great as that between the plate and grid of the 204A type tube. Therefore the appearance of the screen-grid tube, with a capacity so small that neutralization is unnecessary, was welcomed by set designers, and many circuits using them made their appearance. Many of these sets did have enormous amplification, making possible quite satisfactory reception on very short antennas. The selectivity of these sets, however, left much to be desired—so much so that the tube acquired the reputation of causing broad tuning.

In planning the set to be described the natural advantages of the screen-grid tube were carefully considered, and the various methods of overcoming the apparent disadvantages were also investigated. Two stages of r.f. amplification were decided upon as sufficient, as they could reasonably be expected to produce an overall voltage gain of more than one thousand. In order to achieve a high degree of selectivity with this amount of amplification some special form of tuning is necessary. The conventional antenna coupler and two interstage r.f. transformers were found to be wholly inadequate in the matter of selectivity, although the amplification was good. The tuned plate-impedance coupling condenser and grid leak arrangement specified by the manufacturers of the tube was passed up for the same reason. Calculation showed that it was quite feasible to tune both the grid and plate circuits of these screen-grid tubes. This is one of the marked advantages of this type of tube, since an attempt to tune both grid and
Due to the inherent characteristics of loosely coupled tuned circuits each of these doubly tuned r.f. transformers really constitutes a band pass filter. This is quite clearly shown in Fig. 2. In this figure is shown the tuning characteristic of one of these double-tuned loosely coupled transformers. The dotted line represents the response curve of one tuned circuit alone, and the solid line that of both circuits properly coupled. It will be noticed that the dotted curve of the single circuit is a typical resonance curve; very sharp on the top at exact resonance and sloping gradually toward zero as the frequency is increased or decreased. On the other hand the solid curve of the double circuit is quite broad and almost flat on the top over about seven kilocycles, but slopes more steeply on the sides and the response approaches zero much more rapidly above and below the resonant frequency. These curves in Fig. 2 are based on actual measurements of one of the new r.f. transformers used in the Hammarlund-Roberts "Hi-Q 20."

While one of these double-tuned r.f. transformers provides an unusual degree of selectivity, the use of two such stages in cascade results in a vast improvement. As an illustration note that the response of an interfering signal at 20 kc. below resonance on the solid curve of Fig. 2 is but 9 per cent. or about 3 dB of the response at the frequency for which the set is tuned. This is for one stage only. After going through the second stage, however, the intensity of this interfering signal will have been reduced to 7/8 per cent., or about 1½. At the same time the addition of the second stage does not materially affect the shape of the top of the response curve. The top of the curve remains substantially the same as shown in Fig. 2; the sides become much steeper and the response approaches the zero line at a much more rapid rate.

[These percentages, when reduced to losses in TU, give interesting figures. At 20 kc off resonance, for example, the discrimination of a single resonant circuit—using Mr. Oram's percentages—is 1.5 TU, while the double-tuned circuit gives an additional 8 TU or a total loss of 22 TU. When these signals are passed through an additional double tuned circuit this becomes 44 TU, and if the antenna stage has a discrimination of 10 TU at 20 kc. the total selectivity factor becomes 54 TU, which is the difference between signals from two stations at an equal distance from the receiver but differing in power by a ratio of 250,000.]

The width and flatness of the top of the solid curve shown in Fig. 2 has an important bearing on the quality of the received program. This is due to the fact that broadcast stations do not transmit on a single frequency, but rather on a band of frequencies. The width of the signal band is determined by what, depending on the transmitter adjustments and also on the type of program being broadcast. They are, however, generally large enough to allow five kilocycles wide for high quality transmission. It is therefore apparent that the receiver should be able to amplify a band of frequencies with substantial uniformity if the programs is to be received faithfully. Hence the desirability of the wide flat top on the overall response curve of a high-grade receiver. When the top of the response curve is sharp instead of flat all the frequencies in the band do not amplify equally. At certain of these frequencies the detector much stronger than others with the result that even the most perfect a.f. amplifier and loud speaker will be unable to reproduce the program with its original quality.

The two double-tuned r.f. transformers used in the Hammarlund-Roberts Hi-Q 20 necessitate the use of four variable condensers—one to tune each of the four coils. Since all four of the tuned circuits are identical these four variable condensers are rotated by a common shaft actuated by a new model drum dial having a smooth positive drive without backlash. The tuned input circuit to the grid of the first screen-grid tube, often referred to as the antenna coupler, is of the conventional type having a tapped primary making it adaptable to different length antennas. The variable condenser tuning this antenna coupler is on a separate shaft and has a separate drum dial, thus enabling this circuit to be tuned to exact resonance with the received signal.

THE COUPLING TRANSFORMERS

THE remarkable performance of this receiver can best be understood by consideration of the principles involved in its design. The inter-stage r.f. transformers are quite unique, in that they consist of two exactly similar coils. One constitutes the primary of the transformer and is connected in the plate circuit of the preceding tube, and the other coil acts as the secondary and is connected to the grid of the following tube. Each coil is tuned to resonance with the desired signal by means of a 0.00035-mfd. variable condenser. Due to the rather unusual mounting arrangement the mutual inductance or coupling between primary and secondary is very small. However, this does not mean that the energy transfer from primary to secondary is inefficient. On the contrary, when two tuned circuits are coupled to each other, the maximum secondary voltage is obtained when the relation \((2\pi f)M^2 = R_1R_2\) is satisfied, where \(f\) is the frequency to which both circuits are tuned, \(M\) is the mutual inductance in henrys, and \(R_1\) and \(R_2\) are the effective radio-frequency resistances of the primary and secondary, respectively. In the case of the coils used in the receiver under discussion the maximum secondary voltage is obtained with a coupling coefficient of the order of one per cent. The physical arrangement of the coils, as shown in Fig. 3, was chosen because it seemed the simplest way to secure such loose mechanical coupling while still keeping the coils close together, thus conserving space.

FIG. 3. AN R. F. COIL

Both primary and secondary of this interesting transformer are \(1\frac{1}{4}\)" in diameter and \(\frac{1}{2}\)" long, wound with silk covered wire, about 80 turns of No. 28 wire being used. The detector input coil has a tap at about the twentieth turn from the grid end, as indicated in Fig. 5.

FIG. 2

The volume control is quite out of the ordinary and is made possible only by the characteristics of the screen-grid tubes. It consists of a...
100,000-ohm potentiometer, $R_5$ connected across the 45-volt B supply. The center tap of this potentiometer provides a variable voltage which is impressed on the screen grids of the two r.f. amplifier tubes. The amplification obtainable from these tubes varies within wide limits as the voltage on the screen grids is varied, being at maximum around 45 volts and dropping rapidly as the screen-grid potential is reduced. This provides a very smooth control of volume within wide limits without affecting quality or tuning in the slightest degree.

While the screen-grid tubes have a very low value of capacitance between plate and grid, thus almost entirely obviating the tendency to feedback through the tubes themselves, this advantage is nullified if feedback occurs in other parts of the receiver. Taking this into consideration, every effort has been made to isolate all circuits in which coupling might result in instability. The negative bias for the grids of the r.f. tubes is secured by the drop across individual 100-ohm resistors, $R_4$ and $R_5$ in series with the negative leg of each screen-grid tube filament. Since the screen grids of both tubes are biased by the 100,000-ohm potentiometer, $R_5$, 5000-ohm isolating resistors, $R_6$ and $R_7$, are inserted in the lead to each of the screen grids, which are in turn bypassed by means of separate 0.5-mfd. bypass condensers, $C_6$ and $C_7$. The plate circuits of these tubes are likewise isolated by individual filters consisting of separate radio-frequency choke coils, $L_1$ and $L_2$, and bypass condensers, $C_8$ and $C_9$. In addition to the above mentioned precautions the entire r.f. end of the receiver is thoroughly shielded. Each stage is entirely enclosed in a snug fitting aluminum box which is securely fastened to the metal chassis. The screen-grid tubes are so located that the leads to the control grids are as short as possible and well removed from the plate leads, which are also very short. By placing these tubes between the cans as shown in Fig. 4 the can sides are used also as tube shields, effectively preventing coupling between the tube elements and other parts of the circuit. This arrangement provides the minimum coupling between output and input circuits, which is extremely important.

The audio amplifier is of the conventional type consisting of two stages transformer coupled. The a.f. transformers, $T_1$ and $T_2$, have a very flat frequency characteristic over the usual a.f. range. An r.f. choke coil is placed on the plate of the detector tube and the first a.f. transformer to prevent any stray r.f. voltages from getting into the a.f. amplifier. A 171 type tube is recommended for use in the last stage, although other types may be used if suitable A, B and C voltages are available.

**A. C. Operation**

Although the above description is based on the battery operated model, a complete all electric model has been developed. Arcuates a.c. screen-grid tubes are used and some slight changes in wiring are required. Otherwise the operating characteristics and set performance of the a.c. and d.c. models are identical. Constructional data on the a.c. model may be obtained from the kit manufacturers, or through Radio Broadcast. Fig. 4 is a top view of the a.c. set, which is similar in general appearance to the d.c. model.

**List of Parts**

The parts used in the d.c. laboratory model of the Master Model "HI-Q 29" receiver are listed here. The coil data is given in Fig. 3 in case it is desired to make these at home. All the other parts are of standard design, and substitution of other makes of equivalent parts may be made.

- $A_1$, $A_2$, $A_3$—Hammarlund coil set, No. HQ-29
- $C_1$ to $C_5$—Hammarlund midline condensers, 0.00035 mfd., No. ML-37
- $C_1$—Sangamo fixed mica condenser, 0.000025 mfd.
- $C_4$—Sangamo fixed mica condenser, 0.0001 mfd
- $C_4$ to $C_9$—Parvot bypass condensers, 0.5 mfd., series 200
- J—Pair Yaxley insulated phone tip jacks, No. 622
- L1, L2, L3—3 Hammarlund radio-frequency chokes, No. RFC-85
- $R_1$—1 Carter "Hi-Pot" potentiometer with switch, 100,000 ohms, No. 115
- $R_2$—1 Durham Metallized resistor, 2 megohms
- $R_3$, $R_4$, $R_5$—3 Amperites, No. 1-A
- $R_6$, $R_7$, $R_8$—4 fixed filament resistors, 10 ohms (included in foundation unit)
- $R_9$, $R_{10}$—2 fixed resistors, 5000 ohms (included in foundation unit)
- T1, T2—2 Thordarson audio transformers, No. R-300
- Y—1 Yaxley Cable Connector and Cable, No. 669
- 2 Hammarlund knob-control drum dials (walnut), No. SDW
- 5 Benjamin Cle-Ra-Tone sockets, No. 9540
- 2 EBV engraved binding posts
- 1 "HI-Q 29" foundation unit (panel, shields, chassis, shafts, binding post strips, clips, fixed resistance units $R_8$, $R_9$, $R_{10}$ and $R_{11}$, resistor mounts, and all special hardware required to complete receiver).

To place the set in operation the following apparatus is necessary:
- 2 CX-322 tubes
- 2 CX-301A tubes
- 1 CX-171A tube
- Source of A, B, and C voltage (6 volts A, 45, 90, 135 volts B, 45 and 27 volts C)

**Fig. 4. How the Instruments Are Mounted**

**Fig. 5. The Circuit of the "HI-Q 29"**
A Short-Wave Transmitter for 1929

By ROBERT S. KRUSE

AMATEURS are a curious lot—years ago they should and could have had just such a 1929 transmitter as Mr. Kruse describes in this article, a transmitter that stays on the wavelength to which it is set, one which delivers a good note, and in which vagaries of antenna height or power supply are prevented from affecting the frequency of transmitted signals. The transmitter is an oscillator-amplifier set-up that can be put on the air "as is" or that can be used with an external r.f. amplifier employing bigger tubes. Or, as a later article will describe, the present apparatus can be modulated by voice and thereby provide rapid communication over medium distances.

—THE EDITOR.

MY GOOD friend H. B. Richmond once said that it is good practice to discount warnings of radio troubles by 90 per cent. in most cases but by 100 per cent. if a complete disaster is announced.

The rule has worked well for four years. It happens that during those four years I have probably written or edited as many stories about American short-wave radio as anyone. For both reasons I have the utmost confidence in applying Mr. Richmond's entire 100 per cent. discount to the present predictions of the calamities that are to befall amateur radio transmission when the bands are narrowed on January 1, 1929.

There is absolutely nothing to these dangers except state of mind. No legal lightning will strike the transmitting antenna; no one will be arrested for owning a microphone; no startling new apparatus will be needed.

A set not good enough for 1929 was certainly never good enough for 1928; therefore, the set to be described is no more of one year than of the other. Furthermore it is in no way revolutionary except in being so laid out as to permit the use of all of the "practical" bands. Incredible as it may seem, such sets seem not yet to have been built, although their design involves nothing new.

THE "PRACTICAL" BANDS

IT IS necessary at the beginning to gain some understanding of the importance of breaking away from the vicious habit of "choosing a wavelength" or a pair of wavelengths, building a transmitter for them, and then settling down until removed by force. The active experimenter is not quite as guilty of this practice as the more stationary "message handler." Unfortunately the beginner is very likely to hear the latter (who is constantly on the air) and to follow him into the unhappy scramble on 40 and 80 meters. As a result bowing bedlam exists in those bands and its occupants are sure they cannot spare even one kilocycle from either band, whereas 1929 will cut the 40-meter band from 1000 to 300 kilocycles.

The present situation in the amateur bands, with respect to wavelength allocations, is summed up in Table I, on this page.

Analyzing this table, it seems at first that the available space has been reduced from 15,000 k. to 7485 k., and the amateur deprived of half his territory. However, of the 15,000 k. available to the amateur in 1928, the bands actually used were only 4000 k., and this includes the almost uninhabited 150-200 meter band. The wavelengths below 10 meters were vacant—some 11,000 k. of ether space. Now for 1929 the available space on the 10, 20, 40, 80, and 160 meter bands amounts to 3485 k., and this does not include some 4000 k. on the 5-meter band which is crying for development.

We see at once that the saddest possible way of looking at the thing is that we will drop from 4000 to 3485 kilocycles. Somewhere that outlook fails to depress me. It seems as if the beginner will find quite as much room as before, while the present station owner has but to bring his equipment up to the requirements of a year ago in order to be perfectly ready for 1929.

PRELIMINARIES

THE discussion and the table will have made clear that we should have a set and an antenna capable of operating at a variety of wavelengths. Having set the transmitter squarely on one of those wavelengths we are ready to begin telephone or telegraph transmission with the certainty of reaching someone.

The beginning of the whole business is this ability to set to a known wavelength with a transmitter which will thereafter stay on that wavelength. Since we propose to work in 5 and possibly 6 bands it would be very expensive, complex and time-consuming to do this thing with crystal control, nor is that necessary if a suitable wave-meter is permanently stationed alongside the transmitter.

It is perfectly possible to build a suitable wave-meter, but it is a difficult job even for the experienced experimenter who is assisted by calibration from a quartz crystal or else some new standard frequency schedules from our good friends of the Gold Medal Station wco-gx-ghi. It is much more satisfactory to purchase an "amateur band wave-meter."

While the wave-meter is coming we have time to explain to the newcomer in transmitting what is required in the way of licenses. Two licenses are required, both being issued by the Federal Radio Commission through the various Supervisors of Radio under Mr. W. D. Terrell, Chief of the Radio Division of the Department of Commerce. The first license to be obtained is the amateur operator's license. One should accordingly write to the Supervisor of Radio for the particular district in which one lives and request information as to the manner of obtaining the operator's license.

The papers received in reply will explain how the operator's license is obtained and at that or a future time one is advised as to the station license which will state the station call and also the wavelengths at which it may operate. None of the examinations are hard, nor need any fear be felt with regard to the test on code reception, since the necessary skill can be acquired at odd times by listening to short-wave stations and ships with a plug-in coil receiver. If there is any hurry the thing can be done more rapidly by a
week or ten days of tutoring with an operator and a buzzer. It is well if the tutor is very steady, and rather undesirable if he is fast, or thinks he is.

THE QUESTION OF POWER SUPPLY

HAVING done with rumors and law we may now get down to radio. There is space in this article neither for the fundamentals of the art nor for the description of circuits and curves, and the reader may therefore assume the evil preliminaries to have been completed before his arrival. The circuit of the transmitter is shown in Fig. 1, and is a simple variation of the Colpitts oscillator which permits placing fairly large capacity across each of the tube capacities whose variations ordinarily cause wavelength changes. Even with such a circuit the greatest steadiness is not obtained unless it is protected from the variations of the antenna system and from changes in filament and plate voltage. The antenna variations can be kept from the oscillator (to a very large degree) by interposing a stage of neutralized r.f. amplification: our set accordingly consists of a receiving tube used as an oscillator with a somewhat larger tube acting as amplifier. That idea is, of course, very far from new and has during the last few years been carried out in many forms.

To avoid the effects of voltage variation, the use of the oxide filament type of tube represented by the UX-112, or the UX-2014 tube with the thoriated filament, is recommended. Both of these tubes can stand slight variations in filament voltage without much effect on frequency. These are used where storage battery filament supply is used for the oscillator. One may, of course, desire for the greatest steadiness. Since a storage battery is more or less of a nuisance one may wish to use alternating current filament supply. A wide variety of tubes have been tried on a.c. supply by the author, and very much the best, when both steadiness and life are considered, has been the Sangeo Type 28 and Type 30. Please understand that I am not criticizing other small tubes, which are doubtless perfectly good for their normal purposes.

The oscillator plate supply is obtained from a 180-volt battery of dry cells, which can be of the size used for 20 to 30-W lamps or for the larger size. This practice was first suggested by the laboratory and in transmission practice by Prof. Willis Hoffman of the Burgess Laboratories. (NOTE: A special heavy-duty 180-volt unit cataloged PL-1728 has just been put on the market by Burgess for this purpose.)

By providing a very steady oscillator these devices start the whole set off in the right direction.

The circuit layout

The oscillator may be a 2014, 112, 112A, Arcturus Type 28, or even 226 tube. The amplifier may be a 112, 171, 210, 210A, or Arcturus Type 30 tube. Consequently rheostats have been omitted entirely in the diagram and discussions and are to be supplied externally or else built in when the builder has found his pet tube combination. The set as it stands is meant for a 2014, 112, or Arcturus Type 28 tube in the oscillator socket and a 112, 171, or Arcturus Type 30 tube in the amplifier socket. It has, however, been run with a 112 in the first socket and a 210 or 210A tube in the second socket. The operation was satisfactory, but the stopping condenser, C1, in Fig. 1, in the amplifier plate circuit becomes rather warm at voltages above 300. For regular operation with the 210 or 250 35 amplifiers it should be replaced by a Sangeo 1000-volt type. With these changes the amplifier plate voltage may be carried as high as 600, provided that a similar change is made in the plug-in loading condensers for the amplifier.

It will be noticed from the photograph at the beginning of this article that the panel shows three peculiarities which may as well be explained now. The antenna meter is a Weston thermo-galvanometer of the well-known model 245 which gives full scale reading with a current of 115 milliamperes. The antenna current is ordinarily much larger and the meter is then shunted by a short piece of wire whose length is found by trial (starting with a very short wire). When working with very short waves in the harmonic manner explained later, the current is sometimes very small, but nevertheless the shunt should be in place until one is satisfied that it may be removed without damage to the meter. Secondly, it will be noticed that the antenna tuning condenser, below and to the right of the meter, has no dial. This is my personal preference to which the reader is not bound, though I prophesy he will find a dial worthless. Finally we have the three binding posts which have to do with methods of keying, of which more later.

Since it is impossible to guess just what sort of a scale the prospective builder desires he is given the opportunity of pleasing himself by so arranging matters that both the coils and the fixed loading condensers are readily exchanged or removed. Thus any one of the coils may be used with or without a loading condenser and additional coils can be manufactured at will on homemade forms or by cutting sections from the 10-turns-per-inch Hammarlund "stovepipe" coils and equipping them with the same General Radio spring plugs with which these are furnished. The coils to be used in the oscillator are center-tapped, the center-tap being brought to a third spring plug for which a socket is added in the oscillator coil mounting. To permit all coils to be used in any position an extra hole is drilled in the amplifier coil mounting to accommodate this plug.

Table 2 shows how all the standard bands can be reached with a set of Aerom transmitting coils plus a pair of single-turn copper strip coils such as are shown in Fig. 2 for the 40 meter band. The coils illustrated are about 3/4" thick and 7/8" wide. All the bands are well spread out on the dial and will be quite O.K. for 1929, especially as the dials can be read to one part in 1000.

On the 10-meter band it is advantageous to use heavy wire or strip in the tuned circuits, not to reduce resistance but to have less inductance in the leads and therefore a bit more in the coil.

It will be noticed that no arrangement has been made for changing the amount of power fed from the oscillator to the amplifier except by making changes in the size of the feed condenser, C1. Taps on the coil L1 are a nuisance and are therefore avoided. This does not mean that C1 should be tinkered with after the right adjustment for a given amplifier tube has been found. On the contrary it should be left changeless at all times. Thereafter since changes in it will shift the wavelength calibration, which is not serious but rather confusing, C1 may be a small variable condenser but this is not recommended for the reason just mentioned: if a change is really needed the screw terminals of the Sangeo condenser always permit it. A capacity of 50 or 100 mfd. will meet all needs. For the 210 as amplifier the larger capacity is recommended.

Operation

For its normal operation the set needs only one meter which is placed in the antenna circuit. One must admit that it would be somewhat more convenient to operate the set during the first few days if at least one more meter were available. However, the receiving set will serve the same purpose, though a bit less conveniently.

Everything being assembled and the filaments lighting satisfactorily, one should begin by removing the amplifier tube and making sure that the oscillator tube does really oscillate. This can be done by listening with the receiving set and tuning either the transmitter or the receiver slowly. They should not too close together nor should the antenna be connected to either one. If the signal is not found in this way a milliammeter or a pair of phones may be put into the plate supply lead at the point marked W in Fig. 1 and the tuning process repeated. At resonance a click in the phones or a jump of the
meters will be encountered. The phones are to be preferred since with them the observer can recognize the faraker sound caused by an oscillating tube. Do not leave the phones in the plate circuit long, even with a 2A, and do not use them at all with larger tubes. Fortunately, such oscillators usually work promptly. If any doubt remains it may be removed with a very simple device consisting of a small flashlight or a panel light to the terminals of which is soldered a single turn of wire about $1\text{"}$ in diameter. This is hung on the end of the oscillator coil, $L_2$, and will usually light promptly unless the lamp is too large or too closely coupled to the coil, $L_2$. If no light can be obtained with any of the various coils in place everything should be gone over carefully and as a final resort a different grid level or plate voltage should be tried.

Since the r.f. amplifier is very much like those used in reception it has the same troublesome habit of wanting to go into oscillation.

To make sure of this point one removes the lamp-and-loop from $L_2$ and hangs it on the end of $L_2$, after which the oscillator is started but the amplifier plate supply is left off, although it is best to light the amplifier filament. By careful tuning of $C_6$ it should be possible to cause the lamp to light in the new position. Since the absence of plate supply for the amplifier prevents amplification it is clear that the power is being fed through from the oscillator by capacity effect between the plate and grid of the amplifier tube. This can be neutralized by adjustment of $C_6$ until the lamp is out. The adjustment must be made without bringing the hand near $C_6$, which calls for some sort of a wooden screwdriver whittled from a dowel or the like. The lamp will probably go out over quite a wide range of $C_6$.

The condenser should accordingly be set in the middle of this space. It is best to repeat the adjustment with several coils and with different settings of $C_6$, $C_2$, and $C_5$ to obtain the best average adjustment.

A SIMPLE ANTENNA SYSTEM

Having an oscillator and an amplifier in operation, one is ready for the antenna. There is a general belief that to work on five or six wavebands it is necessary to have as many different antennas. Fortunately this is not correct, and a single antenna system of normal dimensions will give a good account of itself on 5, 10, 20, 40 and 80 meters.

An antenna system can be made to oscillate electrically at a variety of frequencies without the necessity of changing its length each time. Thus if we desire to work at 40 meters we need not have an antenna which is "just made" for that wavelength, but can just as well use one which tunes to 120 meters naturally. The third harmonic of this wavelength is 40 meters on which we desire to work. This is exactly what is to be used with this set—a regular broadcast receiving antenna about 4 feet long from the end of the lead-in to the tip end of antenna. In addition a 75-foot counterpoise will be necessary and a good ground connection. When on the 80-meter band the antenna and counterpoise wires are connected together at the point of connection to the antenna coil $L_4$, and a ground is attached to the ground post. In addition a small loading coil may be necessary. On the other amateur bands the ground is not used and the counterpoise is attached to the ground post, the antenna to its proper post, and the loading coil not used at all.

The antenna should be 20 feet or more above ground and may be as high as 60 feet. The counterpoise wire should be closer than 6 feet to ground or any other solid material.

The practical method of getting the transmitter on the air is to tune the oscillator to the desired wavelength by means of the wavemeter, then to tune the amplifier to that same wavelength, as shown by the best response of the wavemeter when placed at that end of the set, and finally to adjust the antenna tuning system so that current shows on the antenna meter.

The movable antenna coil, $L_5$, is not a device for obtaining the largest possible antenna current, which, as a matter of fact, does not give as good performance as does a slightly smaller antenna current. A rough general rule is to start with the coil $L_5$ at about 45 degrees and after the largest possible antenna current is obtained by adjustment of the various tuning condensers this coil may be tilted back to a position giving about 80 per cent. of the largest current.

No rule is good in transmitter adjustment until one has checked the result by listening with an oscillating receiver. This should be done without a receiving antenna, and the receiver should not be in the same room with the transmitter. In most cases it will be found that it is preferable to detune the antenna slightly, rather than to secure the 20 per cent. drop entirely by tilting of $L_5$. An adjustment that is satisfactory on a fair day may not answer through wind and rain. On the first bad day the whole series of adjustments should be checked.

In order to make precise adjustment and reading practical the set is modified which not only have a smooth slow-motion mechanism (generally miscalled a "vernier") but in addition have a true vernier scale which permits reading to one tenth of one division of the dial scale.

\begin{table}
\begin{tabular}{|c|c|c|}
\hline
\textbf{Band} & \textbf{Osc. Coil} & \textbf{Amp. Coil} \\
\hline
10 & turn special & turn special \\
20 & turn standard & turn standard \\
30 & turn standard $+C$ & turn standard $+C$ \\
40 & turn standard $+C$ & turn standard $+C$ \\
50 & turn standard $+C$ & turn standard $+C$ \\
60 & turn standard $+C$ & turn standard $+C$ \\
70 & turn standard $+C$ & turn standard $+C$ \\
\hline
\end{tabular}
\end{table}

The tubes which may be used and the power supply are discussed in the text.
"Strays" from the Laboratory

TWO American patents which should interest technical readers are quoted and illustrated in Radio (Berlin) for July, 1918. The first (No. 659,614) is shown in Fig. 1, slightly redrawn, and was issued to Fritz W. Falck of Los Angeles. It is composed of a system to prevent distortion due to core saturation in an audio amplifier. The idea is to use two transformers as shown and to divide the load so that either transformer will be adequate to "separately handle the current without distortion."

The second patent (No. 148,875) given mention in the July issue of Radio (Berlin) has been granted to a well known worker in radio fields, Dr. Lewis M. Hull, and consists of a two-grid tube circuit, the second grid being used in connection with an external inductance to impress upon the second grid a compensating voltage of proper phase and amplitude to oppose feedback currents flowing through the capacities of the tube between anode and control grid.

The diagram in Fig. 2 illustrates Doctor Hull’s scheme. It has been seen many times within the last year in foreign periodicals, which have done considerably more with multi-grid tubes than has been done in the United States. Technicians will see the purpose of the extra grid and the coupling coil—to do away with the necessity of neutralizing the grid-plate capacity of the tube.

Such a circuit cannot be used with our screen-grid tubes since they have been designed with an entirely different purpose: in mind, i.e., to decrease the inherent grid-plate capacity to such a low figure that danger from unwanted oscillations is minimized.

Radio as a Sconeget

IT HAS become necessary for the Royal Meteorological Office to answer the many people of England who feel that broadcasting has something to do with weather. The prevalence of bad weather in England has been laid to the influence of the radio signals which of course cover that land, and in spite of the loud "no" which the Royal Meteorological Office answers to such ideas, it is probable that people will go on blaming the radio for everything that seems out of season or out of keeping with their plans and pleasures.

It is difficult for people to believe that radio is something that falls under the laws of nature, just as automobiles or flat iron do. Not a week passes by but what some doctor, or lawyer, or teacher, who ought to know better, approaches us with some argument like this: "Now, I don't know anything technically about radio, but wouldn't this be a good idea?" and then he launches forth on some impossible or already old scheme. The fact that the laws of transmission and reception are well known, and that methods of attaching coils, condensers and tubes together are already printed in books, never causes the would-be radio inventors a moment's pause. And when some engineer tells them that their scheme is not worth wasting time on, they always feel they are to steal the idea and hasten for this reason to find another and less trained ear for their schemes.

Mortality Among the A. C. Tubes

THE rapidity with which such tubes as the 171's burn out when their filaments are operated from a.c. may give a clue to the real reason why a.c. tubes seem to be shorter lived than battery tubes. The fault is not with the tubes, it lies with poor power line regulation. At times the line voltage is high, and naturally the filament voltage is high. Some tubes decrease in life by 50 per cent. when the voltage across the filament increases ten per cent.

Mr. A. O. Viereeck, of Springfield, Mass., states that 171 tubes lasted less than 100 hours for him until he hit upon the plan of placing a resistance in series with the filament, and turning it so that the filament was just bright enough to prevent distortion. At the time of writing the letter his 171 "still was going strong," although it had been in use for over two months.

A still better remedy, of course, is to put a resistance in the 110-volt line which feeds the receiver. This may be a bit so that the voltage to the power equipment is below the point where too frequent tube replacement becomes necessary due to overloaded filaments.

Few people realize that considerable power must be dissipated within the tube and that overloading its filament or plate circuits is vastly more important, economically, than overloading its grid with a.c. voltages. A ten per cent. increase in line voltage produces a 20 per cent. increase in power used up in the filament and an equal increase in power required by the plate circuit. The filament must bear the brunt of this increase, and unfortunately it does not have the margin of safety that is found in a machine rated in kilowatts.

Engineers as Salesmen

NOT long ago we read with considerable interest the statement of the head of a well known eastern university that the average salary of the graduates of this institution of the class, let us say, of 1910, is kept down to a rather low figure by the salaries of men now engaged in teaching, those in government service and those who are engineers.

It is only too true that engineering as a profession does not pay so well as selling bonds, or real estate, or selling anything, for that matter. However, it is encouraging to note from time to time the increasing appreciation for the work of the engineer and the laboratorian. The following statement comes from a vice-president of one of the largest banking institutions in New York City and is quoted from Science, April 27, 1928: "When I have to turn to finance any corporation or business, especially one based directly or indirectly upon scientific pursuits, the first investigation made is in regard to the attitude of the institution toward the advancement of scientific knowledge. If there is maintained a scientific laboratory with a generous regard for the advances in pure science, the security is, to that extent, considered good. But if no attempt is being made to keep up with, or a little in advance of, the developments in science, then no considerable loan will be risked upon such a venture. Permanent business success is too intimately linked with scientific attainment to make any other attitude safe."

We chatted recently with the executive of a radio company whose name is everywhere a synonym for quality, for honest dealing and for the genial friendliness of its personnel. This organization is making changes in its methods of selling which will practically eliminate its present selling organization—the non-technical salesmen, who as far as salaries go rate much higher, in general, than engineers.

"We have found," stated this executive, "that our best salesmen are our engineers. They know
what they are talking about, what the organization they are "selling" needs; they can get into laboratories where no salesman would get even a pleasant look. They talk on equal terms with the chief engineer or director of research of the greatest organizations. Not one of our engineers goes out in the field who does not return with an armful of orders.

The Arcturus Company has recently decided to employ graduate engineers in their sales department. Mr. L. P. Naylor, Sales Manager, says: "We need them on the road quite as much as in the lab. A. C. tubes are in a way a highly technical development—as well as something new. Reactionary dealers often bring up specious arguments against their use which can be answered authoritatively only by an engineer. And besides, the logical mind of the technically trained man is psychologically well grounded for sound salesmanship."

And so it looks as though the engineer may come into his own after all. Our idea of a good way for a young man to divide his time in college is to spend about three years in engineering school and three years in business school. He could then get a job selling bonds for the technical apparatus he, as an engineer, has designed.

We gloat over Mr. Naylor's final words, "the logical mind of the technically trained man is psychologically well grounded, etc." They may help to tide us over those bad moments when our contemporaries of the class of so-and-so, who sells real estate, invites us as a ride in the park in his new Packard.

THE following quotation from a letter from Professor Frederick Emmons Terman, of Stanford University, relates to our recent request for methods of testing for soft tubes:

Tubes which contain gas, popularly called soft tubes, can be detected with the circuit shown in Fig. 3. The test is made by touching lead a to the grid lead as shown, thus short-circuiting the grid leak. If a click is produced in the phones the tube is soft. Absence of a click indicates a hard tube.

The test described is based on the fact that in gaseous tubes there is some ionization produced in the tube even at low and moderate plate potentials. The ionization is not strong enough to strike the gas molecules and breaking them in pieces, some of which are positive ions and some negative (electrons). The positive ions are attracted by the negative grid, causing a grid current to flow through the grid leak. Short-circuiting the grid leak raises the grid potential by eliminating the voltage drop of the grid current in the grid leak, thus causing a change of plate current, and a click in the phones. When there is no gas in the tube, no positive ions are produced, and as electrons will not flow to the negative grid, there is no grid current, no voltage drop in the grid leak due to grid current, and hence no click in the phones on shorting the leak.

In carrying out the test a load of at least a megohm should be used. It is also desirable to use a rather negative C battery, such as three or more volts. Soft tubes, such as the 200, will draw a considerable electron current at grid voltages of one or two negative, and upon increasing the C bias the grid current goes through zero and changes direction, being positive ion current beyond about 2 volts. To make certain a suspected tube is soft, it is desirable to test it at two grid voltages to insure that the reversal point of zero grid current is avoided.

With 45 volts on the plate and minus 3 volts on the grid, a 200A tube gives substantially no click, while a 200A tube, which contains much more gas, produces quite a thump.

**Our only comment to this letter lifted from World Radio (England) is that Mr. Bell either has a magnificent DX receiver or a grand location.**

I should like to report on short-wave reception in America. As everyone knows, short waves are no good over short distances. Consequently, reception of U. S. stations is poor. To tabulate:—

**United States.**

2XAD: Always poor, especially at night. 8X: Very fine in daytime. 8X: Excellent on fine days. 8X: Excellent on some nights. 8X: Good only in daytime.

**Australia.**

2XJ: Excellent with loud speaker strength 5:30-8:30 A.M. E.S.T., relayed 5SW recently; 5SW coming 20,000 miles. Jacu.

**Holland.**

PCJ and PCC: Always received with a strong signal, almost any hour.

England.

5SW on 24 meters relaying 5XX. I have left this till the last for I want to write at some length about it. 5SW as received in this part of America is simply phenomenal. Using (o-V-2) every evening I can easily run the loud speaker 5-7 p.m. E.S.T. 5SW at 5 P.M. is as strong a signal as WAF, 50 kw. (200 miles east), 5SW 7:30-8:30 P.M. is received with good headphone strength. But from 2-7 P.M. (when England is in darkness and America in daylight) 5SW is as regular and dependable as many of our U.S. stations. One would think this in view of the future. Big Ben is an old friend. We have been in the Savoy Hotel, Carlton Hotel, Ambassador Club, New Princess Restaurant, Hotel Cecil, and other places. Some of the best programs are the organ recitals from Bishopswood and Southwark Cathedral and the National Symphony concerts.

Now a word about the medium-wave lengths. 2LO is the most consistent. Spain is next. I will tell about one night (January 21) which was a fine night for European reception.—(These stations were on according to World Radio.) (After 5:30 P.M. E.S.T., dark here):

303 meters Nurnberg—Drowned out by WGR.

306 " 2BE  Fair music.

312 " 9NO  Carrier we.

326 " 6BH Drowned out by WPCH.

345 " 6AL Very fine.

353 " 5WA Good.

361 " 2LO Very fine—dance music.

375 " 9AL Very fine.

380 " Stuttgart  Good.

385 " 2XG Good.

396 " Hamburg  Drowned out by WLT.

405 " 5SC  Drowned out by HXW.

426 " Langenfeld, near WRC.

492 " 508 Under weaf.

It is unfortunate that WRC and WAF are always on, making reception of these last two impossible.

Raymond M. Bell.

35 Wilson Street, Carlisle, Pennsylvania

IN ENGLAND the argument as to whether the parts of a radio system should each be perfected or whether the whole system should have a "flat" characteristic has assumed much greater proportions than any such discussion in this country. This is due, no doubt, to the fact that few radio manufacturers prepare a complete tuner, or amplifier, or other assembly of radio equipment, but have been more interested in selling a part such as an audio transformer or a coil.

The curves in Fig. 2 represent the frequency characteristic of the new Remler audio-frequency amplifying system—about which we shall have an article in the near future. It is composed of two stages, as usual, each of which distorts somewhat. When combined together the defects of one stage are taken care of by the other so that a very good characteristic results. The advantage of such "matching" of one unit to another lies in the greater over-all amplification that can be secured. For example it is not possible to build a reasonable 1.65 to 1 audio transformer that will not fall off in voltage step-up at low frequencies. When added to another stage which rises at the low end the result is as shown.

The average gain of a two-stage audio system using high grade parts is about 50 to 1. This curve shows that the Remler amplifier has a gain of 57 to 1 or a difference of voltage step-up of from 300 to approximately 700.

Keith Henney
width of the exposure corresponds in loudness to the sound input to the system. The exposure is also made through a narrow slit.

In reproduction (Fig. 4) the film is run through the projector at the same speed. If the speed in the projector is higher than standard, the reproduces notes will be sharp; if lower, flat. A constant source of light shines through a narrow slit similar to that found in the recorder onto the sound track of the film. A photo-electric cell receives the light passing through the sound track. The light it receives through the film at each instant depends on the density of the record at that point, or its width, depending on which method of recording is used. In either case the output of the photo-electric cell should be proportional to the original intensity of the sound. The current output of the cell is only a fraction of a microampere, but two or three stages of audio amplification bring it up to a level where it can be handled by amplifiers of the usual broadcast type, followed by an output stage the size of which depends on the amount of volume required.

In one type the output stage, in large houses, utilizes four tubes in push-pull parallel, each having an oscillator rating of 50 watts; the total power delivered to the plates is about 200 watts, so it may be conjectured that 30-40 watts of undistorted audio energy are delivered to the loud speakers. The power stage is preceded by six stages of audio amplification. The usual gain controls, meter panels, etc., are on the panels.

The speakers are mounted above, behind, or on the sides of the motion picture screen. In some cases they are made to "fly" with the screen, i.e., the speakers are attached to the screen and may be pulled up with it into the scenery loft. Or the speakers may be pushed around on tracks back stage. The proper number, location, and orientation of speakers depend on the power of the outfit and the acoustic characteristics of the house.

Lord Rayleigh on Sound

In the May, 1928, issue of the I. R. E. Proceedings there is a review of Lord Rayleigh's treatise on the "Theory of Sound." The book has recently been issued in a revised edition, two volumes, 494 pages, by Macmillan in London. The I. R. E. review is by Harvey Fletcher of the Bell Telephone Laboratories.

My comments are a review of a review, but there is enough substance and inspiration in Rayleigh's classic work on sound to stand the attenuation.

Few broadcasters have the physical background to appreciate Rayleigh's book equation by equation, but one has only to page it to realize that one holds the record of a great piece of work by a great physicist. Dr. Fletcher points out that "The Theory of Sound" has been the standard text on the subject for the last 50 years. The first edition appeared in 1877, the year in which Alexander Graham Bell demonstrated his invention of the electric telephone before the British Association of Science. The work on which the book is based was largely finished, therefore before the invention of the telephone. Yet telephone engineers refer to it frequently, and no one can write a book on acoustics or vibrating systems without leaning hard on Rayleigh.

In a second edition which appeared in 1894 a chapter on "Electrical Vibrations" appeared among other additions. This marked the transition of the treatment of audio vibrations from the mechanical to the electrical aspects. But almost all the electrical theorems, however generalized and intricate, are found in the differential equations of Rayleigh's investigation of mechanical vibrating systems. Rayleigh perhaps never saw anything like a wave filter or an artificial line, but his grasp of the general meaning of oscillation was such that his analyses required only a little adaptation to be useful in dealing with such devices.

This unity of the acoustic past and present is manifested in some of Fletcher's sentences, as when he writes, "It is strikingly difficult to transmit energy of vibration from air to steel, or vice versa, for the amount which crosses the junction is only 0.0001 of that which arrives at it. In other words, a transmission loss (sometimes called a reflection loss) at a junction between air and steel is about 20." Rayleigh expressed in ru tells us why a tuning fork makes as little noise as it does, even though it vibrates vigorously; fundamentally it is because air and steel are such different substances. The same loss occurs when we try to transmit oscillating electrical energy from one circuit to another with widely different constants.

Another interesting point brought out by Fletcher is Rayleigh's evident regard for the work of Heaviside, to which he frequently refers in the 1916 edition. Six years before the invention of the loading coil, Rayleigh discussed attenuation and distortion along lines, saying, "The cable formula ... is an example ... where waves of high frequency are attenuated out of proportion to waves of low frequency. It appears from Heaviside's calculations that the distortion is lessened by even a moderate inductance." This also appeared to Professor Pupin. Rayleigh goes on: "The effectiveness of the line requires that neither the attenuation nor the distortion exceed certain limits, which, however, it is hard to lay down precisely. A considerable amount of distortion is consistent with the intelligibility of speech, much that is imperfectly rendered being supplied by the imagination of the hearer."

For this telephone companies can still thank God.

Fletcher also pointed out, in Fletcher's words, "the definite limitations of a horn radiating sounds having wavelengths larger than the opening of the horn." And, while we are admiring Sabine as he deserves, let us not forget the following paragraph which Fletcher has quoted from Rayleigh:

In connection with the acoustics of public buildings there are many points which still remain obscure. It is important to bear in mind that the loss of sound in a single reflection at a surface, where wall is very small, whether the wall be plane or curved. In order to prevent reverberation it may often be necessary to introduce carpets or hangings to absorb the sound. In some cases the presence of an audience is found sufficient to produce the desired effect. In the absence of all deadening material the prolongation of sound may be very considerable, of which perhaps the most striking example is that afforded by the Baptistry at Pisa, where the notes of the common chord sung consecutively may be heard ringing on together for many seconds. According to Aérony it is important to prevent the repeated reflection of sound backwards and forwards along the length of a hall intended for public speaking, which may be accomplished by suitably placed oblique surfaces. In this way the number of reflections in a given time is increased, and the undue prolongation of sound is checked.

Rayleigh also deduced from the equations for the transmission of sound through air of uneven temperature that in the usual auditorium, where the air is warmer at higher points, sound will be refracted upward and consequently a speaker will be heard better by listeners above than below him.

The viscosity of the air is small, sound waves do not decline rapidly in amplitude. The loss is greatest for the higher frequencies. A sound having a wavelength of one centimeter loses two thirds of its initial amplitude in traveling through 88 meters, while a graver sound, with a wavelength of 10 centimeters, suffers the same attenuation in traversing 8800 meters. The attenuation is proportional to the square root of the frequency.

"It is frequently stated," says Fletcher, ending his review, which contains more substance than many an original paper, "that when a treatise on a scientific subject has become 10 or 15 years old, it is ready for the cellar or the garret, its obsolescence being due to the rapid advances which science is making. This book on 'The Theory of Sound' is an exception. It is now more than 50 years old and it will continue to be used for a good many years."
The Sargent-Rayment Seven Receiver

By HOWARD BARCLAY

The receiver described in this article is striking in that it departs successfully from many of the generally accepted tenets of home-built receiver design, and approaches the standards set by the higher priced factory-built sets costing up into the hundreds of dollars. It was developed by Messrs. Sargent and Rayment, the inventors of the Infradynecircuit which created considerable interest several years ago, and it embodies four individually shielded stages of t.f.f. amplification, a detector, and two audio stages of the Clough design. As it has several unusual features it is felt that a description of the salient engineering points of the design will be of interest to readers.

From the photographs and diagram it is seen that the receiver consists of an aluminum shielding assembly which serves the dual purpose of a cabinet for the entire receiver, and individual stage shielding for the different circuits of the set. This cabinet is made up of a pierced aluminum chassis, with the edges turned down, to which are fastened a number of smaller formed pans which serve as partitions, thus dividing the inside of the cabinet off into seven separate and distinct compartments. The assembly is completed by the front and back panels, which are bolted to the chassis and to all eight partitions, and finally by an aluminum cover, the edges of which are turned over to provide tight lap joints when the cover is placed on the receiver assembly. All of the metal work is of 7/64" aluminum, which provides most satisfactory electrical shielding. The complete shielding assembly alone uses nearly fourteen pounds of aluminum; the size is 27½" long, 12¾" wide, and 8¾" high. In the picture on this page the receiver assembly is shown mounted upon a walnut base moulding which trims up the appearance so that the set would not look out of place in the average living room. The aluminum assembly is finished in attractive satin silver.

Examination of the different illustrations and the circuit diagram in Fig. 1 shows that the amplification progresses from the antenna tuning circuit in the extreme left compartment of the aluminum shielding cabinet, through the four stages of tuned r.f. amplification to the detector in the sixth compartment. Four screen-grid tubes are used in the r.f. stages, and a 201A, or preferably a 112A, for detector. In the extreme right compartment is housed the 2-stage audio amplifier and output transformer with the volume control. The center compartment of the receiver is left vacant except for the drum control dial which turns all five of the tuning condensers. All stage compartments are 12" deep, 6½" high, and 4½" wide.

Performance

In tests conducted upon different models of the Sargent-Rayment receiver during the period of its development, rather surprising results were obtained. On the West Coast, where the average receiver capable of giving adequate selectivity for other locations generally fails down quite badly, due to a number of peculiar local conditions, the Sargent-Rayment Seven has given positive 10-kc. selectivity—that is, it will separate distant stations ten kilocycles away from local broadcast stations. As a specific instance, 10-kc. separation was obtained on either side of KGO in Oakland, Cal., and in the same location KRLD of Dallas was brought in between KFI and KFRC. This is very exceptional operation in this locality. Such selectivity seems to leave little to be desired, for the receiver will go down to the noise level and bring in on the loud speaker any station sufficiently louder than atmospheric noises to be distinguished from it. To many radio fans this statement does not mean very much because upon the less sensitive receiver it is seldom indeed that the noise level observed is ever so loud as to drown out signals. This is not true of the Sargent-Rayment. For a simple turn of the volume control knob will increase its sensitivity to a point where weak atmospheric noises come in with a roar under conditions which would
ordinary be quiet for other receivers. Models of the receiver brought to Chicago and tested under the trying conditions produced by twenty or more local stations in simultaneous operation, have brought in as many as one hundred broadcast stations in a single evening’s tuning. One receiver was tuned over the broadcast band, beginning at 550 kc. and going up the frequency scale. As rapidly as the dial could be turned and the verniers trimmed for maximum signal strength, new stations could be logged. When the evening was over, it was found that a station had been logged for every transmission channel, beginning at 550 kilocycles and going up to over 1200 kilocycles before any gaps were found (channels upon which no station could be heard). This in itself is a remarkable record, and one which indicates the high degree of amplification that may be had in a carefully designed tuned radio-frequency receiver taking full advantage of the possibilities of screen-grid tubes and adequate shielding.

CIRCUIT DESIGN

All of the four r.f. stages consist of essentially similar tuning coils and tuning condensers associated with screen-grid amplifier tubes and the necessary bypass condensers and choke coils to insure absolute isolation of the various amplifier circuits. Each stage embodies an r.f. transformer with the secondary wound of 22 turns of No. 25 plain enamelled wire on a threaded bakelite tube 2½” in diameter, the winding occupying a space 1½” inches long. The turns are spaced ½2 per inch. The r.f. resistance characteristics of this coil are most excellent. To each of the interstage r.f. transformer secondaries is coupled a primary consisting of 25 turns of No. 28 d.c.c. wire, wound upon a 2½” diameter bakelite tube, fitting inside the secondary at the filament end.

Upon close observation, the antenna coupling coil, L1 in Fig. 2, will be found to differ slightly from the interstage coupling transformers in the succeeding r.f. stages. This coil is of the tuned rejector type, having a primary winding of 20 turns of No. 28 d.c.c. wire with the turns spaced ½” apart on a tube 2½” in diameter. This winding is common to the antenna circuit and the grid circuit of the first r.f. tube. Surrounding this coil, and coupled closely to it, is a second coil which is similar to the secondary windings in the succeeding stages. This coil is tuned by the first or extreme left-hand tuning condenser and serves to reject effectively undesired signals, without having its tuning greatly affected by various sizes of antenna.

Examining a typical r.f. stage, it is seen to consist of the r.f. transformer; the 0.0005-mfd. tuning condenser with its associated 0.00005-mfd. midget vernier condenser; a tube socket for the screen-grid amplifier tube; two 1-mfd. bypass condensers, and two radio-frequency choke coils. Each amplifier circuit is complete in its own shielded compartment, and the only leads carrying r.f. current running from stage to stage are the plate leads. One of the 1-mfd.
condensers is connected from the screen-grid to the grounded shield, and one from the B plus side of the r.f. transformer primary to the grounded shield. Electrical isolation is further insured by the use of two r.f. choke coils, one connected in the screen-grid lead and one in the plate lead of each r.f. amplifier stage. These chokes are placed on the under side of the chassis. An additional r.f. choke is used in the detector plate circuit to prevent any r.f. currents from straying into the audio amplifier.

With all of these precautions, the receiver is remarkably stable; however, it is capable of being made to oscillate when desirable. A detailed analysis of the functioning of the screen-grid tubes as r.f. amplifiers indicates that even though the plate-to-grid capacity of the screen-grid tube has been reduced to an almost negligible value, this value is still high enough to allow oscillation if sufficiently good circuits are used with the tube. As very good circuits have here been employed to provide as high amplification and selectivity as is possible, the volume control has been combined with a stability control so that the r.f. amplifier stages may be operated at peak efficiency at a wavelength, regardless of oscillation tendency.

Measured amplification curves of the different stages show repeater voltage gains varying from 17 at 350 meters to 30 at 200 meters, these comparatively low values having been selected in order that the full merit of the tuned circuit might be taken advantage of to obtain the selectivity required by modern broadcasting conditions. The rising characteristic of the r.f. amplifier at short wavelengths is compensated by the tuned antenna input circuit, which has an opposite characteristic in that it shows greatest voltage step-up at 350 meters with a decreasing step-up at shorter wavelengths.

The five tuning condensers, C1, C2, C3, C4, and C6, are connected together, and are operated by a single drum control dial, this connection being effected by means of the floating removable shafts, and flexible couplings arranged to link the condensers. The receiver can be tuned over the entire broadcast band with the single tuning drum, no difficulty being experienced in ganging, due to the high accuracy of the double spaced condensers employed. It was felt desirable, however, to equip each stage with individual tuning verniers, V1, V2, V3, V4, and V5, so that there would be absolutely no question in the mind of the operator that his receiver could always be tuned to absolute peak efficiency on any and all wavelengths in the broadcast band.

**NOTES ON CONSTRUCTION**

The construction of the receiver is quite simple, for there is available for it the complete shielded assembly, fully priced, and requiring only the insertion of some 88% screws with their nuts and lockwashers, to put it together. The use of this large number of screws to hold the shielding together is the result of an interesting fact discovered during the development of the set. At first an endeavor was made to use the simple and attractive corner-post type of assembly, attaching these posts to the chassis and slipping the partitions, ends, front and back panels into the slots of these corner posts. The result was a very attractive mechanical job, but of very poor electrical characteristics, for the electrical joints provided between the partitions and the chassis (and for that matter between the partitions and the corner posts) were of such a variable nature as to change the entire performance of the receiver. It was necessary merely to strike the shielding with the palm of one hand to change the electrical contact between the different portions of the shielding, thereby altering their shielding effects on the circuits. From these results it was found that it would be necessary to use lap-joints and thick aluminum and to insure positive contact at many points, which accounts for the use of nine fastening screws to each partition.

The parts, and accessories, used in the Sargent-Rayment Seven are listed at the end of this article, and being of standard manufacture, may all be procured upon the open market, including the especially prepared aluminum cabinet assembly. The coils may be wound at home from the data given in the text. The assembly of the receiver is quite simple, involving only the mounting of the parts upon the pierced chassis with machine screws, wiring them up, and finally, the attachment of partitions and front and back panels with the 88 machine screws previously mentioned. The wiring of the set is surprisingly simple for a receiver of this type, as may be seen from a study of the two pictures in Fig. 2 and Fig. 3. The schematic wiring diagram in Fig. 1 also shows the simplicity of the wiring.

**FIG. 3. THE UNDER SIDE**

This view gives an idea of the simplicity of the wiring of the receiver, resulting from the use of the metal chassis at the A minus circuit return. The mounting of filter condensers and chokes on the under side of the chassis is also clearly shown.
Radio broadcast's home study sheets

Alternating Current

Part 1

An alternating current is one in which the magnitude and direction of flow of the current are continually changing. A direct current flows steadily in a given direction and at a more or less constant magnitude. The laws governing direct current phenomena and the apparatus and the associated circuits are fairly simple. Ohm's law will enable the experimenter to solve nearly all direct current problems by himself. The laws of a.c. circuits, on the other hand, are more complex—but also more interesting. This very reason provides more enjoyment for the experimenter and those who like to solve problems.

Home study sheet no. 3 shows how Ohm's law is to be applied to some radio problems. This sheet gives the fundamental facts about alternating currents.

Definitions

At regular intervals the direction of flow of an alternating current reverses, and therefore its variations in magnitude are as follows: the voltage starts at zero, rises to a maximum in one direction, decreases to zero, changes its direction, increases to a new maximum and then falls to zero, after which the cycle is repeated. Figure 1 is a representation of a single cycle of a.c. voltage. Such a picture is called a SINE WAVE. The time required for one cycle is called its FREQUENCY; the time required for one cycle is the PERIOD.

The reciprocals of cycles per second are frequency ranges from a low as the ear can hear, about 30 cycles per second, to as high as we can hear, about 15,000 cycles per second. Radio circuits have frequencies ranging from about 10,000 cycles per second to 30,000,000 cycles. Long-wave waves are in the range of frequencies produced by the sun, the stars and other localities 25-cycle and 133-cycle circuits exist. So slowly do the alternations take place on a 25-cycle circuit that lights burning from them seem to flicker, although people who have never seen lights operated from circuits of higher frequency seem not to notice the steadiness of their illumination. Audio-frequency currents have frequencies ranging from about 5,000 cycles per second to 15,000 cycles per second. Radio circuits have frequencies ranging from about 10,000 cycles per second to 30,000,000 cycles. A kilocycle is one thousand cycles.

PLOTTING an a.c. current

To show graphically what happens when an alternating current flows, let the rotating armature of a c.a. generator be such a device as is represented in Fig. 2. When the armature is rotated at a constant speed such that it moves the distance of its diameter in the time it takes the rotating arm to make one complete rotation in a counter-clockwise direction, the tip of the arm is attached to the end of the arm touching the circle. What sort of figure would it trace out as the two motions referred to take place? It would be a wave form exactly like the alternating current curve in fig. 1. The arm represents (mechanically) the rotating armature of an a.c. generator, and the movement of the circle to the right represents the passage of time. The curve is a graphic representation of the changing values of an alternating current.

Phase

Since a complete circle has 360 degrees, we may speak of the position of the arm in terms of the number of degrees it has rotated within the circle. Suppose the armature of the generator is situated such that it has traversed 90 degrees or a quarter of 360 degrees or 90 degrees; when it is parallel but pointing in the opposite direction, it has gone through 180 degrees, or one ALTERNATION, and so on. These various positions of the rotating arm are called its PHASES. Thus we speak of the 90-degree phase, and so on.

The magnitude of the voltage in an a.c. circuit is continually changing, it becomes expedient to have a means of knowing what the voltage is at any particular instant. At 90 degrees it is zero, at 90 degrees it is maximum, at 180 degrees it is zero again, at 270 degrees it is maximum, at 270 degrees it is zero again, and at 360 degrees the cycle is completed, and the voltage is again zero.

AC—INSTANTANEOUS VALUE

The instantaneous value of an a.c. voltage or current is always referred to with regard to the maximum value. That is, if we multiply the maximum value by some factor which connects it and the phase, we shall have the instantaneous value.

A measure of the instantaneous value is the vertical height of the end of the rotating arm above the horizontal axis. The vertical height is measured from the length of the line dropped perpendicularly from the end of the arm to the horizontal axis: it is known as the vertical component. Notice that the position of the vertical axis is arbitrary, and make what is known as a vector diagram at the 45-degree phase. In fig. 3 let us label the arm at the 45-degree position, and we might say that it has traversed (instantaneous voltage), and the angle which represents the phase, φ.

Now if we divide the vertical component by the length of the arm, that is, E/E, we shall have a ratio which is defined mathematically as the SINE of the angle usually written sin φ. This is the factor which connects the length of the arm and the vertical component.

Thus sin φ = E/E or E = F sin φ

The numerical values of the sine of a number of angles are given in Table I, and with their use we have a means of calculating the instantaneous values of a voltage provided we know the maximum value and the phase angle in degrees. At 90 degrees the vertical component is equal to the arm E and so the instantaneous value of the voltage at this phase is the maximum value. Can you prove this mathematically, using the data in Table II?

Effective or r.m.s. value

Since an alternating current is reversing at a rapid rate, the needle and mechanism of an ordinary d.c. meter would indicate only an average value which would be zero. Some other means must therefore be provided for comparing an a.c. current with a d.c. current. We say, therefore, that the index current is equal to a given d.c. current when they produce the same heating effect, and this value of the a.c. current is referred to as its EFFECTIVE value. It is equal to the maximum value divided by the square root of 2, or

I eff = \( \frac{I_{max}}{\sqrt{2}} = 1 \times 0.707 \)

and

E eff = \( \frac{E_{max}}{\sqrt{2}} = E \times 0.707 \)

Since the heating effect of a current is proportional to the square of the current, we may obtain the effective or heating value over a complete cycle of alternating current by taking the average of the squares of several instantaneous values of current and extracting the square root. This value of current is called the root mean square "r.m.s." which is another term for effective value. In this expression "mean" and "average" have the same meaning.

The maximum or "peak" value of an a.c. voltage is used in determining the C BIAS necessary for an amplifier; the r.m.s. value is used in all power problems. It may be obtained by dividing the maximum value by 1.4 or by multiplying the maximum value by 0.707. Measurements made on a.c. circuits include the effective or r.m.s. values. The effect of the wave in which an a.c. power circuit is nearly a true sine wave, that is, one in which the relation between the length of the rotating arm (the maximum value F) and the vertical component (the instantaneous value E or E) is the sine of the angle between the arm and the horizontal axis. If the a.c. current is not a true sine wave these relations do not hold.

Problems

1. Express in kilocycles the values of frequency given in paragraph four of this study sheet.

Assume that the maximum value of an alternating current is 10 amperes. On cross section paper plot its instantaneous values through one complete cycle by using the data in Table I.

3. The effective value of an a.c. voltage is 110 volts. What is the maximum value?

4. What is the effective value of current in a circuit in which the maximum value of current is 10 amperes?

5. The maximum value of a certain current is 10 amperes. What is the phase when the instantaneous value is 5 amperes?

6. In a certain circuit the effective value of the voltage is 15 volts. What is the instantaneous value of the voltage at the 45 degree phase?

7. Check the relation between the maximum and r.m.s. values by giving the square root of the average squares of several currents as plotted in problem 2.

8. If power in watts is equal (in I r.m.s.) x E r.m.s., what is the power used under heating a resistance of 10 ohms when the peak voltage is 10? 100.

9. Express by means of a vector diagram and in a formula the voltage in a circuit at phase 45 when the maximum value is 20.

10. Tell all you can about what the equation, e = 10 sin 30°, means.

Table I

<table>
<thead>
<tr>
<th>Angle in Degrees</th>
<th>Sine</th>
</tr>
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<tr>
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</tr>
<tr>
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<tr>
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</tr>
<tr>
<td>120</td>
<td>0.0</td>
</tr>
<tr>
<td>150</td>
<td>0.0</td>
</tr>
<tr>
<td>180</td>
<td>0.0</td>
</tr>
<tr>
<td>210</td>
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</tr>
</tbody>
</table>
No. 8  
Radio Broadcast's Home Study Sheets

Alternating Current  
Part II

If the experimenter wishes to know the difference between ac and dc, let him try to measure the current flowing through a 30-henry choke when it was passed across the 90-volt tap of his plate supply unit, and then when placed across the 110-volt line. Evidently the choke has a much different effect on an ac line than it does on a dc line. What is this difference?

Let him, too, try to measure the current through a 1-mfd bypass condenser when it was placed across this 90-volt tap, and across the 60-cycle line. Here again we see the difference between ac and dc.

The choke—another name for an inductance—passes much less current on 60 cycles than it does on d.c.; the condenser passes none at all on d.c. and an appreciable amount on 60 cycles.

Inductive Reactance

The opposition to the flow of a.c. currents offered by a coil of wire is proportional to its INDUCTANCE, the property of a coil which tends to prevent changes in the flow of current. If one could measure the rate at which the current flows into a choke coil and the rate at which it flows into the same length of wire stretched out straight, he would see that the final value of the current was attained much later when flowing into the coil. The same fact would be observed were the current flowing out of the coil or straight wire. The spark which takes place when the connection from a battery to an iron core coil in broken is evidence that the current tends to keep flowing even after the connection is broken.

How does an inductance tend to prevent changes in current?

Such a tendency is the result of several fundamental electrical phenomena. In the first place, when current begins to flow into a coil, lines of force from each turn of wire extend themselves out from the core into the space which is the magnetic field of the coil. In the second place, whenever a line of force cuts across a conductor, or vice versa, a voltage is induced in that conductor. Thus, when the many lines of force thread their way through the coil of wire, each turn of wire is cut by the lines of force from the other turns, so that a voltage is built up across the terminals of the coil. Now the third fundamental fact is that the voltage, which is called the magnetic emf, is in such a direction that it tends to prevent any increase or decrease of current in the coil.

We have been following phenomena then to explain the effect of inductance on changes of current: current flows into the coil causing lines of force to cut the individual turns of the coil; this in turn induces a voltage in the coil which has such a polarity that the increase in original current flowing into the coil is retarded.

When the connection is broken the opposite effect takes place; that is, the induced voltage tends to prevent the decrease of current with the result that its existence is prolonged. This voltage, then, must be in the same direction as the voltage tending to force current into the coil, so that across the ends of the coil, or the break in the circuit, a large voltage is built up. This voltage consists of the original impressed voltage from a battery, plus an added voltage. This explains the phenomenon which takes place and the rather severe shock which may be felt from even small improved voltages and a small coil.

It is important to note that it is only when the current in the coil is increasing—or decreasing—that the lines of force in the magnetic field change. And it is only the change in the lines of force that give rise to induced voltages; hence the retarding effect of inductance occurs only when the current is flowing.

Since alternating current is continually changing, increasing in value, reversing its direction of flow, decreasing in value, etc., the opposition which inductance offers to its flow is considerable.

The opposition which an inductance offers to the flow of alternating currents is measured in ohms just as resistance is, and its technical term is called INDUCTANCE. Inductance is numerically equal to the product of the inductance and the frequency of the current and the inductance of the coil, and is numerically equal to 6.28 times the frequency in cycles.

The abbreviation and formula for inductive reactance are

\[ XL = \frac{E}{I} \]

Thus, doubling the frequency doubles the reactance in ohms, so does doubling the inductance at the same frequency.

Since the current into an inductance does not rise to its maximum value instantly but lags behind the voltage, it is able to increase the volt at the time of maximum voltage and maximum current. The maximum current is not reached in a pure inductance (no resistance) until the voltage has gone through 90° of the cycle. The current in an inductive circuit, therefore, is said to lag behind the voltage by 90°.

\[ E = I XL \]

This time lag is represented in Fig. 1, which shows the maximum value of the current and the voltage are 90° apart. It is also shown in the vector diagram Fig. 2 which represents two arms rotating at the same speed, but 90° or one fourth of a cycle apart.

Since the maximum values of the current and voltage are 90° apart, we must take this fact into consideration when we desire to know the instantaneous value of the current in an inductive circuit. If the voltage is at an 150° phase, the current is 90° behind it, or at its own 60° phase. This difference of 90° is called the ANGLE OF LAG, or the PHASE ANGLE BETWEEN the voltage and the current. The instantaneous value of the current is expressed by

\[ I = \sin(\theta - 90°) \]

**Example**, What is the instantaneous current at the 150° phase in an inductive circuit in which the maximum current is 10 amperes?

\[ I = 10 \sin(150° - 90°) \]

\[ = 10 \times 0.87 \approx 8.7 \text{ amperes} \]

Figure 3 is the vector diagram for solving this problem. It is drawn to scale so that the various lengths of line represent the various values of current and voltage.

**Current in Inductive Circuits**

Just as the current in a resistance circuit is expressed by Ohm's law, so does the current in an inductive a.c. circuit differ by a similar formula:

\[ I = \frac{E}{XL} \]

and if the voltage is effective, or maximum, or instantaneous, the current will be effective, maximum, or instantaneous.

**Problems**

1. Plot the reactance of a coil of 0.1 henry as the frequency is increased from 100 to 10,000 cycles, and from 10 to 1000 kilocycles. What would the reactance be if the inductance were 1 millihenry? One henry?

2. A coil has the following dimensions: length of winding, 2 inches; inside diameter, 1 inch; number of turns, 65. What is its reactance to a current of 700 kilocycles? What current would flow through it if the voltage (effective) were 100 volts? (See Home Study Sheet No. 2, July Radio Broadcast.)

3. Make a vector diagram for the following condition and solve by means of the formula above. The instantaneous voltage at the 135° phase is 5 volts; what is the instantaneous current at the 135° phase if the effective current through the circuit is 10 amperes?

4. How much inductance must be placed in a 110-volt (effective) circuit, at 60 cycles to limit the current to 1 amperes? At 6000 cycles?

5. The maximum value of the voltage in an inductive circuit is 140, the maximum value of the current is 10 amperes. At what phase angle is the instantaneous current equal to 7 amperes? What is the instantaneous value of the voltage? What inductance must be added to reduce the maximum current to 7 amperes if it is a 115-cycle circuit? What will be the effective current then?

6. Can you explain why a 25-cycle transformer is larger, heavier, and more expensive than one built for 60 cycles? What would be the result of placing a 60-cycle transformer on a 200-cycle circuit? What would happen if a 500-cycle transformer were placed on a 60-cycle circuit?

7. Suppose you couple a loud speaker to an output tube by means of a choke and a condenser. The output a.c. voltage at 1000 cycles is 50; this appears across the choke which has an inductance of 30 henrys. What a.c. current flows through the choke? If the condenser offers no impedance to the flow of current at this frequency, and if the loud speaker, which is, then, shunted across the choke, has an impedance of 4000 ohms, how much a.c. current flows through it? Suppose the power into the loud speaker is equal to the current squared multiplied by the impedance of the speaker. What power is going into this speaker? Suppose 2 percent of electrical power is turned into sound energy by the speaker. How many watts of sound output power comes from the speaker? How many micro-watts?

8. Draw the diagram of a two-stage audio amplifier using 31 transformers working out of a detector tube which has an impedance of 20,000 ohms; the power or second stage working out of a tube with an impedance of 15,000 ohms and a tube of R. These plate impedances are in series with the impedance of the primary of the following audio transformer. Suppose across the first anode impedance of 100 cycles. The transformer primaries have effective impedances of 100 henrys. Figure the a.c. current in the plate circuit of the detector and the first audio tubes. (Combine the tube and transformer impedances by adding them.)
The 222 Tube as an R. F. Amplifier

Part II

By GLENN H. BROWNING

In this, the second article from Mr. Browning's notebook on the 222 tube, the author discusses two common methods of coupling a screen-grid tube to a detector or a following amplifier. The equations by which Mr. Browning arrived at his conclusions should be interesting to the mathematically inclined; the results of these equations and the laboratory data will be interesting to anyone who likes to keep up to date in radio.

—The Editor.

In the article on page 252 of September Radio, the author discusses the characteristics of d.c. and a.c. types of screen-grid tubes were discussed and their performance in untuned amplifiers was also considered. It is the object of this article to treat of two types of tuned radio-frequency amplifiers, one the common radio-frequency transformer where a primary and secondary winding is used, and the other the auto-transformer usually termed tuned impedance.

The function of a tuned radio-frequency amplifier is not only to amplify incoming signals but also to give the desired amount of selectivity. There is also the question of the tendency of the preceding circuits to oscillate, which is very important with tubes which have a great deal of capacity between grid and plate. This effect, however, is minimized with the screen-grid tube, and consequently will not be dealt with at length here.

To determine the design of an r.f. transformer for the screen-grid tube the mathematics for a one-stage amplifier such as shown in Fig. 1 should be examined and the voltage amplification, i.e., output voltage E divided by input, E, calculated. As far as alternating current is concerned, Fig. 1 reduces to Fig. 2, where a voltage of $\mu E_g$ is applied in series with the plate resistance, $R_p$, and the primary of the transformer. Analyzing this circuit and making certain simplifications the voltage amplification is

$$ E = \frac{\mu \tau \sqrt{L_a/L_i}}{3 \sqrt{v_1 v_2}} \quad (1) $$

Where $\mu$ = amplification factor of the tube
$\tau$ = coefficient of coupling between primary and secondary
$E_a$ = secondary inductance in henrys
$E_i$ = primary inductances in henrys
$v_1 = R_p/4 \pi$
$v_2 = R_p/\pi$
$\omega = 2 \pi f$

It will be readily seen by equation (1) that there is a relation between $v_1$, $v_2$, and $\tau$ that will make the amplification a maximum. This relation is

$$ \tau^2 = \frac{v_1}{v_2} \quad (2) $$

for maximum voltage amplification.

The amplification obtained by the transformer and tube when this relation is satisfied is

$$ E = \frac{\mu \sqrt{L_a/L_i}}{2 \sqrt{v_1 v_2}} \quad (3) $$

From this analysis it may be seen that $L_a$ should be as large as possible consistent with tuning down to the lowest wavelength desired. $L_i$ should be as small as possible consistent with satisfying the relation $\tau^2 = \frac{v_1}{v_2}$.

It should be noted that when $L_a$ is small that $v_1$ is large and consequently the coupling must be increased. Thus it is advantageous to make the coupling large consistent with keeping the capacity between the primary and the secondary windings small, as this capacity between the two circuits has the effect of introducing a voltage in the secondary circuit somewhat out of phase with the voltage induced by the magnetic coupling.

With the ordinary 109, 214A, 225, and 227 type tubes, the plate resistance is sufficiently low so that all the above relations may be satisfied, and maximum gain may be obtained. (See Proceedings of Institute of Radio Engineers, December, 1925.)

However, with the screen-grid tube the plate resistance is between 400,000 and 700,000 ohms so that $v_1$ is very large and the relation $\tau^2 = \frac{v_1}{v_2}$ can never be satisfied. Of course the primary inductance of the r.f.t. may be increased up to the point where the distributed capacity of the winding itself tunes the primary to some frequency in the wavelength band. $v_2$ is made as small as possible but can never be reduced below a value of about 0.04 except with regeneration. Therefore, it is essential in the design of a transformer for the screen-grid tube to make the coupling very large. This problem was attacked by the writer some months ago and by careful design the coefficient of coupling was increased from its usual value of about 0.5 to 0.91. This factor depends upon the geometrical relation between primary and secondary in such a way that the shorter the secondary winding with the primary in a given position the larger $\tau$ becomes. The coils which showed a $\tau$ of 0.91 were wound on a 2" form and had a winding length of $\frac{10}{9}"$. The primary was slot wound and placed $\frac{1}{4}$" from the low potential end.

With these coils in the one-stage amplifier the circuit of which is shown in Fig. 1, and using a CcCo a.c. 22 tube, an amplification of about 20 would be obtained, as shown in Fig. 4.

![Fig. 3](Image)

**Fig. 3**

Theoretical and actual voltage amplification curves over the broadcast band for the types of r.f. coupled discussed in this article.

![Fig. 4](Image)

**Fig. 4**

The solid curve is the actual resonance curve of the transformer shown in Fig. 1 and 2 at 400 meters. The dotted peak is the portion of the calculated curve which does not coincide with the actual curve. The dot-dash curve is the resonance curve of the tuned impedance shown in Figs. 5 and 6.
RADIO

per stage could be obtained. The method of measuring this gain was to put in a signal from an r.f. oscillator of 0.1 volt, as measured on a Rawson Thermal Multimeter, and to measure the voltage developed across points 3 and 4 by means of a vacuum tube voltmeter. The results are shown in Fig. 3. In curve 1 voltage amplification is plotted against wavelength. The theoretical amplification as calculated from equation 1 is shown by curve 2. The discrepancy between measured values and calculated ones is probably due to the capacity between primary and secondary windings of the r.f.t., as the effect of any capacity would be more pronounced on the short than on the longer wavelengths.

As a matter of comparison the amplification of a 220 A tube used in conjunction with a well-designed transformer is shown by curve 3. Not only does the screen-grid tube with the transformer described above give more amplification per stage, but furthermore a number of stages may be used without neutralization, whereas with the 220 A, careful neutralization is necessary.

Before considering the amplification given by a tuned impedance, let us consider the selectivity obtained with the transformer and the Cenco a.c. 22 tube. The selectivity depends primarily upon the resistance, Rs in the coil and condenser in the secondary circuit. However, this resistance is increased due to the effect of the primary. Instead of considering the resistance itself let us consider which is nearly constant over the band and gives directly the sharpness of tuning of the circuit. The smaller this factor the sharper the circuit tunes.

For a given amount of amplification the selectivity of the radio-frequency transformer as a whole depends upon the coefficient of coupling, so that when it is increased to obtain amplification the selectivity of the transformer is also increased.

The solid curve in Fig. 4 shows the selectivity curve of the transformer at 400 meters. The following chapter describes the characteristics of rotating loop installations of the following types: Radio Communication Company, Ltd., Société Française Radio-Électrique, Gesellschaft für Drahtlose Telegrafie (Telefunken), Siemens Brothers and Company, Ltd., U. S. Bureau of Standards, Washington, Marconi’s Wireless Telegraph Co., Ltd., Radio Corporation of America, and the Federal Telegraph Company. The descriptions are quite extensive and well illustrated with diagrams and photographs.

Chapter 5 is devoted to an analysis of the Bellini-Tosi system, which uses large fixed loops for directive transmission and reception. Another chapter goes into the theory and practice of map drawing. The radio engineer will have his hands full with such terms as “The Gnomonic Grid,” “The Orthomorphic Cylindrical Projection.”

Book Review

By CARL DREHER


The statement that a given work is indispensable to those interested in the subject is a much misused cliché of technical book-reviewing, but in the case of Keen’s “Wireless Direction Finding and Directional Reception” it is merely the literal truth. This book was first published in 1922 under the title of “Direction and Position Finding by Wireless.” In the second edition the title was changed to include directional aerial systems, which had in the meantime assumed importance. Keen’s work is an important contribution to the specialized literature of radio. It is a serious technical job and not intended for those to whom radio is a plaything. The mathematics is fairly simple, but the victorial and diagrammatic treatment is very thorough and obviously designed for the attention of engineers and engineering students.

After an introduction, which includes an impartial historical treatment of the subject, directional transmission and reception are discussed. The wave antenna of Beverage, Rice, and Kellogg is described at the end of Chapter 2. The third chapter is devoted to “Frame Aerial Reception.” This is discussed in detail, such topics as “Elimination of Vertical” (the antenna effect of a loop, which plays a part in reception) being treated. The theory of practical “Chute” “The Orthomorphic Cylindrical Projection” in this chapter and the one following, on “Position Finding and Wireless Navigation,” he will have brought home to him that radio direction finding is as much a branch of geometry and navigation as of wireless communication.

Chapter 9, on “Night Effect and Other Freak Phenomena” is of general interest to students of the vagaries of radio transmission. In the following two chapters the discussion returns to types and characteristics of apparatus on shore and afloat. Theory, testing, calibration, and operation are considered in turn. Chapter 12 tells about “The Aircraft D. F. Installation”; it is as complete as possible, but in his preface the author says that this chapter “is still necessarily curtailed. Although there has been much activity in this direction, there are few concrete designs of aircraft D. F. available for inclusion here.” For this state of affairs the difficulties encountered in such installations, as well as the indifference of many signal responsible.

Two more practical chapters, on “Fault Clearing and Maintenance,” and “Notes on Field and Nautical Astronomy” complete the work. A bibliography of 374 references and an index are included. If anything material on the subject has been omitted it has escaped the present reviewer.
Coupling Methods for the R. F. Amplifier

By BERT E. SMITH
Aero Products, Inc.

WHEN the screen-grid tube was first introduced it was heralded by many as a panacea for all the ills associated with r. f. amplifiers. That such is not the case is becoming more and more evident. The tube undoubtedly is valuable, but just what can be expected of it can be determined only from the data obtained from carefully done laboratory investigations. In this article are presented some such data indicating the comparative gain and selectivity that can be obtained from the tube when it is used with different types of r. f. transformers.—The Editor.

For several years the development of radio-frequency amplification has been practically dormant, with little, if anything, new in sight at the present time. Recent improvements have been confined to the sonic end of the receiver, with the result that radio has been lifted from a fad to an art, but the old thrill of "distance" has passed! No longer do eager commuters rush for the morning train to brag about the dx of the night before, and no longer do "Radio Widows" get divorces because their husbands desert them to spend the nights with the radio set and the thin elusive signals from a transmitter three or four thousand miles away.

For, strangely, in spite of the fact that receivers now average six or seven tubes where they used to have perhaps three, and broadcasters use ten or a hundred times their former power, it is harder and harder to get distant stations.

Many theories have been advanced to explain this, but in the final analysis, it becomes increasingly evident that the truth must be that in the rush for selectivity and quality, designers have lost sight of sensitivity. The science of radio-frequency amplification has seen retrogression rather than progress. Nothing of any real value has been introduced since the Hazeltine neutrodyne system several years back, and even that, insofar as the principle of neutralization by external capacitive reactance is concerned, was only a variant of the earlier Rice system.

In the years immediately following the introduction of the neutrodyne, many schemes have been advanced purporting to produce the full theoretical amplification of the tube and transformer, or to enable the tubes to be stabilized without any loss of efficiency, but all have proven impractical, and 100 per cent. efficient radio-frequency amplification continues to be a vainly sought chimera. A surprising number of manufacturers have returned to the oldest method of stabilizing known—potentiometer grid control. Some are cutting down the plate voltage applied to the tubes. Some use variable leaks across the tuning condenser, broadening the tuning and losing all the well known advantages of low-loss coil and condenser construction. Practically every manufactured receiver to-day on the market employs one of the 'losser' systems which were so violently, although justly, condemned a few years ago!

Small wonder, then, that receivers do not reach out for distance now as they did.

There is still a call for sets which will bring in distant stations was distinctly evidenced by the sudden rush when the screen-grid tube was announced, and it is decidedly unfortunate that this tube was heralded by so much misleading publicity, which led builders to expect much that has proven impossible. Many of the leading publications carried editorial matter describing the great amplification obtainable from a tube which would not oscillate, and even the largest tube manufacturers and best engineers in the country allowed statements to appear such as "a voltage amplification of 200 per stage is obtainable, but at broadcast frequencies the resonant impedance is lower reducing the amplification by 25 per cent. of this value."

It may be possible to get such gain from the tube in laboratory apparatus, constructed by competent engineers, and under ideal conditions, but performance of this kind cannot by any means be secured from the ordinary broadcast receiver. It has become extremely doubtful, in the writer's opinion, whether the tube in ordinary use in tuned radio-frequency receivers operating at frequencies of 500 kilocycles and higher can produce great deal better all around results than the 200 A type tube which has been standard for so long a time.

With all these facts firmly in mind, an investigation was recently undertaken with the object of determining two things: First, whether some existing method of stabilization could not be so modified as to give really passable results by permitting r.f. amplifiers to be built without the intentional introduction of losses except as desired for a volume control; and secondly, whether this amplification might be obtained within appreciable limits of selectivity, regardless of type of tube used. However, all the tests described below utilized the 222 type of tube. No new ground was gone over, and nothing was developed which did not bear out previous empirical design, but there had been so much theoretical data published, and so little of the result of actual quantitative tests, that it seemed that figures obtained through concrete experimentation might be at least refreshing.

Prior to commencing any actual work, certain limits were laid down as essential if the results were to be of any value in designing a receiver which could be constructed by the kit builder. First, standard apparatus, obtainable by anyone, must be employed. Second, the need for any complicated balancing, by means of expensive and accurate apparatus after construction, must be avoided if possible. Thirdly, the use of shielding, while not barred, was considered undesirable as introducing superfluous expense and trouble. Last, no involved or critical adjustments of any kind were allowable, as a receiver must be infallibly sure to give good results if the connections are properly made, in the hands of the most inexperienced operator.

The Test of Coupling Methods

The first actual operation was the determination of the method of coupling tubes, and the optimum values to be used in the coupling device. For this the set-up shown in Figure 1 was utilized originally, but since the conditions in the grid circuit of the amplifier tube were not identical with those which would be encountered in actual practice, it was found advisable to add a second stage, coupled to the grid of the test stage tube by a special radio-frequency transformer having an absolutely flat amplification against-frequency characteristic. The use of this stage allowed the test stage to be adjusted to operate in a manner exactly identical with its performance in an actual receiver, permitting oscillation to take place in the same way and at the same point. The output of a modulated oscillator, variable in frequency over the broadcast spectrum, was led through an adjustable attenuator to the grid of the first amplifier tube,
also actuating a very sensitive vacuum tube voltmeter. By this means the input signal could be kept constant regardless of frequency variation. The output of the coil under test was led to a second vacuum tube voltmeter whose input characteristics were similar to those of a typical detector circuit. A second transformer, having the same flat amplification-against-frequency characteristic already mentioned, was used as a standard of comparison for plotting figures of merit on all couplers used.

This test was given to coils of sixteen types, as many of each type being tried as were deemed necessary to determine their worth. Inasmuch as the reproduction of all these curves here would only lead to confusion, due to their number, and would serve no particularly useful purpose, we will show the results obtained in those most usual types which had a bearing on the final result. However, as a matter of information, it may perhaps be advisable to outline roughly the types involved and the major reason for their abandonment.

All coils were of the general type illustrated in the photograph on page 361, having 27 turns of wire in the secondary circuit, air-spaced to conform to an approach to the ideal shape factor and supported by a skeleton bakelite frame, so that the insulation losses are kept at a minimum figure. The self-inductance of the secondary alone was 167.4 microhenries and the radio-frequency resistance of the coil in series with a Cardwell condenser varied from 3.85 ohms at 550 meters to 9.6 ohms at 200 meters. These figures are meaningless in direct relation to almost all of the actually tested coils, as the introduction of a primary coil, or the use of a portion of the secondary coil for coupling, have a decided effect on both the inductance and the high-frequency resistance of the secondary.

Among the types tested were:
1. A tuned impedance, directly from plate and grid to ground. Fig. 2-A.
2. An auto transformer, in which a portion of the secondary is used as primary, the low potential end being common. Fig. 2-D.
3. A transformer in which the primary and secondary are coupled by a bypass condenser at the low potential ends, the direction of the winding being continuous from plate to grid, and the coil being tuned from plate to ground, as in the R. B. Lab. circuit and Betts circuit adaptations.
4. A primary wound to take up a length of 1½", inside the secondary. Fig. 2-B.
5. A primary wound to take up ½", placed inside and in the center of the secondary.
6. A primary wound to take up ½", placed inside and opposite the low potential end of the secondary. Fig. 2-C.
7. A primary wound with a length of ¼", placed in both positions above described.
8. A primary wound in a ½" slot, coupled adjacently to the secondary.
9. A secondary wound on the same diameter as, and at an adjustable distance from, the secondary.
10. A tuned primary with adjustable coupling to the secondary.

Each was tested with a varying number of primary turns, and where possible, with varying degrees of coupling, as well as with primary windings in both directions in the first few tested. Empirical analysis previous to the test had led us to believe that where capacitive coupling existed between the plate circuit of the preceding tube and the grid circuit of the following tube, the voltage in the secondary due to this coupling would be in quadrature with that generated by the inductive coupling when the winding was continuous in direction from plate to grid, and hence would reduce the amplification obtainable, although probably flattening the curves somewhat due to the change in relative energy transfer by capacity and inductance at varying frequency. This was borne out in the first few curves, and since the object of the test was to secure the highest possible amplification throughout, the balance of the tests was made entirely with the windings in opposite directions.

RESULTS

In FIG. 3 curves of amplification are shown on three windings in types 2, 4 and 6, and will be discussed at more length later. Type 1, illustrated in Fig. 2-A, generally advocated for use with the screen-grid tube, showed no greater amplification than several other types, and was pronouncedly poor in selectivity. Type 3 gave beautifully flat curves, but the amplification was low, as only a portion of the built up voltage was impressed across the grid and filament of the following tube. The selectivity was rather poor. Types 7 and 8 appeared desirable from some angles for particular purposes, but in general were not considered as useful as the standard types. Due probably to the large distributed capacity of this type of winding, decided resonances and unsatisfactory results were obtained which varied in their amplitude with the degree of coupling and number of turns used. When a coupling was adjusted to the optimum degree where only three peaks were observed in the broadcast spectrum and a merit figure of 45 to 50 was obtained, the selectivity was very poor, and when either coupling or self-inductance was so adjusted as to allow appreciable selectivity, variations in amplification as high as 50 per cent. were unavoidable. It seems therefore evident that this type of winding is not as desirable as desirable. Type 10 gave extremely good results, but was impractical for use in receivers because each stage would require three controls, two for tuning and one for coupling, each of which required adjustment for every frequency change.

Types 4 and 6 are very commonly used, and hence we have selected them for detailed presentation in connection with type 2, which was finally adopted as best. Type 4, illustrated in Fig. 2-B and generally advocated for use with the screen-grid tube, the tuned impedance arrangement is employed, is shown on the chart of Fig. 3 in dot-dash lines, and it will be noted that after the number of turns increases to a certain point, no further increase in amplification is obtained. The winding arrangement which has been recommended is not only unnecessary, but undesirable, since the selectivity, poor at all times with this type of construction, is very bad when more than eighteen turns are used.

Type 6, illustrated in Fig. 2-C, is the type most commonly used at the present time and the results indicate that if conventional circuits are to be employed, it is considerably superior to any of the others tried. It is at least as good in amplification as the widespread primary, with
a considerably improved selectivity factor. It will be noted in Fig. 3 that a variation in the number of turns results in a change of the point where maximum amplification is secured, and hence in a multistage cascade amplifier where selectivity is a matter of importance, two stages may be sacrificed, comparatively uniform amplification can be secured over the whole band by adjusting the number of turns in the primary of each transformer.

Results obtained from type 2, illustrated in Fig. 2-D, are of extreme interest. In this type of coil a varying portion of the secondary acts as primary, with the primary and secondary currents in this portion of the coil in quadrature. The inductive coupling for the same number of turns in the primary is much greater in this type of coil, hence a comparatively high plate circuit impedance is built up with a relatively small number of turns, with consequent greater overall amplification. It will be noted in Fig. 3 that when many turns are used as primary, the amplification on the shorter wavelengths is reduced, because the portion of the coil in which the currents are in quadrature is appreciable and hence the voltage at the grid of the following tube is lower. This can be seen in a multi-stage amplifier to secure substantially uniform amplification over the whole spectrum. The selectivity of this arrangement compares very favorably with all of the types tested, and is pronouncedly superior to both the more or less commonly used types directly compared.

In the selectivity curves shown in Fig. 6, a selectivity factor of 50 is fair, 55 is good, and 60 is an extremely desirable value. At 350 meters this selectivity figure can be obtained with the autoformer circuit with an amplification figure of merit of 5.7, whereas with the 1" primary corresponding selectivity is secured with an amplification of only 3.6, or about 65 per cent. In this particular instance the superiority of the autoformer type is very outstanding.

As shown in Fig. 2-D the autoformer circuit is not very practical due to the high potential (d.c.) of the tuning condenser. The circuit of Fig. 4 retains the advantages of the coil construction while eliminating this drawback.

**Oscillation Control**

Up to this point no mention has been made of oscillation. Depending upon the tube used and the constants of the circuit, this was frequently encountered, even with the screen-grid tube, unless some means were taken to prevent it. In this connection, it must be borne in mind, in analyzing the results obtained, that they only hold good in a circuit carefully adjusted in such a way that oscillations cannot take place.

A review of various methods of stabilization indicated that the best results were probably obtained by shifting the phase angle of the currents in various stages, by a method somewhat similar to that illustrated in Figure 4. Here the plate circuits of each branch consisting of resistance only and another of capacity and inductance in series, the latter value depending upon where the tap is placed on the tuning coil.

By varying the resistance, it is possible to change the angle by which the current leads the voltage in any one stage, and in this way control the tendency towards oscillation. Unfortunately, however, when resistances of the proper value to give us adequate control of the phase angle are employed, it will be found that any variation of the resistor varies the plate voltage applied to the tube and may seriously affect the amplification obtained. In order to avoid this, the circuit shown in Fig. 5 was finally adopted. The r.f. choke, L₅, having a comparatively low d.c. resistance, was shunted around the resistance, maintaining a maximum static value of plate voltage at the tube, while offering a very high impedance to radio-frequency currents. The resistance, Rₛ, can now be varied without affecting the static value of the plate voltage and will be found to serve very nicely as an oscillation control; and if it can be reduced to a low value, so as to effectively short circuit Cₛ, it can also be employed as a volume control for the receiver.

In a circuit containing two stages of r.f. amplification, it will rarely be found necessary to employ more than one such resistance, as sufficient adjustment can be obtained to avoid oscillation while still maintaining a satisfactory value of overall amplification. Maximum results, regardless of the type of tube used, can be obtained by varying the proportion of L₅ which is used in the plate circuit of the preceding tube. Little trouble was experienced from inductive coupling between coils, provided a distance of at least 6" was kept between them.

Shielding always introduces certain losses in the coil, and also complicates the mechanical construction of the receiver. It will be seen from the curve in Fig. 7 that the necessity of shielding is mitigated as far as inter-stage coupling effects go, while the diameter of the coil is so small that direct pick-up from local stations is reduced to a minimum.

In the interest of compactness, a trial was made of another method of mounting the coils where three or more tuned circuits existed. The coils were mounted comparatively close to each other but in such positions that their fields were opposed. It will be recalled that this "sacred angle" construction was used in practically all of the earlier neofundines. While placing the inductances at such an angle that the magnetic fields of several coils intermingle, the least, gives some relief against unwanted coupling of this type, at the same time the coupling due to the capacity then existing between the coils vitiates the most of the benefit theoretically secured.

When the coils were placed sufficiently close to secure any advantage from compactness, capacity coupling was encountered to such an extent as to destroy completely any possible advantage to be gained from this method of mounting. In addition, the length of grid leads required was in excess of a passable figure, and consequently the scheme was abandoned.

The next portion of this article will describe the construction of a receiver using two stages of tuned radio-frequency amplification with screen-grid tubes employing the "Chronophase" system whose final evolution is pictured in Fig. 5. The particular receiver in question has fully justified the long period of experimentation preceding its actual construction and will be found both in sensitivity and selectivity to be superior to most receivers with one or two additional stages of radio-frequency amplification. On a 25-foot antenna located on the shore of Lake Michigan, in the heart of the most congested mass of broadcasting stations in the world, it has been possible to cut through locals and secure good loud speaker reception of stations a thousand miles distant.
Obtaining Screen-Grid Bias

For the most efficient operation of screen-grid receivers a positive bias on the screen grid is required. Few power units designed prior to the introduction of the 222 tube provide the proper screen voltage. By means of a Duplex Clarostat, connected as a potentiometer between the negative and plus 90 volt posts on my power supply set, I am able to secure the best biasing potential. The circuit is simple and is shown in Fig. 2. Both adjustment screws should be given about two and a half turns (from a tight adjustment) and then the lower screw adjusted until signals are amplified most efficiently. The bias potential should be bypassed to energize the primary. Take the tube in hand, covering the glass as much as possible, and touch any of the terminals to the high tension lead from the coil, watching the while for glow. No sign of ionization indicates a hard tube—or one full of air. In this latter case, of course, the filament would burn out when connected across the usual battery circuit.

A pale greenish glow, close to the inside surface of the glass, indicates about the right amount of gas for a good detecting tube. If the glow is purple, and is confined to a small area directly around the plate and filament, the probability is that there is too much gas for efficient detecting action.

Alfred A. Ghirardi, Stapleton, N. Y.

Matching Condensers and Coils in Tandem Tuned Circuits

While the general procedure for matching isolated coils and condensers is fairly well understood, I have never read anything on the process involved in matching coils and condensers already connected in a receiving circuit. The following system will be of value to the experimenter who desires to match an r.f. tuning combination more closely than can be done by the trial and error method on a station.

The method employs an oscillator with a meter in the plate circuit to indicate resonance. It is not essential to know the wavelength to which the oscillator is tuned, as long as it is within the broadcast band. Fig. 3 shows a circuit that can be employed as an oscillator. The number of turns of wire wound on a 3\(\frac{1}{2}\)" winding form is indicated on the diagram. The size of wire is not important.

The additional materials are about three feet of rubber covered wire and a small clip facilitating a temporary connection to the grid side of the circuit being tuned. Cut the wire in half and twist two ends of it together for about one inch, making a small condenser. One of the two remaining ends is soldered to the clip and the other to the grid terminal of the oscillating tube.
"OUR READERS SUGGEST—"

The procedure is as follows: Have the condenser sections of the combination to be matched half way out. (If the condensers are to be matched with the aid of trimmers, the trimmers also should be at half maximum capacity.) Start the oscillator and snap the clip to the grid side of one of the condensers. Tune the oscillator to resonance, which will be indicated by a maximum dip on the meter. If the dip is too broad, reduce the capacity of the twisted rubber-covered wire—by cutting down the overlap—until a sharp dip is obtained.

Snap the clip on the next condenser, and adjust this to resonance (without touching the oscillator adjustment) either by use of the trimmer, or by tapping the plates into place. At maximum deflection the two stages are in resonance with each other. The procedure is the same for additional circuits.

JOHN BENEDICT, Maspeth, L. 1.

An Amplifier Kink

HAVING an occasion to revamp an old set for a friend of mine, I used the audio-frequency arrangement shown in Fig. 5. The Thordarson 33-1 transformers, originally supplied with the set, were merely rewired to conform with the diagram.

The tone quality was considerably improved, particularly on the lower registers. Another further improvement by the use of 112a tubes in the detector and first audio sockets.

EDWIN M. WRIGHT.


STAFF COMMENT

THE arrangement suggested by Mr. Wright emphasizes the low notes. Reproduction of the higher notes can be enhanced by the substitution of a 30-henry choke for the 5,000-ohm resistor in the plate circuit of the first audio tube.

Dynamic Speaker Field Supplied from B-Power Unit

I T IS possible to excite the windings of several of the d.c. type of dynamic loud speakers from the plate current of a receiver operated from a line power supply source. It is merely necessary to connect the excitation windings of the loud speaker between the choke coil nearest the output of the socket power unit and the maximum voltage post. The connection is broken and the circuit recomposed through the windings, care being observed to connect the positive loudspeaker post to the choke coil. The current drain to the receiver should be in the neighborhood of 100 milliamperes. This, however, is generally the case where a dynamic speaker is justified.

A. V. Svenonse, New Zealand.

A Simple Audio Channel Equalizer

I HAVE found several sets in which the combination of a good audio channel and a good speaker gives an overemphasis to the low notes. I find that the addition to the usual choke output device suggested diagrammatically in Fig. 4, is most effective in controlling the amount of low-frequency reproduction.

The 0,000-mfd. condenser bypasses the high frequencies anyway, and varying the 100,000-ohm resistor (a Pilot Resistograph) adds the low notes to taste.


STAFF COMMENT

MR. HATCH'S idea should prove most effective in eliminating the "boom" experienced with many cone and airplane cloth speakers.

A. C. Tube to Reduce Microphonics

MANY battery-operated receivers, the operation of which is characterized by excessive microphonic disturbances, can be improved by the substitution of a UX-227 a.c. tube in the detector socket with the proper filament resistor to permit its operation from a 6-volt battery.

Previous to making the suggested change, enjoyable reception from the writer's battery-operated set was practically impossible. Footsteps in the room, or the passage of a truck in the street, was sufficient to set up ringing microphonics in the loud speaker.

Appreciating the fact that the rigidity of cathode structure in a.c. detectors together tends to reduce the vibratory motion responsible for microphonics, I replaced the UX socket in my receiver with a 3-prong socket, wiring a 6-ohm rheostat in series with the filament circuit. The cathode is connected to the positive filament terminal on the socket—that is, "C" and plus "F" are strapped together. An UX-227 tube can now be used as a detector. If the time lag—30 to 40 seconds—is objectionable, an Arcturus type 127 tube can be used instead. This latter tube "comes up" in about seven seconds.

A simple equalizing arrangement that controls the reproduction of low notes. This device will eliminate the "boom" in many modern speaker-amplifier combinations

FIG. 4

An Antenna Booster For Loop

I HAVE a loop-operated set which is badly shielded by surrounding walls. To correct this I am using an outside antenna inductively coupled to the loop by means of a coil. The coil is placed inside the loop and connected to the outside antenna and to the ground.

I am using a #20 wire with 30 turns of No. 20 wire. I find that by tapping this coil in four places, that is, every ten turns, the reception is greatly improved over the entire range of wavelengths. That is, on short waves the 10-turn tap is just right while on long waves 40 turns or 50 turns is about right, with proportionate taps in between.

WILLIAM D. Esch, Chertyville, Kans.

STAFF COMMENT

AN ARRANGEMENT practically identical with Mr. Esch's suggestion was described in this department for December, 1927, and January, 1928. A commercial coupling coil for this purpose is made by the Jenkins Radio Company of Davenport, Iowa.

An Output Filter Without a Condenser

A VERY effective output device for use with the average receiver may be made with the use of a choke only (the condenser being omitted) providing the characteristics of power tube and speaker are known so that the proper choke may be employed.

In a receiver constructed by the writer, a 171 type tube was used in conjunction with an R. C. A. 100 speaker, which is comparable in characteristics to most cone reproducers. A condenser of sufficient capacity not being available, the speaker was connected in parallel with a 25-henry choke as shown in Fig. 6-A. The equivalent circuit, based on a frequency of 100 cycles, is shown in Fig. 6-B. At this frequency the impedances are, approximately: tube—2000 ohms choke—15,700 ohms, and speaker—2000 ohms. The d.c. resistance of the choke is 500 ohms and that of the speaker is 1800 ohms.

It will readily be seen that the speaker, being of relatively low impedance, will take about 99 per cent. of the a.c. current, but due to its high resistance, compared to that of the choke, will allow but one third of the d.c. current to pass. This will be in the neighborhood of 6 milliamperes, which is not objectionable. The resistance of the plate circuit is considerably lower than that of the actual output device, and hence the voltage drop will be smaller.

The quality of reproduction, using this combination, was found to be excellent.

GLENN R. TAFT, Ticonderoga, N. Y.

An output device using a choke coil without the conventional condenser. The wiring circuit is shown at A, and at B is the equivalent schematic circuit
The "Vivetone 29" Receiver

By R. F. GOODWIN

THE receiver which Mr. Goodwin describes in this article is a r.f. set which performed in the Laboratory in a fashion to indicate that its designer is not prone to exaggeration. There are several novel features; one is an automatic regeneration control, consisting of a resistor which changes its value as the set is tuned, thus adjusting the C bias on the r.f. tubes and keeping them from oscillating at any dial setting. Another is an a.c. voltmeter which is mounted on the panel so that the operator can tell at all times the voltages across his tubes. If the constructor builds one of the amplifier-power supply units the author has developed, he will have in it a regulating device which will enable him to keep this voltage at its proper value regardless of line voltage fluctuations.

—THE EDITOR.

Sensitivity, selectivity, quality of reproduction, beauty in appearance, and simplicity of operation—these are the five paramount requisites of a modern receiver. Every discriminating radio constructor or enthusiast must consider each of these features separately and in connection with each other when he decides what receiver to build, buy, or operate. Some of these features are often secured at a sacrifice of others; as in other phases of life one cannot get something for nothing.

The "Vivetone 29" is a receiver in which the effort has been made to incorporate all these features to as high a degree as possible without too great a compromise. In other words, it embodies a circuit that has considerable radio-frequency gain, that is simple to operate—there are only two controls—and yet is sufficiently selective to cope with modern broadcasting conditions. More will be said about the sensitivity and selectivity later when the writer describes his own success with the receiver in a location which is none too good for dx reception. It is enough to state now that the selectivity is sufficient to enable one to tune through many local stations with a minimum of interference, and that the sensitivity is such that distant stations can be picked up with a great deal of ease.

DESIGN FEATURES

THE fact that the set contains three stages of r.f. amplification, each separately shielded and constructed of the best "low loss" apparatus now on the market, may account to the technical reader for the set's gain. With the addition of the detector input, which is tuned, the receiver has four tuned circuits, each working with a minimum of regeneration so that the order of selectivity is rather high.

There are two novel features, one of which has not been seen heretofore so far as the writer is aware, and the other—an a. c. voltmeter on the panel—is omitted from the vast majority of otherwise well designed sets. The novel feature which impresses the writer most is a simple but effective method of automatically controlling the regeneration in the r. f. stages. This is done by automatically varying the bias of the grids of the r. f. tubes as the set is tuned to various frequencies.

It is well known that all r.f. receivers tend to oscillate badly on the high frequencies (shorter wavelengths) and that many such receivers have included in their mechanism a resistor which changes the plate voltage, or C bias, of the r. f. tubes so that actual oscillation does not take place. Such devices are always manually operated, so that at each setting of the tuning condensers it becomes necessary to adjust the regeneration control—often labelled a volume control—to the point of best operation.

In this receiver all such adjustments are made automatically by attaching a 2000-ohm variable resistance, PP-2000 in Fig. 2 and 3, to the shaft of the tuning condensers. It is so adjusted that as the tuning condensers are varied the bias is reduced at the lower frequencies and increased at the higher frequencies. This has the same effect as changing the plate voltages to these tubes, but in the writer's experience is a neater method of accomplishing the same result, i. e., the maintenance of greater stability as a whole.

In addition to the automatically changing resistance, another resistance is shunted across the bias adjuster for fine adjustments. This resistance, PP-5000, is located on the panel so that manual regulation may be had when desired. It must be understood that it is not necessary to change the setting of this resistance at all for ordinary operation, but when one is dx hunting he often needs just that small additional control which "brings 'em in."

On the panel is an a. c. voltmeter which, after the receiver has been placed in operation, is permanently connected across the heater element of the detector tube. It shows the voltage across that tube at all times, and since this tube in common with all the others is fed from a filament supply transformer the meter's indication tells what the general voltage conditions are. The writer has developed a series of power units for this receiver in which are incorporated voltage regulating devices. It is a simple matter, then, to keep the voltages across the filaments and heaters of the tubes at the proper value at all times.

If the receiver is operated with another power device in which there is no provision for voltage adjustments, the operator may obtain such regulation by placing a power resistor in series with his power transformer primary.

AUDIO AND POWER UNITS

THE "Vivetone 29" receiver proper does not incorporate an audio amplifier, since the writer does not believe that an audio amplifier should be built in the same cabinet with the r.f. portion if the size of the set is to be kept within attractive proportions. Keeping it separate from the tuning elements of the receiver not only gives the builder a choice of audio equipment, but also permits him to have more room for the disposition of his r.f. apparatus. Space in this part of the receiver is most important when one is interested in sensitivity and selectivity.

The writer has developed two power amplifier units that can be constructed for the "Vivetone 29." One of these uses a CX-310 tube in the last stage with a Thordarson 210 power pack. This unit will be described in a later issue. Each of these units incorporates a complete audio amplifier and A-Il-C-power supply. The home con-
OCTOBER, 1928
THE "VIVETONE 29" RECEIVER
367

Before drilling any new holes, mount 4 box shields on chassis, then mark pencil lines on chassis around inside walls of shields. Remove shields and use pencil lines to locate positions of new holes.

**VIEW OF END A**

- Indicates holes already in chassis.
- Indicates additional holes to be drilled. These should be 3/16 dia. unless otherwise specified.

**VIEW OF END B**

- Indicates holes already in chassis.
- Indicates additional holes to be drilled. These should be 3/16 dia. unless otherwise specified.

**BACK VIEW OF CHASSIS**

- Indicates holes already in chassis.
- Indicates additional holes to be drilled. These should be 3/16 dia. unless otherwise specified.

**FIG. 1. THE LAYOUT OF THE CHASSIS**

FIG. 2. THE SCHEMATIC DIAGRAM

It will be noted that the circuit diagram calls for grid suppressors of 400, 500, and 600 ohms for the three radio-frequency amplifiers. Decreasing the values of these resistances increases the amplification. For example, a good combination would be 300 ohms in the first stage, 400 in the second, and 500 ohms in the third. They may, however, be decreased to as low as 200, 300 and 500 for the three stages respectively. This, of course, is to be determined only by the one who is constructing the receiver, since some like to tune in stations without experiencing regeneration, while others like the "swish" of a slightly regenerative set as they go through a carrier signal.

**THE CABINET**

The writer's receiver is housed in a Corbett cabinet 7" x 26" x 16" deep. The cabinet had to be prepared for its reception by cutting out holes for the cable plug and the antenna and ground connections. To have the chassis of the receiver fit snugly in the cabinet it was necessary to remove a small portion of the wood at both the front and back corners. These cabinets, however, may be secured from the Corbett people with such alterations already made.

If the constructor is careful his efforts will be rewarded with a magnificent receiver. The set can be placed on a table or in one of the special cabinets which houses the power supply apparatus in the bottom.

A model of this receiver has been in operation at the writer's laboratory for several months and its performance has given considerable satisfaction. The laboratory is located not over a half mile from...
three New Jersey stations, WOR, WAAT, and WREO. In this location we are able to tune
webern and WBBR in Chicago, WOR, and sev-
eral other stations within a radius of 1000
miles. On several occasions, shortly after mid-
night, we have listened to programs broad-
cast by KFI and KHJ, Los Angeles, on a loud
speaker. The Chicago stations were often mis-
taken for local broadcasters.
All in all, the "Vivitone 29" is a receiver
which is not difficult to build or operate, and
which is sufficiently selective to cope with the
present broadcasting situation and, with su-
cient sensitivity to amplify weak signals up to
the point where they can be enjoyed.

LIST OF PARTS

As noted above, all the parts used in this
receiver are of standard design, and may be
replaced by equivalent parts of manufacturers
other than those mentioned below. The type
numbers of the parts listed below correspond
with the lettering on the diagrams.

1. Hammarlund variable condensers, 0.00015
mfd., type ML-00005
2. Dubbler condenser, 1.0 mfd., No. 907
3. Hammarlund illuminated drum dial
4. Centralab potentiometer, 2000 ohms, type PP-
   2000
5. Centralab potentiometer, 15 ohms, type PP-
   015
6. Centralab switch-type Radiohm, 200000
   ohms, type RS-200
7. Daven grid stabilizers, 400, 500 and 600 ohms,
   respectively
8. Dubbler Metalak, with mount, 4 megohms
9. Aluminum Junior box shields

FIG. 3. INSTRUMENTS AND WIRING ABOVE THE CHASSIS

With the rotor plates of the condensers fully meshed, the position of the variable arm of resistor PP-2000,
when viewed from the left end of the chassis in this diagram, should be two thirds of the way up towards the
vertical on the left hand side. The coded holes in the chassis correspond to the numbers in Fig. 4.

FIG. 4. THE UNDER SIDE OF THE CHASSIS

The potentiometer, PP-015, is insulated from the chassis, and its shaft should not touch the aluminum. Care
should also be taken in mounting the cable plug receptacle that its position is such that none of the pins will
touch the aluminum chassis.
The Bosch Model 28 Receiver

4. Volume Control.
   This control consists of a high resistance potentiometer, R, connected across the input to the first r.f. tube. In this position it functions to regulate the signal energy entering the r.f. amplifier and therefore prevents tube overloading.

5. Filament Circuits.
   The filament leads to the various tubes are twisted pairs of wires connecting between the transformer and the various tube sockets. The type 226 r.f. tube filaments are supplied with approximately 1.4 volts, the 227 type detector with about 2.4 volts, the first a.f. tube—a type 220—with 1.4 volts, and the power tubes with 5 volts. Resistances, Rs, Ra, and Rc, are connected across the various filament circuits for hum balance.

6. Plate Circuits.
   The plates of the r.f. tubes in this receiver are supplied with approximately 100 volts and the grids with 7 volts. The detector is supplied with the same voltage as the r.f. tube, but this voltage is reduced to about 50 by the resistance, Rf, in series with the plate circuit. The first a.f. tube has 100 volts on the plate and 7 volts on the grid. The power tube receives about 130 volts and the grid bias is about 35 volts. The filament circuits of the r.f. tubes are bypassed to ground by C1 and C2, each with a value of 0.5 mfd. The plate circuits are bypassed by the 1.0 mfd. condenser, C5. The 1.0 mfd. condenser, C6, also has a capacity of 1.0 mfd. Rs reduces the maximum voltage to 100.

   Grid bias for the various tubes are obtained by connecting resistors across the taps of the filament circuits and Gm.7, which corresponds to ground. Seven volts for the r.f. and first a.f. tubes is supplied by Rs and 35 volts approximately for the grid of the power tube is obtained from Rs. There is zero bias on the grid of the detector.

   The transformer, T1, in the power supply unit supplies low voltage to the filaments of all the tubes and the dial light and also high voltage to the rectifier system which uses a type 280 tube in a full-wave system. A single section filter is used consisting of C2, L, and C7. The maximum output voltage from the filter is supplied to the output stage. The primary of the power transformer is tapped to permit the operation of the receiver on line voltage from 100 to 130 volts.
The Splitdorf "Inherently Electric" Receiver

**TECHNICAL DISCUSSION**

1. **Tuning System.**
   The tuning system comprises four r.f. transformers and tuning condensers consisting of L1 and C1, L2 and C2, L3 and C3, and L4 and C4. A single-gang assembly contains all four tuning condensers, each section of which has a capacity of 0.0005 mfd. The antenna is connected to L1, L2, or L3 depending upon whether it is short, medium, or long. The small variable inductor forming part of L4 is in the circuit so that the effect of the antenna on the first tuned circuit may be compensated and this circuit brought into exact resonance at all wavelengths.

This receiver is not neutralized but is stabilized by grid resistors, R1, R2, and R3, each with a value of 600 ohms. This method of oscillation control is used in many receivers and is quite effective.

2. **Detector and Audio System.**
   The grid-leak-condenser type detector employed in this receiver is a combination grid condenser, C1, in conjunction with a 2-megohm grid leak, R8. The detector is a type 227 tube and its output is fed into a two-stage transformer-coupled audio amplifier. The grid of this second stage is bypassed by C3 with a capacity of 0.0001 mfd. The first stage audio transformer, T1, has connected across its secondary an adjustable condenser, C4, of 0.0015 mfd, probably to prevent ringing in the r.f. amplifier at high frequencies. The output of T1 supplies signal voltage to the grid of T2, a 225 type a.c. tube. The load speaker is isolated from the plate circuit of the power tube by a choke-condenser combination consisting of choke coil, X1, and condenser, C2; this condenser has a capacity of 1.0 mfd.

3. **Volume Control.**
   A 500,000-ohm variable resistance, R4, is connected across the input to the detector in this receiver and functions as the volume control. The input circuit of a grid leak and condenser type detector is generally quite low and as a result the tuned circuit preceding it has poor selectivity. It is therefore a good idea to place the volume control at this point, for at this point in the circuit it cannot affect the selectivity of the receiver to any marked degree. Since the control is ahead of the detector it is possible to regulate the volume to prevent overloading of the detector tube.

4. **Filament Circuits.**
   Filament current for the various tubes in the receiver is supplied by the power transformer, T3. Secondary winding S1 supplies 1.5 volts to the 226 type tubes, secondary S2 supplies 2.5 volts for the heater of the detector tube and secondary S3 supplies 3.0 volts for the power tube. S1 also supplies current for the dial light. All the filament circuit leads are twisted to prevent hum, and 30-ohm potentiometers, R4 and R5, are connected across the secondarries, S1 and S2, to make it possible to obtain a very accurate hum balance.

5. **Plate Circuits.**
   The output tube, V2, of the audio amplifier is supplied with the maximum voltage from the power supply unit—180 volts. All the r.f. tubes and the first a.f. tube receive 110 volts and the detector is supplied with 45 volts. The plate circuits of the r.f. tubes are bypassed in the set with condenser C6, whose capacity is 0.5 mfd. The detector plate supply bypass condenser is C7, located in the power unit. Its value is 1.0 mfd.

6. **Grid Circuits.**
   The output tube of the set has a bias on the grid of 40 volts, supplied by sections of the resistor, R4, in the power unit. The bypass across this resistor, C8, has a value of 1.0 mfd. Section D of the resistor supplies this bias for the first a.f. and all the r.f. tubes. This bias voltage is 7.0 volts and the bias resistor is bypassed by the 2.0-mfd. condenser, C9. The tone quality would be very poor, due to loss of the lower frequencies, if these bypass condensers were not included in the circuit across the C bias resistances.

7. **The Power Supply.**
   The A-B-C supply for this receiver consists of the power transformer, T1, the rectifier, V1, which is a type 250 tube, the filter system and the voltage divider resistor, R5. This resistor has a total value of 15,200 ohms divided as follows: section a, 2500 ohms; section b, 3500 ohms; section c, 4500 ohms; section d, 1900 ohms; section e, 650 ohms. The filter circuit consists of the filament choke coil, X2, and the two filter condensers, C7, with a value of 3.0 mfd., and C8, with a value of 0.6 mfd. The primary of the transformer is fused at P and the entire receiver is turned on and off by the switch, Sw.
Practical 5-Meter Hints

By ROBERT S. KRUSE

THIS short article contains some operating data which Mr. Kruse did not cover in his article on 5-meter transmission and reception in the September issue of Radio Broadcast. Several "freak" transmission effects on the 5-meter band are also explained.

—The Editor.

THE 5-METER WAWEMETER

In the preceding stories the very attractive possibilities of the 5-meter band have been discussed. There will be added here a few time-saving hints.

Very early it became evident that the average experimenter did not make a satisfactory job of building and calibrating a 5-meter wavemeter. At the writer's suggestion the General Radio Co. developed the very rugged little meter shown on this page, which remains the only one on the market, although the band-covering meter of the same firm also has a 5-meter coil. The meter here shown is most convenient when mounted on a short wooden or bakelite panel, although the hand-capacity effects are small because of a good C.L. proportion.

In the previous articles the plate and filament supply were not mentioned. It is best to use alternating filament supply, but one should not use the center-tap of a transformer secondary. It is far more satisfactory to use a double 1000-ohm resistor or a 200-ohm potentiometer. The latter has the advantage of permitting one to find exactly the right point. Either method permits one to use any toy transformer or even a bell-ringing transformer.

The plate supply may be raw d.c. as a starter, as was suggested, but had better be rectified. The filter should not have a condenser next to the rectifier tube. First should come a choke of 1-5 henrys inductance, then a 2.0-mf. condenser, then a choke of 10-100 henrys and finally another condenser, as large as convenient, shunted by a resistance of 25,000-100,000 ohms. The reasons for this type of filter are good but too lengthy to mention here.

Although the UX-832 tube is excellent for the 5-meter band, no proper rectifier for it is available. One is compelled to use electrolytic rectification, or else a too-large kienoton, mercury arc or d.c. generator. A new gas tube may be available soon.

When the set is taken into the field one must of course have some sort of automatic key at the station to keep making signals. A suitable one is shown herewith. It consists of the motor of a 10" electric fan, a standard Boston Gear Works worm gear and a cam in the edge of which are milled code letters as desired. A bake-lite cam worked out with a file is just as good. The edge of the cam bears on a brass strip screwed under the knob of an ordinary telegraph key which controls the transmitter. Parenthetically, it is best to key the set by the method shown in Fig. 2—for reasons good but lengthy.

Having the key going one gets into the field with the receiver and is then uncertain whether things are proceeding well. The appearance of the following effects is normal and reassuring.

AUTOMOTIVE EFFECTS

Before one is long afield the automobile injects itself into the picture. Its ignition noises are rather troublesome, although this is lessening as the Model T Fords and their spark coils diminish in number. After a little practice one can distinguish the type of motor and its condition to a considerable degree by listening with a 5-meter receiver as a car passes. Cars with monthly service programs have usually the best average performance as regards the steadiness of their 5-meter signals.

If one is near the road another effect will be observed: each passing car detunes the received signal a trifle. This statement is made general, though we must admit lack of evidence against the Rolls Royce, which did not come along that road. It was possible to tune the station out, and then bring it back by interposing a suitable automobile. "Suitable" means any type of about the right size and body structure; a Buick and a Nash are interchangeable for the purpose, whereas a Franklin and a Stutz are not! The gist of the difference lies in the difference between the wood-and-aluminum body of the "Benjamin" as compared with the fabric-covered Stutz body, and the only possible value of the stunt is to suggest the importance of small absorption effects at 5 meters.

"WEST'S PEAKS"

To C. H. West of 2CSM we are indebted for his calling attention to the curious effect shown in Figure 1. He observed that in driving along a road there appeared to be "humps" in the signals at 12-foot intervals when one was some 3 or ½ mile from the station. Subsequent observations produced the same effect at various stations, the spacing between peaks remaining reasonably constant, though sometimes the peaks are entirely absent at a particular station. The same thing has since been observed at 2-meter wavelength with all the dimensions of the picture about one-seventh as large. It looks like an interference pattern, but in most cases appears to be stationary and of much the same proportions regardless of the things alongside the road at that place.
New Apparatus

PRODUCTS of radio manufacturers whether new or old are always interesting to our readers. These pages, a feature of Radio Broadcast, explain and illustrate products which have been selected for publication because of their special interest to our readers. This information is prepared by the Technical Staff and is in a form which we believe will be most useful. We have, wherever possible, suggested special uses for the device mentioned. It is of course not possible to include all the information about each device which is available. Each description bears a serial number and if you desire additional information direct from the manufacturer concerned, please address a letter to the Service Department, RADI0 Broadcast, Garden City, New York, referring to the serial numbers of the devices which interest you, and we shall see that your request is promptly handled—The Editor.

Shielded Wire Prevents Stray Coupling

X60 Device: SHIELDED HOOK-UP WIRE. This hook-up wire is a rubber-covered No. 18 with an additional braided of metal over the rubber insulation. When this metal braid is grounded it forms an effective shield around the wire. The metal braid is sufficiently flexible so that the wire may be readily bent into any desired form. It has all the conveniences of a regular hook-up wire with the additional advantage that it is shielded. It is available in rolls of 100 feet. Manufacturer: Belden Manufacturing Company. Price: $3.50 per 100' roll. Application: In constructing high gain r.f. amplifiers, especially those using type 222 screen-grid tubes, it is absolutely essential that no coupling of any sort exist between the input and output circuits of the tube. Frequently it is possible that the comparatively short leads connecting one tube to the next will give rise to sufficient capacitance coupling to some other part of the circuit to cause the amplifier to oscillate. Coupling of this type can be eliminated by the use of shielded wire. The circuit diagram in Fig. 2 indicates at what point in the circuit of a stage of r. f. amplification it might be wise to use shielded conductor.

For Smoother Volume Control

X61 Device: VARIABLE HIGH RESISTANCES. For volume control. Many of us when operating a volume control have noticed that frequently the volume does not vary uniformly as the control is turned. Turning the control a given distance at a certain point will produce a given change in volume and then turning it twice as far will produce a very much greater change in volume. It would be desirable to make use of a volume control resistor of a characteristic such that the changes in volume were more nearly proportional to the movement of the control.

Resistances of this type have been designed to give uniform variation of volume and can be obtained in sizes ranging from 2000 to 10,000 ohms. The curves of such resistances are given in Fig. 1. The solid curves indicate that of an ordinary resistance in which the variation in the resistance is directly proportional to the dial setting. The dot-dash curve is that of the new type resistance. It will be seen that the resistance does not vary directly with the dial setting but varies slowly at first and then more rapidly, which results in smoother volume control.

The catalog numbers and prices of these new type resistances are given below.

<table>
<thead>
<tr>
<th>No.</th>
<th>Volume (ohms)</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1806</td>
<td>2000 ohms</td>
<td>$2.25</td>
</tr>
<tr>
<td>1807</td>
<td>5000 ohms</td>
<td>2.25</td>
</tr>
<tr>
<td>1808</td>
<td>10,000 ohms</td>
<td>2.25</td>
</tr>
</tbody>
</table>

Manufacturer: Herbert H. Frost, Inc. Application: As indicated above these units are designed for use as volume controls in radio receivers, and because of their special characteristics have certain advantages over other types of resistances. All of these resistors are made with three terminals, like a potentiometer, and can be used as a potentiometer type of control or, if desired, by connecting to the center terminal and one of the outside terminals, the unit can be used as a two terminal resistor. The direction of rotation of the knob to decrease or increase the resistance will depend upon which outside terminal is connected.

A Safeguard for A. C. Tubes

X62 Device: CENTRALAB RADIO CONTROL BOX. This is a device designed for use in conjunction with light socket operated receivers. It consists of a small metal box in which is placed a variable resistance. The power lead on the box is plugged into the light socket and then the power lead from the receiver is plugged into the receptacle on the box. This places the variable resistance in series with the line. If the line voltage is excessive, i.e., greater than that on which the set is designed to operate, the control on the box can be adjusted so that part or all of the resistance is in series with the line and the excess voltage will then be absorbed.

Manufacturer: Central Radio Laboratories. Price: $3.50.

Application: Excessive line voltages have evidently caused considerable trouble with a.c. operated receivers. If a.c. tubes, or any tubes for that matter, are subjected to excessive filament voltage, their life is materially shortened. Excessive line voltage supplies excessive filament voltages to tubes in a set, and it is suggested that some device be used to permit compensation for line voltages greater than about 110, the voltage on which most receivers are designed to operate. A device of this sort, of course, requires internal control if the line voltage varies during the day and night. Also there is no means of determining when the voltage applied to the set is 110. Probably the best method of operation, therefore, is to gradually increase the resistance (which reduces the voltage applied to the receiver) until an effect on reception is noted and then to decrease slightly the resistance.

Devices can be obtained which will automatically regulate the line voltage so that the receiver is always supplied with exactly 110 volts. Such devices are expensive, costing perhaps five times as much as this device. For a simple unit that will permit longer life from a.c. tubes the power control box is to be recommended.

A Complete Push-Pull Amplifier

X63 Device: PUSH-PULL AMPLIFIER, MODEL P-P-2. A complete single-stage push-pull amplifier designed for the use of two 171 type tubes. This device does not contain any power supply, but must be operated in conjunction with batteries of A and B power units. Manufacturer by HAROLD POWER, INC. Price: $38.00, with tubes. Application: This amplifier is designed for use in conjunction with a radio receiver in those cases where more power output desired than can be obtained without distortion from the power tube incorporated in the receiver. This amplifier can deliver at least 1400 milliwatts of power without overload—about ten times as much as can be obtained, for example, from a 12AX7 type tube.

A Plug Which Can't Be Broken

X64 Device: SOFT RUBBER PLUG. Ruggedly constructed of solid soft rubber. Shaped to form a convenient grip for the fingers when pushing it in or pulling it out of a socket. Only sold attached to Belden cords which come in 10-, 30-, and 50-foot lengths. Manufacturer by the BELDEN MANUFACTURING COMPANY. Price: $2.75. Application: This plug can be thrown around, dropped, or stepped on without fear of breaking it. Judging from the number of ordinary hard rubber plugs that have been broken in RAPPO Broadcast Laboratory we venture a guess that we ought to have about 100 of these.

A 30-Henry choke for Filter Circuits

X65 Device: SAMSON FILTER CHoke-Coil, Type 312. A choke coil designed for use in the filter circuits
of h-power units. It is capable of carrying direct currents up to and somewhat in excess of 120 milliamperes. At 120 ma, its inductance is 30 henrys. The d.c. resistance of the choke is approximately 290 ohms. Manufacturer: Samson Electric Manufacturing Company. Price: $12.00. Application: The choke coil is applicable to various filter circuits in which it is necessary that the circuit handle currents of about 120 ma, if the value of current does not reach values higher than about 80 ma, then the Samson choke type 380 ($11.00) may be used; for currents not in excess of 30 ma, the type 30 ($5.00) is satisfactory.

The low-resistance characteristic of these choke coils makes them very satisfactory for use in filter systems, for with low-resistance circuits the voltage regulation of the power unit will be better than with high-resistance circuits; the resistance of the filter choke coils should be low enough so as not to have any great effect on the regulation of the system. These requirements are fulfilled very satisfactorily by Samson chokes.

Radio-Frequency Choke Coils

X66 Device: Radio-Frequency Choke Coils. Two types are available.

Code No. RFC-85, with an inductance of 85 millihenrys, a distributed capacity of 3 mfd's, and a resistance of 215 ohms. Price: $2.00. Code No. RFC-250, with an inductance of 250 millihenrys, a distributed capacity of 2 mfd's, and a resistance of 420 ohms. Price: $2.25. Manufacturer: Hammarlund Manufacturing Company. Application: These r.f. chokes are for use in the r.f. B-plus leads and in the detector plate lead to keep the r.f. currents out of the plate supply unit and out of the audio amplifier. Although two types are available it is likely that in broadcast receivers the cheaper 85-millihenry choke may be satisfactory in all cases. The impedance of these coils at broadcast frequencies will be determined by the distributed capacity of the coil. At 1500 kc, the impedance of the 85-millihenry coil will be about 31,000 ohms and the impedance of the 250 millihenry coil about 45,000 ohms. The 85-millihenry coil, however, will give at broadcast frequencies a sufficiently high impedance so that satisfactory filtering action can be obtained. It is interesting that the coil with the higher inductance has less distributed capacity than the smaller coil.

R. f. choke coils of this type can also be used in constructing an intermediate-frequency amplifier for a super-hetereodyne. An example of such a use can be seen by referring to the article by L. T. Goldsmith in the May, 1928, issue describing the construction of a super-heterodyne.

A Neon Lamp for Television

X67 Device: KING LAMP. A neon tube designed for use in television receiving apparatus. The tube measures 65 inch high and about 3 inch in diameter and is fitted with a vacuum type base so that it can be plugged into a standard tube socket. The a. c. resistance of the tube is about 1200 ohms and the current through the tube should not exceed about 20 milliamperes d. c. This corresponds roughly to about 200 volts across the tube. The three circuit diagrams in Fig. 4 show circuits in which the tube may be used in television receivers. All three circuits are quite satisfactory, circuit A probably being the simplest in construction and operation. Manufacturer: Raytheon Manufacturing Company. Price: $12.50. Application: The principal use for this tube is in the output circuits of television receivers, although it may be used in any place where a gas discharge tube is required. Probably other applications for it will suggest themselves to our readers. Since the plate of the tube is about 15 square inch the printed circuit picture will be of the same size. A word of caution—never overload the tube. Don't put it across a d. c. source of voltage without a current limiting resistance series with it. Keep the current as low as possible, for the lower the current used, the longer the life of the tube will be.

An A. C. Screen-Grid Tube

X68 Device: A. C. Screen-Grid Tube. Type A. C. 22. The tube is of the same general construction as the screen-grid tubes with the exception that the electron emitting member has a heater similar to that used in type 227 tubes. The heater requires 2.5 volts to operate it. This tube may therefore be connected in parallel with 227 type tubes, since they also require 2.5 volts. The a. c. 22 tube fits into a standard 5-prong socket. Manufacturer: CeCo Manufacturing Company. Price, $8.00. Application: This tube is for use in the construction of a.c. operated receivers requiring the use of a screen-grid tube. The connections of a single r. f. stage using this tube are given in Fig. 3.

Filter and Bypass Condensers

X66 Device: ACME PARVOLT Condensers. These condensers are available in all standard capacities and voltage ratings. Both bypass condensers designed for comparatively low voltage and filter condensers designed for 200, 400, 600, 800, 1000, and 1500 volts can be ob-
Radio Helps in the Coast Survey

By D. L. PARKHURST
Chief, Instrument Division, U. S. Coast and Geodetic Survey

THE method of acoustic range-finding described by Mr. Parkhurst seems to have several advantages over the radio beacon system, when used for short distances over uniform masses of fairly deep water. The actual distance of the ship from shore stations is measured by the time taken for sound waves to pass through the water from ship to shore, whereas in the beacon system only the bearings of shore stations may be determined. Furthermore, the acoustic system is entirely automatic, the time of the signals being mechanically recorded on the chronograph tape aboard the ship. With the beacon system there is always a possible error due to the operator. On the other hand, the acoustic method has proved itself useful only over short distances (200 miles at the most), and through water that is uniform in temperature and not broken up by shoals. These advantages indicate that it might have great usefulness as a guide to ships at the entrances of harbors.

—The Editor.

THE use of radio for direction and range-finding has made great strides in the past few years, especially in the development of directive beacons for sea and air navigation. The U. S. Coast and Geodetic Survey has recently developed another interesting method of range-finding, which makes use of both sound and radio waves. In making depth measurements off the coast it is frequently necessary for the Survey ships to be out of sight of land, so that ordinary triangulation methods of accurately locating the position of the ship cannot be used. In such cases the position of the ship is determined by a method known as acoustic range-finding, in which the distance of the ship from shore is measured by the velocity of sound waves through water, the recording being effected by means of radio.

When the surveying ship has made a depth measurement, or sounding, a bomb containing a pound or so of high explosive, such as TNT, is dropped overboard and exploded twenty or more feet beneath the surface. The sound produced is picked up by a submerged microphone, or hydrophone, located on the ship, and the impulse transmitted through a three-stage radio amplifier to the pen-actuating magnet of a chronograph, making a mark on a paper recording strip. The sound of the explosion also travels through the water in all directions, and is picked up by hydrophones anchored in approximately fifty feet of water at two or three known points on the shore. Insulated cable connects these hydrophones to a three-stage amplifier at each shore station. The amplified signal actuates a relay which sends a flash from a simple 140-meter low-power radio transmitter. The radio signal is picked up by a tuned receiver on board the ship, and amplified, and this current also actuates the chronograph pen before-mentioned.

The paper strip, or tape, has been moving at a uniform rate during the time between the bomb explosion and the reception of the radio flash, and consequently the space between the two pen marks is an index of the elapsed time.

Accurate measurements have determined that the velocity of sound through sea water is approximately 4920 feet per second, varying somewhat with the water temperature. For example, if the elapsed time is 60 seconds, the ship is consequently 205,200 feet, or 55 to 61 miles, from the shore station.

The information is not complete if only one shore station is in operation, as the ship may be anywhere on a circle whose radius equals the time multiplied by the velocity of sound in water; consequently, two or more stations are used and the crossing point of the arcs for each station in-
Radio Helps in the Coast Survey

October, 1928

Radio helps in the Coast Survey.

The transmission of the apparatus is as follows: The bomb, a tin can or cast-iron container, is filled with loose TNT, and just before firing a No. 8 blasting cap, with a length of cord, powder train blasting fuse crimped to it, is inserted, the joint being sealed with wax or other plastic. The fuse is anchored so that the can will not pull out. A moment later, after the sounding has been completed, the fuse is lighted and the bomb thrown overboard. When the explosion occurs, the sound excites the carbon grain button in the ship's hydrophone, which is located in a small tank of water attached to the outside of the shell vessel. The ensuing current is amplified in a three-stage amplifier, using two 2012A and one 171 tubes and 6 to 1 transformers. The amplified current passes through the coil of the exciting magnet on a chronograph. The chronograph, shown in Fig. 2, is of a commercial type, having two pens, and is driven by a 6-volt, storage battery shunt motor. Such a motor will run at practically constant speed, as the load is very light. In fact, it is only necessary that the speed be constant during the first and last seconds.

The timing device consists of a high grade marine chronometer fitted with a circuit breaking device which operates each second, causing the second chronograph pen to make a mark on the record strip, which is standard 1-inch stock ticker tape. Fig. 2 shows at the bottom the type of record made on this tape.

After the record of the explosion has been made by means of the ship's hydrophone, the tape continues to pass through the chronograph, each second being marked upon it by the chronometer. The sound from the bomb travels through the water to the hydrophones of the shore station. These are sometimes anchored as much as two miles offshore, depending upon the character of the sea bottom, as it has been found that the system does not operate so well unless the hydrophones are at least 50 feet below the surface. Submarine cable, armored where wave action may cause chafing, connects the hydrophones to the shore station apparatus.

The energy from the hydrophones is amplified in a three-stage amplifier, which is very similar to that used aboard ship, and the current acts as a 800-ohm relay which completes a circuit through a 140-meter transmitter, sending out a radio flash. At the same time this relay sets an automatic telegraph key in operation which sends out three additional, equally timed flashes from the transmitter. No two keys have the same timing, so that each station may be identified by its characteristic markings on the chronograph tape. The automatic keys, one of which shown in Fig. 1, are made up with an ordinary musician's metronome as a time element, having the spring removed and weight driven away from it. A standard pony relay is mounted directly beneath it with a finger attached to its armature which engages with a similar finger on the pendulum of the metronome when it is in the off position. The impulse from the bomb pulls the armature over, releasing the metronome mechanism, and a suitable system of contacts acting on a notched wheel attached to the time shaft opens and closes circuits in such a manner that the armature is held over during one complete revolution of the time shaft and at the same time sends out three flashes through the radio transmitter. When one revolution has been made the armature is released and the metronome stops.

The transmitter is a single UX-210 tube instrument designed to transmit at 140 meters. It is sufficiently powerful to transmit through approximately two hundred miles.

The initial and the three identifying flashes from the shore transmitter are picked up on the ship by a standard make of short-wave radio receiver. This receiver contains a detector tube and two stages of audio amplification, and additional amplification is secured by connecting this receiver to the three-stage amplifier previously described. The panel of this amplifier is fitted with a double throw switch, by means of which either the hydrophone or the radio receiver may be connected to it. As soon as the explosion has occurred and has been recorded, the switch is thrown over, disconnecting the hydrophone and connecting the radio receiver ready for the impulse from the shore station to be recorded. The amplified radio signal actuates the second chronograph pen previously referred to, making a mark upon the tape.

The tape now contains a line punctuated at one side with the one second marks recorded by the chronometer. The other side of this line is punctuated with the impulse from the hydrophone and also those from the several shore stations with their characteristic identification marks. The time elapsed between the bomb explosion and the radio reception may be readily determined by counting the number of second marks and by measuring the fractions at each end. Multiplying this figure by the velocity of sound through water gives the distances from the ship to the several shore stations. As the geographic positions of these stations are already known, arcs of the proper radii are struck from each and their intersections indicate the ship's position. Ample accurate results for the type of work have been obtained by this means.

This system possesses certain difficulties of operation in some localities. Experience has shown that the apparatus works better where the bottom falls rapidly away from the shore and where the water is cold and of fairly even temperature. Shoals also seem to present difficulties in the transmission of sound through water. The exact influence of each of these factors has not been fully determined, but active investigation is being carried on. On the Atlantic Coast of the United States, where the continental shelf extends for a good many miles offshore, and also where the water is comparatively warm, considerable difficulty has been experienced in getting the apparatus to work satisfactorily over any great distance. On the other hand, on the West coast, where these conditions do not obtain, excellent results have been achieved over a distance of about two hundred miles.

The system has such attractive possibilities for the location of positions at sea rapidly and economically, that development work will be rapidly carried on in an effort to perfect its use under all conditions.

The bomb exploded under water by the ship produces sound waves that are picked up by the hydrophones of the two shore stations, causing the two shore stations to transmit radio signals. These are picked up by the ship, and the elapsed time between explosion and signals gives the data for the calculation of the distance of the ship from the two shore stations. Thus its position can be located.
Radio Broadcaster Laboratory Information Sheets (Nos. 1-190) in BOUND VOLUMES

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THORDARSON R-300 AUDIO TRANSFORMER

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The amplification curve of this transformer is practically a straight line from 30 cycles to 8,000 cycles. A high frequency cut-off is provided at 8,000 cycles to confine the amplification to useful frequencies only, and to eliminate undesirable scratch that may reach the audio transformer.

When you hear the R-300 you will appreciate the popularity of Thordarson transformers among the leading receiving set manufacturers. The R-300 retails for $8.00.
The Radio Broadcast
LABORATORY INFORMATION SHEETS

THE aim of the Radio Broadcast Laboratory Information Sheets is to present, in a convenient form, concise and accurate information in the field of radio and closely allied sciences. It is not the purpose of the Sheets to include only new information, but to present practical data, whether new or old, that may be of value to the experimenter, set builder or service man. In order to make the Sheets easier to refer to, they are arranged so that they may be cut from the magazine and preserved, either in a blank book or on 4" x 6" filing cards. The cards should be arranged in numerical order.

Since they began, in June, 1926, the popularity of the Information Sheets has increased so greatly that it has been decided to reprint the first one hundred and ninety of them (June, 1926-May, 1928) in a single substantially bound volume. This volume, "Radio Broadcast's Data Sheets" may now be bought on the newsstands, or from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Inside each volume is a credit coupon which is worth $1.00 toward the subscription price of this magazine. In other words, a year's subscription to Radio Broadcast, accompanied by this $1.00 credit coupon, gives you Radio Broadcast for one year for $3.00, instead of the usual subscription price of $4.00.

—The EDITOR.

No. 225
Calculating Grid Bias for A.C. Tubes

CORRECT RESISTANCE VALUES

In all A.C. receivers, grid bias for the various tubes is obtained by connecting resistances of the correct value at the correct point in the circuit. The calculation of the value of the resistance and its placement in the circuit has been the subject of quite a few letters written to the Technical Information Service, and we therefore devoted this Laboratory Sheet to the subject. The circuit diagrams of six combinations are given on Laboratory Sheet No. 220.

If these diagrams are examined one important point will be noted, which is that the resistance, R, which supplies C bias to the tube, is always connected between the center of the filament, or the cathode in the case of heater type tubes, and negative B. The resistance is placed in this position in relation to the circuit no matter what tube or combination of tubes is used. With the resistance in this position the plate current of the tube must go through it in order to reach the filament, or cathode, and therefore the voltage drop across the resistance is equal to the plate current times the resistance in ohms. To calculate the value of resistance, we must therefore know the value of grid bias that we desire to obtain and also the plate current flowing through the resistance. For example, in diagram A we have indicated a 220 type tube. By reference to any table of tube characteristics we can determine that the 220 type tube with 90 volts on the plate requires a grid bias of 0 volts and the plate current is 3.5 milliamperes. It is found by dividing the grid voltage required, 6, by the plate current in amperes, 0.0035, which gives a value of 1700 ohms as the required value of resistance.

In diagram C, a 171 tube is used. Forty volts of grid bias are required if the plate voltage is 180 volts. The plate current under such conditions is 20 milliamperes, and 60 divided by 0.02 amperes gives 3000 ohms as the value of the resistance required for C bias.

If a circuit utilizes more than one tube of the same type for which we require the same value of grid bias, the circuit is arranged as indicated at E, in which case the plate current of both of the tubes flows through resistance R. If the plate voltage on the 227 type tube is 90, the plate current is 3.7 milliamperes and the required grid bias is 6 volts. The grid bias resistance is then equal to 6 divided by 3.7 (the total current of the two tubes) which gives 800 ohms as the correct value for R.

No. 226
Grid Bias Circuits for A.C. Tubes

RADIO BROADCAST Laboratory Information Sheet

October, 1928
4 NEW HI-Q RECEIVERS
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AGAIN Har-mer-lund-Roberts open-thor-di-o ses-sion with advance-ments in con-struction and per-formance that will be marveled at throughout the entire radio world.

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Use of Milliammeter in the Plate Circuit

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Weston Electrical Instrument Corporation
604 Frelinghuysen Ave.,
Newark, N. J.

No. 227
The Audio Transformer

THE EFFECT OF ITS INDUCTANCE

The diagram on this sheet indicates at A a single stage of audio-frequency amplification. B is the cathode circuit, in which R1 is the signal voltage in the plate circuit, Ia is the leakage resistance of the transformer, L is the inductance, and C is the distributed capacity of the secondary and the tube input capacity, transferred to the primary, R2 is the plate resistance of the tube. Let us study this circuit to see what happens at various frequencies. The treatment given below is not exact but is approximately correct.

The low frequencies of C in comparison with L is very large and the reactance of L is very large in comparison with that of L. Therefore at low frequencies the voltage in the plate circuit divides between L and R2. The voltages across these two parts of the circuit are 90 degrees out of phase and the percentage of the total voltage that appears across L depends upon the ratio of the reactance of L to the resistance of R2, and varies as indicated in the second column in the table, column 1 being the ratio of the reactance of L to the resistance, R2.

Now suppose that we desire to work the transformer out of a 201 A-type tube with an R2 of about 11,000 ohms and that at 60 cycles we wish to utilize at least 70 per cent. of the total voltage. Then, from the table we shall have to make X/L of the coil L at 60 cycles, equal to the resistance of the tube. Therefore:

X/L = 11,000
L = 50,000
6.28 x 60 x L = 11,000
L = 300 ohms

We might look at the problem in another way. Suppose we desire a transformer with a voltage drop at 60 cycles of not more than 1 TU. When a circuit is 1 TU down in voltage, the actual voltage loss is about 1 per cent., leaving 99 per cent. This corresponds to a ratio of X/L over R2 of 2. Therefore, from the table the reactance of L at 60 cycles must be twice the reactance of the tube or 2,200 ohms.

No. 228
The Dynamic Loud Speakers

THE FIELD MAGNET

The dynamic-type loud speaker depends for its operation on the production of a very strong magnetic field in the air-gap in which the moving coil is placed. This air-gap is indicated in the sketch on this sheet. The useful magnetic flux is indicated by the light solid lines flowing directly across the gap, and the leakage flux—fluctuating part of the magnetic field which serves no useful purpose—is indicated by the dot-dash lines.

The flux which any given amount of magnetic material, such as iron or steel, can handle efficiently is definitely limited by saturation. When the iron is saturated its reluctance—resistance—is the technical term—to the flow of magnetic lines through it increases and then the leakage flux increases. The flux the iron will tend to take that path which has the lowest reluctance. To prevent leakage the pole pieces are frequently shaped in some peculiar manner, such as indicated at B, in order that the actual air-gap will be a very much lower voltage drop, or flux, than any other path. The leakage flux in sketch A does not have to travel a path much longer than the actual air-gap, i.e., the two paths have about the same reluctance. In the pole shape indicated at B, the flux path outside the air-gap is much longer than the other path through the air-gap. The latter arrangement therefore tends to reduce the leakage flux.

Assuming that the iron does not saturate, the flux in the air-gap will increase very rapidly as the size of the gap is decreased. However, in practice the gap is always made as small as possible, leaving just sufficient room for the coil to move without any danger of its striking the pole pieces.

No. 229
The Telephone Transmission Unit

The table shows that the maximum output voltage for 900 ohms at the sending end of the telephone line is 30 millivolts. However, this drop in voltage is unimportant in the telephone line, as the telephone is used as a sensitive voltmeter, and 30 millivolts is more than adequate for this purpose. The output voltage is therefore determined by the characteristics of the telephone instrument used. It will be noted from the table that the output voltage is about equal to the sending voltage. In other words, the telephone instrument does not appreciably affect the sending voltage. The telephone industry, therefore, has always used a telephone instrument with a resistance equal to the characteristic resistance of the line, i.e., 900 ohms. It will also be noted from the table that the sending voltage of 30 millivolts is not the same as the output voltage of 30 millivolts, as the telephone instrument has an output of 20 millivolts, and the sending voltage of 30 millivolts is the sum of the output voltage of 20 millivolts and the loss of 900 millivolts in the telephone line.
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Ideal with one or more Frost-Radio units except in size. The length is reduced in Bakelite case measuring 1 1/2 x 1 1/2 x 1/2 in. Price $1.52 and $1.99.

Frost-Radio Bakelite High Resistances

Mighty good little rheostats. Built to give long service and stand the rough. Take up little room, are single hole mounting and are easy to mount in any position and operate with Bakelite switch. Price includes both rheostat and switch. Price $1.25 with switch, $1.99.

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Like our blocking condensers, frost filter condensers are a quality product, made of the highest grade of paper and least grade foil, conservatively rated. Will give long service. 3 to 3 mfd. $1.45 to $7.00.

Frost-Radio High Pass Condensers


Frost-Radio High Pass Condensers

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Do You Read the TECHNICAL JOURNAL of the RADIO INDUSTRY

No. 230
Radio Broadcast Laboratory Information Sheet

October, 1928

Filters

How the Various Types Differ

In Telephone and radio circuits various types of filters are used and in this Laboratory Section it is important to understand the differences.

First let us define a filter. We might say that a filter is an apparatus that will separate different wave lengths of direct current or alternating current and pass one or a group of frequencies from alternating currents of a different frequency or group of frequencies.

Filters can be divided into three general classes:

(A) Low pass filters: (B) High pass filters: (C) Band pass filters.

Low pass filters are designed to pass all frequencies below a certain cut-off frequency and to oppose the passage of frequencies above the cut-off frequency. The characteristic curve of an ideal low pass filter is shown in sketch A. The r.f. choke coil used in the plate circuit of a tube, or the audio frequencies as a low pass filter, since it permits audio frequencies to pass into the radio amplifier but excludes from the amplifier the high carrier frequencies.

High pass filters are those that pass the frequencies above a certain cut-off frequency and oppose the passage of frequencies below the cut-off frequency. The characteristic curve of a high pass filter is shown in sketch B. It is given for a frequency of 50 cycles, assuming that this is the lowest frequency which we desire to amplify uniformly. It is apparent that the tube has a plate impedance of 20,000 ohms and a reactance of 30, and that the grid resistance, R, of such as values as that do not affect the amplification. If 100 per cent amplification were obtained, the gain would be 20, and with an infinite high impedance this gain might be realized at low frequencies. With practical values of impedance, however, the gain is less than this and varies with the impedance as indicated by this curve.

The value of the coupling inductance should be the smallest value that will give satisfactory gain at the lowest frequency to be amplified, which we have assumed in this case to be 60 cycles. At medium frequencies the amplification obtained from a circuit of this sort is approximately equal to the amplification constant of the tube and we might assume as a reasonable one that this constant at 60 cycles shall be not less than 75 per cent. The amplification obtained with medium values of inductance, frequencies 75 per cent. of 20, is 15, the value therefore of the gain at 60 cycles. This corresponds to an inductance of 100 hensi.

If a value of inductance much greater than this is used to obtain more amplification at low frequencies, it will be found that the high frequencies begin to fall off due to the shunting effect of the coupling coil coupling coil capacitors. Amplifier curves with various values of coupling coil impedance will be given and explained in a future Laboratory Section.

No. 231
Radio Broadcast Laboratory Information Sheet

October, 1928

Impedance-Coupled Amplifiers

The Effect of the Size of the Inductance

In connection with impedance-coupled audio amplifiers, the statement is frequently made that the coupling inductances should have as large an inductance as possible, creating the idea impression thereby that the larger the inductance the better the results. Such is not the case. First, let us examine the effect of the inductance at low frequencies.

The curve on this sheet indicates how the amplification from a stage of impedance-coupled audio varies with the inductance in henries of the coupling coil. I.e., the curve is calculated for a frequency of 60 cycles, assuming that this is the lowest frequency which we desire to amplify uniformly. It is apparent that the tube has a plate impedance of 20,000 ohms and a reactance of 30, and that the grid resistance, R, of such as values as that do not affect the amplification. If 100 per cent amplification were obtained, the gain would be 20, and with an infinite high impedance this gain might be realized at low frequencies. With practical values of impedance, however, the gain is less than this and varies with the impedance as indicated by this curve.

The value of the coupling inductance should be the smallest value that will give satisfactory gain at the lowest frequency to be amplified, which we have assumed in this case to be 60 cycles. At medium frequencies the amplification obtained from a circuit of this sort is approximately equal to the amplification constant of the tube and we might assume as a reasonable one that this constant at 60 cycles shall be not less than 75 per cent. The amplification obtained with medium values of inductance, frequencies 75 per cent. of 20, is 15, the value therefore of the gain at 60 cycles. This corresponds to an inductance of 100 hensi.

If a value of inductance much greater than this is used to obtain more amplification at low frequencies, it will be found that the high frequencies begin to fall off due to the shunting effect of the coupling coil coupling coil capacitors. Amplifier curves with various values of coupling coil impedance will be given and explained in a future Laboratory Section.

No. 232
Radio Broadcast Laboratory Information Sheet

October, 1928

The Voltmeter

How it Works

In preceding Laboratory Sheets, Nos. 205, 211 and 222 we explained the construction of the galvanometer and the ammeter and indicated how they differed. The voltmeter is quite similar to these two instrument units except that it is more sensitive and more reliable. Its purpose is to indicate the source of potential.

To measure the voltage of some source of potential, we might take a very low reading ammeter, one having a maximum reading of perhaps 0.01 amperes, place it in series with a known high resistance and to zero it we connected it across the source of potential. The ammeter would read the current that flowed and then by Ohm's law, it states that the voltage is equal to the current times the resistance, we could calculate the voltage of the source.

In a voltmeter this high resistance is permanently connected inside of the instrument and the scale is calibrated to read volts instead of amperes. In other words we might say that the instrument solves Ohm's law for us and makes it unnecessary to calculate the IR drop every time we wish to measure a voltage.

Ammeters and voltmeters may in general be distinguished in one or two respects. Vometers may be read at any time when they are not connected to any circuit, whereas ammeters are always connected to the circuit in which the current is flowing. Vometers are generally of a lower sensitivity than ammeters, however, and if the volt meter terminals are accidentally short-circuited then the source of potential is shortcircuited. A short-circuit may be a serious thing when measuring a battery, but may cause damage if it occurs when measuring the voltage at a light socket or when measuring the output voltage of a large generator.
PEP UP YOUR SET!

Replace your Balkite Acid Jar with the Authorized Solid, Dry ELKON Replacement Unit. Get away from Acids, Water, Corrosion, Trouble.

BUY ELKON — The Authorized Replacement Unit

Throw away the acid jar! No more fuse, no mess, no trouble. Simply replace the acid jar and snap into the Elkon Replacement Unit - solid, dry, self-healing — no attention or adjustments, and for 5000 hours.

The only ones authorized for replacing the acid jars in Balkite Power Units.

With the Elkon Self-Healing Replacement Rectifiers, your type K will charge at the rate of 3 amperes. The charging rate of type J, the largest charge, is raised 20%. Increased efficiency, too! Why not see your dealer today?

ELKON, INC.
Port Chester, N.Y.
Division of P. R. Mallory & Co., Inc.

Perhaps you need a New Elkon Rectifier

If your set hasn't the same pep and kick it did when you first installed your "A" Eliminator, you need a new Rectifier in the "A" Eliminator. And you are lucky if you have a Majestic, Elkon, Arkay, Fada, Sentinel, Webster, Metro and many others for then you can slip the old rectifier off and put in a new Elkon Replacement Rectifier in less time than it takes to read this. And the old eliminator is as good as it ever was! Buy one today from your dealer.

If your trickle charger isn't keeping the battery up as well as it did when you bought it — buy a set of Elkon replacement rectifiers and it will be as good as it ever was. Elkon Type V-1 replacement units can be placed in Aeslim, Elkon, National, Cleveland, Precision, Bernard. Today's a mighty good time to pep up the trickle charger — see your dealer.
The Nerve Center of Your Radio

Because Cunningham Radio Tubes carry the true tone and reproduce pure harmony, they are rightly called the nerve center of your radio.

Tubes that have had long, constant use should be replaced with new, correct Cunningham Tubes to enable you to enjoy modern broadcast reception.

Never use old tubes with new ones—use new tubes throughout.

E. T. Cunningham Inc.
New York
Chicago
San Francisco

Cunningham Radio Tubes

AUSTRIA'S PRESIDENT SIGNS A "FULTOGRAPH"

Dr. Siegel, President of Austria, is at the left, signing a photograph of himself transmitted by radio by the method perfected by Captain Orso Fulton (in the center, with his hand on the table). Captain Fulton developed his apparatus, the "Fultograph", in Vienna; the British Broadcasting Company is now considering its adoption.

Photo Broadcasting in England

By WILLIAM J. BRITAIN

Regular broadcasting of pictures is promised for Great Britain by October. The British Broadcasting Corporation is now considering the adoption of the "Fultograph," the apparatus of Captain Orso Fulton, an Englishman who has been experimenting in Vienna for three years.

Captain Fulton gave me a demonstration of his apparatus when I met him in Vienna. The photograph to be transmitted is printed on a copper foil coated with sensitized fish glue. Exposure to light makes part of the glue surface insoluble. Washing removes the soluble parts, which have not been exposed to light, and a half-tone picture in glue is left.

The foil is then placed on the transmitting machine. All you can see is a box containing a small clockwork motor, and at the side a cylinder which can move slowly round, like the one on Edison's first phonograph. The foil is wrapped round the cylinder, which is then set going. Over the foil a metal needle passes.

When the needle is touching a part of the bare foil a current passes and is transmitted. When it touches a part where the glue is, the glue acts as an insulator, and no current passes.

In receiving the picture a large receiver of a simple type is sufficient for distances within a mile of the broadcasting station, for greater distances a larger receiver of two or more tubes is necessary.

You can hardly tell the receiving set from that at the transmitting end. Round the brass cylinder a piece of paper dipped in chemicals, and still damp, is placed. A platinum needle passes over it, and when current is being sent out at the transmitting end a current passes between the needle and the cylinder, and the paper is stained brown through the action of the current on the sensitized paper. Thus the picture is traced out.

In his early experiments, Captain Fulton told me, he synchronized reception and transmission by means of a pendulum device devised by himself and Mr. T. Thorne Baker, of London, with whom he formerly collaborated. Both receiving and transmitting instruments were fitted with a long pendulum which made an electric contact at every tenth second and released the cylinders for a new revolution.

With this method it was found that unless there was absolute stability, the picture was ruined; so now Captain Fulton has devised a series of relays giving him electro-magnetic synchronization. This enabled him in a test to take his apparatus on a ten-day steamboat trip along the Danube and receive pictures from his laboratory in Vienna during the entire trip.

The fact that the glue on the copper foil is easily scratched demands some remedy. One is to "burn in" the picture; another, used by Thorne Baker, is to roll the glue picture between polished steel, so that the picture sinks into the metal, like a picturesque commutator.

For the chemicals in which the semi-absorbent paper is dipped, several mixtures are used. One is a potassium iodide and starch solution, which gives a coloration with the passage of a current of less than two milliamperes; and another solution, used in the Jenkins laboratories, contains ammonium nitrate, ammonium chloride, and potassium ferrocyanide.

"All the time I have tried to simplify radio picture apparatus for the man at home," Captain Fulton told me. "I consider my latest apparatus is as simple as a cart: a cart has only the wheels and the body, and if you take either away it isn't a cart any more. My assistants and I have worked hard and now we have made a home set to be sold to the public for about seventy-five dollars. They have already been adopted in Vienna."

The pictures are 4½ inches by 3½ inches, and those I saw received were as distinct as huddled newspaper photographs.
The broadcast of the Army-Navy game last year was enjoyed by hundreds of thousands of fans all over the country.

The Big Game Comes Over -- BETTER -- CLEARER

MILLIONS of enthusiastic football fans are listening this fall to the play by play broadcasts of America's greatest games. They are experiencing almost as keen enjoyment as if they were sitting in the stands. The voice of the announcer comes to them clearly and distinctly because their receiving sets are Aluminum equipped.

Leading radio manufacturers are using Aluminum extensively for shielding, for condenser blades and frames, for chasses, sub-panels, front panels and for many other parts -- because Aluminum so ideally meets the varied conditions that radio design presents.

It combines remarkable shielding properties, high electrical conductivity, great strength and extreme lightness.

Examine the set you contemplate buying. If it is Aluminum equipped you may rest assured that the manufacturer has done everything in his power to give you the finest possible reception.

And if you are building a receiving set use Aluminum for finest results.

We will gladly send you the booklet, "Aluminum For Radio," which explains the varied radio uses to which Aluminum is adapted.

ALUMINUM COMPANY OF AMERICA
ALUMINUM IN EVERY COMMERCIAL FORM
2161 Oliver Building
Pittsburgh, Pa.

ALUMINUM
The mark of Quality in Radio
Easy to build . . unequaled performance . . at a price you will be glad to pay

Marvelously Realistic Reproduction . . REMLER Audio System . . Perfect Control of Volume from Maximum to a Whisper.

Simple to Operate . . Expert Results for Every Member of the Family.

All the Selectivity That Could Be Desired . . Clean-Cut Separation of Stations on Adjacent Channels.

Superheterodyne Sensitivity . . Shield-Grid Amplification.

Stable Operation . . Completely Shielded Throughout.

Easy to build . . Can be Assembled, Wired and Put into Operation in One Evening. No Special Knowledge or Experience Necessary.

Most of the Wiring Completed and the Circuits Balanced at the Factory . . Only a Few Wires to be Installed by the Buyer in Accordance with Color Code.

Eliminator or Battery Operated.


Steel Chassis Amplifier Construction . . Compact and Rigid.

Power Transformer Primary Tapped for Different Line Voltages.

REMLER POWER AMPLIFIER

The story of the "29," what it is and what it does, is complete in Bulletin No. 17. Sign the coupon for your free copy.

REMLER Division, Gray & Davidson Mfg. Co. 950 First Street, San Francisco, California.

Gentlemen: Please send me:
□ All the "dopes" on the "29".
□ Bulletin service for professional set builder.

Name ____________________________
Address __________________________
City ____________________________ State __________________________

Do you build and sell sets? __________________________

Letters from Readers

The Last Word

What appears to be the final answer to the questions that arose over the meaning of Greenwich Mean and Greenwich Civil Time, as used in the list of short-wave stations in the May issue, has come from Captain C. S. Freeman, U. S. N., Superintendent of the U. S. Naval Observatory. The necessary corrections for the errors which occurred in the original list appeared in this column in the August issue, but we appended a request for information as to whether there was any recognized system of time computation which used a day starting at noon. Captain Freeman answers:

To the Editor:

There is no longer any time in use by which the day is reckoned as beginning at noon. That kind of day was called the astronomical day, and was used principally by astronomers, navigators, and persons engaged in longitude determinations. In making their computations, the above mentioned persons used data from the national ephemerides (astronomical ephemerides). Beginning in 1925, all the national ephemerides discontinued the use of the astronomical day, and all users of these publications changed accordingly.

It would have been better probably if the term "Mean Time" had not been continued in use in referring to the day beginning at midnight. However, it is not yet been due to confusion in the minds of the users, since among them are the astronomers and time authorities of Europe, who undoubtedly understand the significance of the terms involved.

The matter may be summed up as follows: Greenwich Mean Time (G. M. T.) and Greenwich Civil Time (G. C. T.) refer to the same system of time computation, the first being the European designation and the second the American designation. This system of computation begins its day at midnight (6 hours) in the longitude of Greenwich, England. No system in use to-day begins the day at noon.

Volunteer Proof Readers

It seems that our embarrassment in the September issue over the presence of errors in these pages has inspired several readers, ambitious for the position of million-dollar proof reader, to point out several other mistakes in the September number. However, since each of the two correspondents quoted below points out only one error, and fails to find the error noted by the other, the lucrative position in the proof room remains vacant, and the firm is still holding on to the million dollars.

To the Editor:

After reading the article in the September Radio Broadcast on page 308 in regard to mistakes, I hardly have the heart to write you about a glaring error on page 253 of the same number. But really, your contributors, compilers and proof readers should know the difference between "flaunting" and "flouting." It seems rather strange, but almost every time I have seen the word "flaunting" used recently, especially in the daily press, the writer has actually meant "flouting." "Ftoting the constitution, (or the 18th amendment)" seems to be a favorite phrase with the newspaper writer.

I would suggest to the editor of every newspaper and magazine that a little notice be put up in the office to the effect that the words "flaunting" and "flouting" had better not be used at all. Then there will be no confusion between them.

B. R. White, New York City

(Continued on page 368)
Majestic Music—Martial Volume
From Your Present Radio Set

equal to the coronation music of Rheims Cathedral, can be obtained by adding a Samson PAC2 which will also eliminate all A, B and C batteries with their attendant care and replacement.

Rich bass notes, remarkable clarity and a volume which can be controlled from a whisper to 7 watts—sufficient undistorted power to operate 12 to 16 loud speakers or 500 to 700 headsets.

Samson PAC2 Amplifiers are designed to meet AIEE Standards and Underwriter's Requirements. Nothing is left to chance—even the filter condensers are built to our own rigid specifications. Compensation is provided for 105 to 120 volt, 50-60 cycle current. External voltages are provided for 45, 90 and 135B, -45/C and raw AC current for two 227's and five 226's tubes. An 874 regulator tube is used to maintain B voltages. When used in conjunction with tuning units PAC2 Amplifiers are ideal for supplying music or instruction to schools, hospitals, apartments, clubs, etc.

Send for folder R. B. on Samson Amplifiers

Samson Electric Co.
Manufacturers
Since 1882

Main Office:
Canton, Mass.

Factories at Canton and Watertown, Massachusetts
Letters from Readers
(Continued from page 386)

To the Editor:

In a spirit more of sorrow than of censure, I am writing to call your attention to what appears to be a grave discrepancy in a certain paragraph notice contained in the copy headed "Here and There" on page 255 of your September issue. And to think that said discrepancy should occur in the same issue in which the little article "Our Mistake" unfolds its shameful tale, is enough to make any lover of RADIO BROADCAST break down and weep. However, you evidently said your "prayer to the radio gods" with little or no faith, for, lo, the "letters are already commencing to come in," Which "ain't no way to pray!"

Now don't think for one moment that I discovered above mentioned error—for I didn't; I am chronically near-sighted and sadly afflicted with "necroticitis" when it comes to details—like, to loathe the word! But one of our Argus-eyed announcers (he's lots of other things around here, too) sorrowfully pointed it out to me—"and to think it's in our dear ole RADIO BROADCAST too," he sobbed. And so, I hurried straightway to my typewriter and decided to call your attention to it immediately, thinking maybe you might wire that Mencken man that you'd found a "millon-dollar-a-year typewriter", as that salary would come in right handy.

On Page 255 in September issue, you will note, in black and white, that the "cost of broadcasting the Republican National Convention through 42 stations amounted to $77,000, or a little over a dollar a minute." And right there we've got you! You mean seconds, of course. For had the Grand Old Party been on the air 72,000 minutes as you say, it would have sure been some convention, as it would have broadcast 1200 hours or 50 days. Beats the Democratic 1924 record by about 4 weeks solid.

GENE BROWN, (Station WJAL) Baltimore, Md.

Furthermore, we ourselves have also discovered a few typographical pecadillos, which we are not going to mention for the reason that we want to keep our job.

Java on the Air

FROM George E. Morcroft, Pittsburgh, Pa., comes this interesting news of the new radiotelephone service between Holland and Java:

To the Editor:

In your September issue (page 256) I noted a little news except in which you told of the opening of a high-frequency radiotelephone system between Holland and Java, but you were unable to give details "as the dispatch from abroad was garbled."

If you are interested in further information as to these stations I would like to say that the Dutch station is called "Kootwijk, Holland" on a frequency of 16,900 kc. with a power input of 5 kw. I have often received this station and have had reception confirmed. The Java station is called "Am, Java," and is taken care of by two transmitters which are modulated at the same time, according to a letter I have just received from the Chief of the Radio Laboratory at Bandung, Java, confirming my reception of one of these stations, AM. The two transmitters are AM at Malabar, Java, on a wavelength of 170 meters, and AM at Hardang, Java, on 155 meters. The letter from Java also contains the information that music is broadcast several days a week from AM on a wavelength of 1500 meters from 1300 G. C. T. to 1700 G. C. T. (8 A. M.-12 P. M.—Eastern Standard Time). The telephone communications are carried on on Thursdays and Saturdays from 1500 G. C. T.—1900 G. C. T. (10 A. M.—12 noon E. S. T.) PCLL at Kootwijk, Holland, also

(Continued on page 300)
The New Knapp "A" Power Kit

Greater Efficiency—
Improved Design and Appearance—Lower Price—Money-making Plan for Set-builders

Your radio fans who loved my "A" power the largest selling "A" power last spring have made it possible for me to offer the finest "A" Power ever developed—in Kit form—even more complete than before. Study the illustrations—read the improvements—and you will wonder how I could have reduced the price. You are the answer. I sold 5 times as many "A" Powers as I expected to—and this season I am counting on you to help me again by buying even more.

The 8 Improvements

2. Improved Choke Coils
3. Pendant Switch Controlling "A", "B" Eliminator & Set
4. Dial for regulating voltage
5. Celeron Front Panel
6. Baked finish
7. Heavier gauge metal cover
8. Die Cast Base Plate instead of wood

COMPLETE KIT—EASILY ASSEMBLED

Like my Kit last year, the New Knapp Kit is a tool job—the parts seem to fall into place. Every hole is drilled—all that is necessary for you to do is to put the screws and nuts in place and connect a few wires. Everything is supplied. Nothing for you to buy extra. The fool-proof instruction sheet makes it easy for anyone to assemble.

THE SET-BUILDER TAKEN CARE OF

You set-builders played with me (as the saying goes) and I am going to continue to play with you. My engineers have designed an "A" Power which is well-nigh perfect—my production men, based on tremendously large quantities have cut their cost, so that I can keep faith with you by reducing the price. And regardless of what the established trade may think about it—I am going to continue to give you the maximum discounts. The coupon will bring you the full details of both the new "A" Power and the special discounts to set-builders.

David W. Knapp, Pres.

KNAPP ELECTRIC, Inc., Port Chester, N.Y.

The H. H. EBY MFG. CO., Inc.
How is your SHORT-WAVE Reception?  
Let HAMMARLUND Improve it!

Short-Wave PLUG-IN COILS

Wound with a definite space between turns, wire anchored and supported by a thin film of strong, efficient dielectric material.

- Distributed capacity and resistance are minimum. Widely-spaced plug-in terminals. Adjustable primary held in position by friction.

The 8 Standard 3-coil set (illustrated) covers the 150-107 meter range with a .00014 mfd. Capacitor. Other coils available for from 8 to 215 meters.

Send 10c. for the
HAMMARLUND SHORT-WAVE MANUAL
Brimful of Useful Data

HAMMARLUND MFG. CO.
424-438 W. 33rd Street
New York, N. Y.

Letters from Readers

(Continued from page 388)

transmits musical programs 1300 G. C. T.—1650 G. C. T. (8 a. m.—11:50 a. m. E. S. T.) on Wednesdays.

Another Kruse Fan

IN THE September number we spoke of the enthusiasm accompanying the addition of Rebert S. Kruse to our list of authors. It hasn't stopped yet. To prove this we quote from a letter from Alphy L. Blais (VE-2AG—VE-24S), Thetford Mines, P. Q.

To the Editor:

When R. S. Kruse signed off from QST, I thought he was lost to the amateur world. It was a great and comforting surprise to meet him with the R. B. gang, still keeping on the same “amateur spirit.” Gosh, I'm glad he's with us again—and that 5-meter band has got me in a trance. Give us more and more of it. R. S. K. has a way all his own to make one understand, and nobody can go wrong when following his instructions.

The radio work done here at VE-2AC, VE-2AS (O. R. S. of A.R.L.) is mostly amateur traffic handling on 20 and 40 meters. The 10-meter band is tackled with little results due to heavy local QRM.

I believe it would be very useful for us if R. B. were to give us an article on a frequency meter for the amateur bands. With the new laws coming in 1929 our old equipment goes kerplunk. Kruse is familiar with our wants and can give us a hand.

In 1923 I wrote to Radio Broadcast saying how good a magazine it was. In 1924 and 1925 also, especially commenting on Keith Henney and his “Home Lab.” articles, unsurpassed so far. In 1926 and 1927 I wrote again giving you a cheer, and in 1928 it would take a book to write my praise. Radio Broadcast has reached a point where everywhere in it needs praise and no knocking. With QST you are the perfect magazine. Your advertising policy is very fine, and I side with you—no trash, only quality.

Wired Wireless

Wired wireless is up for discussion again. On page 10 of our May issue we discussed editorially the probable place of wired wireless programs with respect to “space” or radio broadcasting of programs. Wired wireless has its place, but we feel that it does not yet offer serious competition to radio broadcasting. In St. Paul, Minnesota, as in several other communities in the Middle West, wired wireless programs are being offered commercially. The letter below is from a St. Paul resident whose name is omitted for obvious reasons.

To the Editor:

The St. Paul wired wireless system is comprised of a central receiving station where the programs are picked up on a well-designed receiver and then put over the land wires to the subscriber's home at high amplification. The subscriber has nothing but a speaker in his home, with some sort of resistance volume control.

The operator at the central station either picks the programs off the air, or, in the absence of suitable programs, puts on a little Orthophonic music for the subscribers—rather a limited service for $4.00 monthly! However, 1 am in the opinion that the A. T. & T. may furnish the St. Paul wired wireless concern with the blue and red networks of the N. B. C.

In talking over the wired wireless situation with fellow members of the radio trade, I have run into the argument of what will the advertiser do if wired wireless should predominate over the radio. In my opinion, the advertiser would be assured of a more regular audience than he is at
WHEN you install a set of CeCo Tubes in your radio, you immediately notice the greater clarity of reproduction—the increased sensitivity and the better volume.

But your greatest satisfaction will come with their longer operating life—making CeCo the most economical tubes to buy, and worthy of their slogan “they cost no more, but last longer”. This is made possible partly by the exclusive method of evacuation.

To avoid disappointing results, make sure each socket is equipped with CeCo tubes. Whether for battery or A.C. operation. There’s a CeCo for every radio need—including “special purpose” tubes that are not obtainable elsewhere. They are sold by leading dealers everywhere.

Push-pull Transformers with impedances to match power tubes and dynamic speakers

Type “BX” Input Transformer has extremely high primary inductance. Secondary accurately divided.

 Price, each ................. $6.50

Type “GX-210” Output Transformer. Especially designed for push-pull amplifier using UX-210 or CX-310 tubes. Secondary connects directly to moving coil of dynamic speaker.

 Price, each ................. $6.50

Type “HX-171” Output Transformer. Same as above except impedance matches UX-171, CX-371, or UX-250, CX-350 tubes.

 Price, each ................. $6.50

Free circular giving audio hook-up and complete information on request

SANGAMO ELECTRIC COMPANY

Springfield, Illinois
Lost in the Arctic
But Tuned-In on Pittsburgh, Pa.

The Vigilant Group of Gen. Nobile's ill-fated expedition was lost on an ice-ile in the Arctic, but listened nightly to the news flashes and concerts from Pittsburgh and other American and European broadcasting stations. And day by day it sent out a call for help which was heard and as we know, answered before it was too late.

New wonders of science become accepted facts in our lives in such rapid succession that the wonder soon wears off.

The first messages from ship to shore and shore to ship were indeed miracles. Here was a degree of safety never found before in all the centuries of seafaring. When the channels of the ether were filled with music and the spoken word, ready to be chosen and enjoyed by any owner of a simple broadcast receiving set, here was a greater miracle.

A greater miracle still has been the development in the use of short waves. These have circled the globe and made possible the messages that saved the lives and reason of the lost Italians.

A Short-Wave Receiving Set will make you able to hear easily radio broadcasts from all over the world. More and more stations here and in Europe, Australia and New Zealand are putting their programs on the short-waves. New marvels are waiting for you and your friends.

NATIONAL COMPANY INC. has developed new and better equipment for the simple construction of non-radiating short-wave receiving sets employing the 4 electrode 222 Tube. This equipment is described in our Bulletin No. 151-B. Write us for it today.

Letters from Readers
(Continued from page 390)

present able to get by radio with its weather and interference problems to contend with. Say that the subscriber had a choice of two national programs over his wired wireless installation, as is possible in one Minneapolis hotel, the chances are he would be more apt to be listening during weather that is ordinarily bad in radio, yet would not affect the telephone lines carrying his wired wireless programs to his home.

Radio can be greater than wired wireless could ever dream of, but its broadcasters must be progressive and not allow two or three chains to corner the entertainment features of the country. Because of a lack of power and talent in the part of Midwest broadcasters, we here must look to the chains and if it is the chains we must look to very long, the fickle public can be quickly won over to the possibilities of the telephone companies bringing these programs into their homes, free of static, interference, squeals, etc. It is show that why this would be so easy to bring about I give you a little idea of what the listener in these cities is up against.

Chicago, while close to us, is not heard regularly, nor is Washington, D.C., to be termed consistent entertainment. Neither are Michigan broadcasters. Omaha and Des Moines, as a rule, come in like locals day or night but now devote most of their time to the red and blue chains of the N. B. C. With but few exceptions, our two best broadcasters spend their efforts toward rebroadcasting the chain programs. I have heard it said men and time again the ardent radio fan that 99 percent of his listening time is devoted to listening to the chain features.

The recent action of Congress in really cutting down super-broadcasting has placed the hands of the big interests, who will some day attempt to put this wired wireless idea across, for unless we can have a sufficient number of station broadcasting throughout the country, the advertisers will boycott the independent radio stations and in turn we face a loss of talent by these broadcasters for lack of financial support to put on their own broadcasting. The very life of the radio industry depends on a sufficient number of high-powered radio stations that can be heard consistently and with a greater variety of programs than is now possible for the average radio fan to obtain.

The radio industry should feel alarmed at the wired wireless situation before it becomes too late.

American Interference Patrols

THAT the big light and power companies of this country are as anxious as the radio fan to remove the nuisance of man-made interference is evidenced by this letter from the Union Electric Light and Power Company, of Saint Louis:

To the Editor:

Our attention was first attracted to Radio Broadcast by its articles on radio interference, and in particular, the series of articles of Mr. A. T. Lawton. It was to receive this series of articles that our subscription was entered.

Our company has been quite interested and active since 1923 in locating and removing all sources of interference for which it is responsible. It has been somewhat discouraging at times when this service, rendered voluntarily, has been taken advantage of by many listeners and some dealers, who have blamed all their troubles on "leaky transformers." In most cases we have found this situation was caused by ignorance of the nature and source of interference. Many of the early articles on interference in magazines and newspapers were incorrect in their descriptions by the incorrect or misleading statements contained in them.

Such articles as those by Mr. Lawton are not only doing much to correct this misconception, but are of great assistance to those who are earnestly trying to trace and eliminate interference. We hope to see more such articles.
Goodwin

“VIVETONE 29”

Truly a Standard of Efficiency for A-C Operation

HERE is a receiver that embodies to the highest degree those five features of paramount importance, namely—Sensitivity, Selectivity, Quality Reproduction, Beauty of Appearance and Simplicity of Construction with resulting Ease of Operation. In measuring up to these five necessary requirements the Goodwin “Vivetone 29” is truly a standard of efficiency.

All the parts used in the “Vivetone 29” are made by radio's most reliable and reputable manufacturers. Each part sets the standard in its line and is recognized as such by radio's leading engineers. The use of these quality parts in the “Vivetone 29” insures long and satisfactory service.

The constructor and commercial set builder can purchase all the parts used in the “Vivetone 29” from any dependable dealer.

BLUE PRINTS FOR THE “VIVETONE 29”

Send today for the four complete full-sized constructional blue prints incorporating every detail for the construction of the “Vivetone 29.” Enclose $1.00 to cover cost of mailing and the actual cost of the blue prints.

Goodwin Radio Research Lab.

167 Glenwood Ave.

Jersey City, N. J.
Cuts Wiring Time in Half
Shave back the insulation, solder the connection and the braid slides back into place, leaving no exposed sections of bare wire. Braidite is the quickest and easiest working hook-up wire made.

Safe as insulated wire and as convenient as bare wire. You cannot short or burn Braidite with a soldering iron. Use Braidite in the next set you build.

At All Dealers
25 Feet Stranded .......... 35c
25 Feet Solid ....... 30c
Red, Green, Yellow, Blue, Black.

FREE Send us the name and address of your dealer and we will send you a sample package of Braidite FREE. Include too for Postage.

CORNISH WIRE CO.
38 Church Street New York City

Put your set and loudspeaker anywhere. Place them as far apart as you wish. Then connect them with the wonderful Belden Extension Floor Cord. It lies flat under the rug. Out of the way—no wiring—no fuss. Get one at your dealer, now!

Belden
Speaker Extension Floor Cord
Belden Mfg. Company
1311-A S. Western Avenue Chicago

TROUBLE?
If your set or power pack refuses to work, or you want to improve the quality of reception or increase selectivity—

If you want to modernize and electrify your present receiver—

Let us help you solve your difficulty
For example: It will cost you only from $5.00 to $10.00 for the repair service consisting of testing the receiver, tracing the trouble and then repairing it. The set will then be shipped to you in perfect operating condition and guaranteed.

For further details address
SILVER RADIO LABORATORIES
2514 Mapes AVE. New York, N.Y.

$2.00 Insures Your A.C. Tubes
The Vitrohm 507-109 Unit costs $2.00. Installed on your radio set, it lengthens a.c. tube life by automatically lowering filament voltage.

Attached in a moment—Nothing combustible—Nothing to wear out—Does not get excessively hot. It consists of a Vitrohm Resistor mounted within a perforated metal cage, a plug, and a receptacle.

Write for free information on this and other Ward Leonard Radio Products.

WARD LEONARD MOUNT VERNON ELECTRIC CO. NEW YORK
For Greater Utility and Enjoyment of Radio

**Yaxley**

*Wire Your Home for Radio*

**Yaxley Radio Convenience Outlets**

Enjoy your radio programs in any room in the house. Put the batteries in any out-of-the-way place. Bring aerial and ground connections to most convenient point. These outlets fit any standard switch box. Full instructions with each outlet.

- No. 155—For Loud Speaker Connections......$1.00
- No. 156—For Aerial and Ground Connections......1.00
- No. 134—For Several Loud Speaker Connections...2.50
- No. 122—11 Conductor—For Power Pack Connections...3.00
- No. 137—9 Conductor—For Battery Connections...2.50
- No. 138—For AC Connections......1.00

Also furnished in two and three plate gang combinations.

**WITH BAKELITE PLATES**

Newly furnished with rich satin brown Bakelite plate, with beautiful markings to harmonize, at 25 cents extra.

**Cable Connector Plug**

Complete as illustrated with your cable and cable markers. Mounting plate and mount are heavy panel and bracket Bakelite construction; positive spring contacts; no loosening of plug in pins or spring insulating. You cannot put the Cable Connector Plug together improperly. All terminals and cable ends plainly marked.

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Small in size—1/2" diameter—yet have exceedingly fine adjustment. Contact arm rides smoothly on resistance strip. Extra heavy metal base and an expanded metal mesh panel help dissipate heat, retarding overheating. Mount in 1/2" panel hole.

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- Junior Potentiometers, with knob, ratings up to 100 ohms......1.00
- 1000, 2000 and 3000 ohm sizes......1.25

**Colored Phone Tip J eck s**

Have distinctive colored caps, red for positive side of loud speaker and black for negative side. Cap is of Bakelite. Take standard Phone Tips. Phone tips near all the way in Jack, making excellent spring contact.

Lesser danger of shorts. For Bakelite or metal panels.

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YAXLEY MFG. CO.
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**Improved Quality with this new valve**

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**Harold P. Donle's Latest Achievement**

The inventor of the famous Sodion Detector valve brings out this DA2 6-volt amplifying valve which can be used in any type D. C. set with no changes.

Amplification for both audio and radio frequency are greatly increased, and the quality of your set vastly improved.

Those that have tried these valves are enthusiastic about them.

Here is what some of them say:

"We seem to obtain far greater volume and clarity."

"Really, it is the most marvelous valve I have ever come in contact with."

"I have tried two of these tubes in my regular tuned radio frequency broadcast receiver, and I am delighted with the increase in volume and distance obtained."

"Received the four tubes ordered, to-day. Must say that they even exceed all my expectations."

"It is a pleasure to report that the three tubes I received from you Saturday have increased the sensitivity of my Hammarlund-Roberts Hi-Q to a considerable degree. I also tried one in the R. F. stage of a Browning-Drake and there too, the gain was considerable."

"Excellent for low wave sets"

Full size illustration of the DA2 amplifying valve. Price $3.00 each.

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"A" FILTER

Tobe Transformers consist of a step down transformer and a 3 ampere rectifier unit completely assembled in one unit. Fits neatly on top of a Tobe "A" Filter as shown. No wiring required, just plug into the house supply.

The Tobe "A" Filter and the Tobe Transformer make a good, complete A Supply.

The same Tobe "A" Filter attached to any good two ampere charger such as a Tungar, Rectigon or even a good Electric charger, will make a complete A Supply.

Tobe "A" Filter $18.00
Tobe Transformer $15.00
Tobe A Supply includes Tobe "A" Filter and Tobe Transformer, completely wired and assembled 5 tube capacity 33.00

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Cambridge, Mass.

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for use with U-X 250 TUBES

This newest Dongan Transformer is designed for full wave rectification using two UX 281 tubes to supply B and C power to receiver and power for two UX 250 Tubes.

There are two low voltage windings, one for 226 tubes and the other for 227 tubes so that you can build a power amplifier for either the radio receiver or for phonograph pick-up.


Approved Parts for UX-250 Tubes

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No. D-600 Power Amplifier Condenser Unit has been designed for use with the CX 281 rectifier tubes, and CX 210 or 250 power tubes. Having a working voltage of 1000 volts and mounted, in crystal lacquered steel cases, they will be found unsurpassed for reliability and stability. Unit contains sections of 2-2-4 Mfd. $16.50

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Type 541-A
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Bulletin No. 930 with direct to consumer prices will be sent on request.

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The Tobe "A" Filter and the Tobe TransAformer make a good, complete A Supply.

The same Tobe "A" Filter attached to any good two ampere charger such as a Tungar, Rectigon or even a good Electricl charger, will make a complete A Supply.

Tobe "A" Filter ........................................... $18.00
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This transmitter contains no carbon, and is entirely free from background noise. Its yearly upkeep is practically nothing. It is extremely rugged, and will withstand hard usage.

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Yes sir, it works on your
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No need to be troubled with an outdoor antenna or lightning arrestors any more — simply plug in the Dubilier Light Socket Aerial — clear reception, less static and interference and plenty of volume. No current consumed. All good dealers sell it on a 5 day money-back guarantee. If your dealer is out of stock write to us.

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A simple explanation of the new, amazing power dynamic speaker that has swept the radio market at $25

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Dynamic speakers get their POWER by the use of an electromagnetic field. Translated from Engineering into English this means that the permanent field magnet of the average radio speaker is replaced by a powerful electromagnet.

Comparing the possible POWER of electromagnets and permanent magnets is like comparing a magnet to a dynamo.

The dynamo uses permanent field magnets. It will serve admirably as a shocking machine but cannot light a single lamp bulb. The dynamo uses electromagnets. Even a moderate sized dynamo will run the lights of an entire village.

Hitherto, the use of dynamic speakers was limited to a comparative few who could afford them because they required a separate battery to supply the current for their electromagnet coils.

DYNACONE eliminates the battery and utilizes current direct from the set to operate its field coils.

A continuous direct current is always flowing in the plate circuit of the power output tube of the radio set. Upon this direct current is superimposed the fluctuations of the signal.

It has been customary to keep the direct current out of the loudspeaker because so strong a current would tend to paralyze the speaker by pulling its armature over against the field magnet.

To get rid of this strong direct current, a transformer, or a condenser is used, which allows only the signal fluctuations to enter the speaker armature. DYNACONE uses the latter method for keeping the direct current out of its armature but makes use of this very current, which other speakers throw away, for energizing its field electromagnets.

By thus ingeniously utilizing energy heretofore thrown away, DYNACONE achieves POWER and QUALITY only attainable with the dynamic principle, without any special batteries or other apparatus. It is simply connected directly in the output circuit of any set using a 171 type power tube operating at 180 volts on the plate.

* If the set has an output transformer, this is disconnected by the dealer when DYNACONE is installed.

The above description applies to the Type E DYNACONE. The Type F DYNACONE, which has four connections to the set, takes its direct current from ahead of the output transformer instead of using a condenser to effect its separation from the voice current which actuates the armature.

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First place in realism ... extreme fidelity of reproduction ... is accorded Magnavox Dynamic Speaker by fourteen makers of fine radio sets. They use it as built-in equipment to assure rich, undistorted reproduction, with great volume.

**Belvedere Model**
Two-tone walnut floor screen
For A-Battery Operation ... $50
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Gracefully proportioned cabinet finished in light mahogany.
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