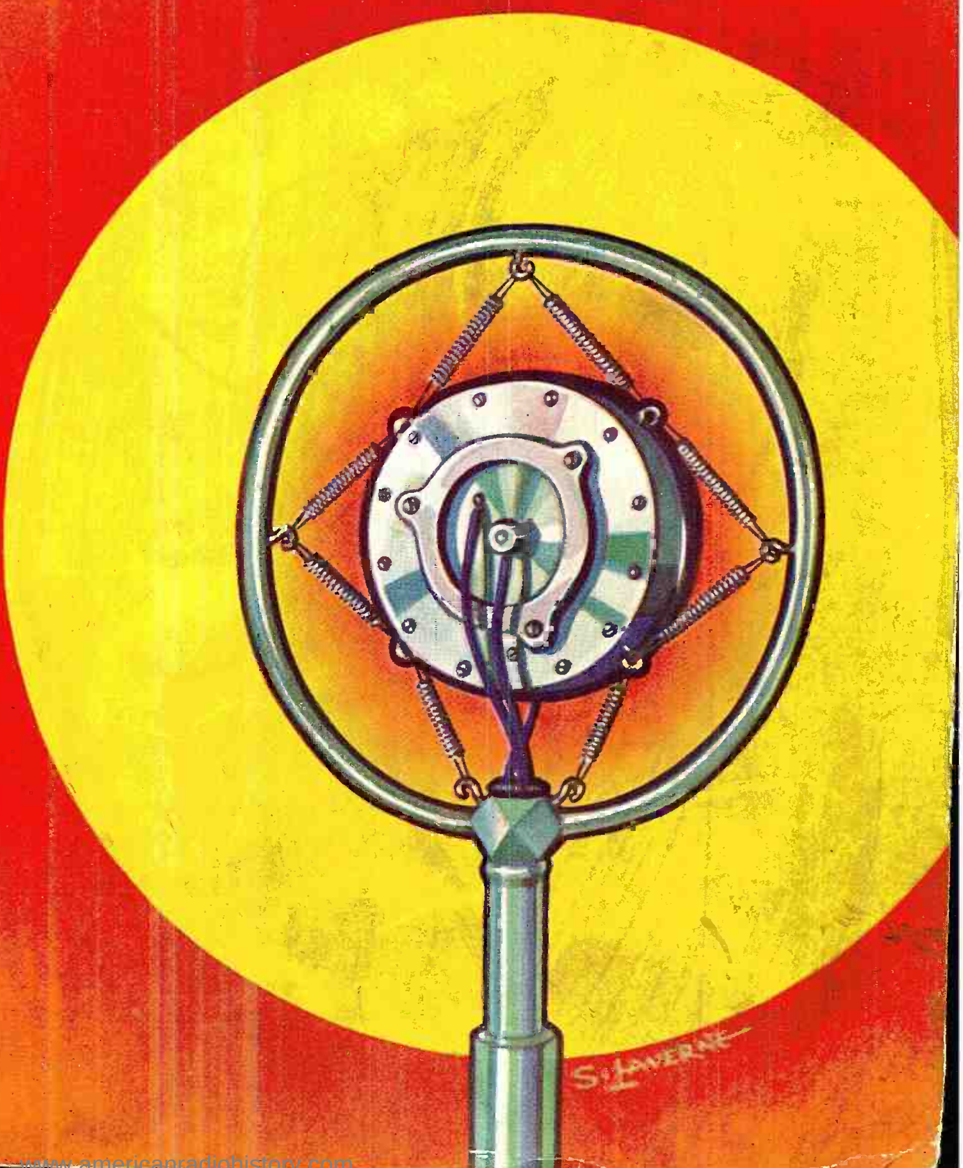
RADIO NEWS

FEBRUARY
25 CENTS



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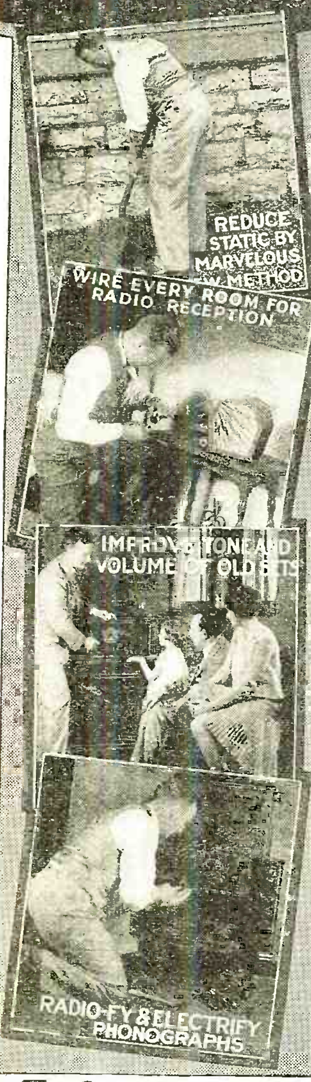

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Radio News

Vol. XI — CONTENTS FOR FEBRUARY, 1930 — No. 8

ARTHUR H. LYNCH, Editorial Director

JOHN B. BRENNAN, JR., Technical Editor — STUART C. MAHANAY, Managing Editor — EDWARD W. WILBY, Associate Editor

In Radio News Next Month

Commander E. H. Loftin and *S. Young White* give the constructional details for building a direct-coupled amplifier.

What happens when you adjust the hum-balancer in your radio receiver will be discussed by *Benjamin F. Miessner*, who tells more about his research work in the development of hum-prevention methods.

Ralph L. Peters in the second of his series of interesting articles on how police in different cities are utilizing radio-equipped prowling cars to speed the capture of lawbreakers.

Another illuminating article by *Carl Dreher* will discuss some specific technical problems encountered in the making of talking movies and how they have been solved.

More data on different types of automobile radio receivers will be presented, together with constructional details for building a set which has proven highly successful.

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Carl Dreher

Director of Sound Department
R.K.O. Studios

EDITORIAL

A New Day in Radio Conventions

THE Eastern Great Lakes Division of the Institute of Radio Engineers recently held a convention at Rochester, N. Y. Some of the extremely interesting subjects discussed at this convention are completely described in other portions of this issue of RADIO NEWS. Aside from the extremely high quality of the papers themselves, and the able and interesting manner in which they were presented, there is one point in particular for which those men who comprised the committee in charge of the convention are to be congratulated. This particularly significant feature of the convention was, we understand, frowned upon by certain of the Board Members at the National Headquarters of the Institute.

The innovation was the manufacturers' show which was made a part of the convention. Members of the Radio Manufacturers' Association were invited to display their wares in a large room adjacent to the convention hall. The manufacturers provided displays, and saw to it that some of their technical staff were on hand to answer the questions propounded by the engineers. There was no high-pressure selling. There was, for the first time, a real get-together between the manufacturing organizations and the engineers.

The Rochester Convention was extremely successful, and it is very likely that the good example which they have set will be followed at other I. R. E. conventions.

Another and equally impressive convention was recently called at Washington, D. C., to commemorate the fifteenth anniversary of the foundation of the National Radio Institute. This, we understand, is the first convention held for correspondence school graduates. The idea is a particularly attractive one, and we feel sure that it will be taken up as a practical proposition by correspondence schools in other fields of endeavor.

The growth of the National Radio Institute, which came into existence at just about the time that radio began to be important in our commercial life, is a fairly good gauge of the progress radio has made. Fifteen years ago the Institute had four students; there are at present over fourteen hundred. We heartily congratulate the National Radio Institute upon the progress it has made, as well as upon the genuine service it has rendered radio.

Radio for Your Car

WE have, for some time, been talking about the idea of applying radio receivers to automobiles. We have done a great deal of experimental work with receivers of this kind ourselves, and have learned a great deal about the problems which must be overcome before this type of receiver is completely successful. It is our desire to assist the readers of RADIO NEWS in every way possible, and we believe that by serving our readers we automatically serve those manufacturers who are called upon to supply our readers' needs. Therefore, we called a group of automotive and radio manufacturers together a short time ago to discuss the automobile radio idea. Among those who attended our meeting were the presidents and vice-presidents of four radio tube companies; important executives of most of the automobile, radio, spark plug, storage battery and dry battery manufacturers in the eastern part of the country. The consensus of opinion was that the automobile radio receiver is going to be one of the most important developments in radio during the spring and summer. It is with pleasure that we can advise our readers that several manufacturers have decided to provide complete radio receivers for automobile use and other manufacturers are arranging for the merchandising of kits for this purpose. Here is an entirely new and extremely interesting field of endeavor.

Arthur H. Lynch

Looking through the glass of a sound-proof "tank" of earlier talkie days. It was designed to silence and prevent the recording of camera clicks. The headphones convey to the operator everything that is said on the stage, outside

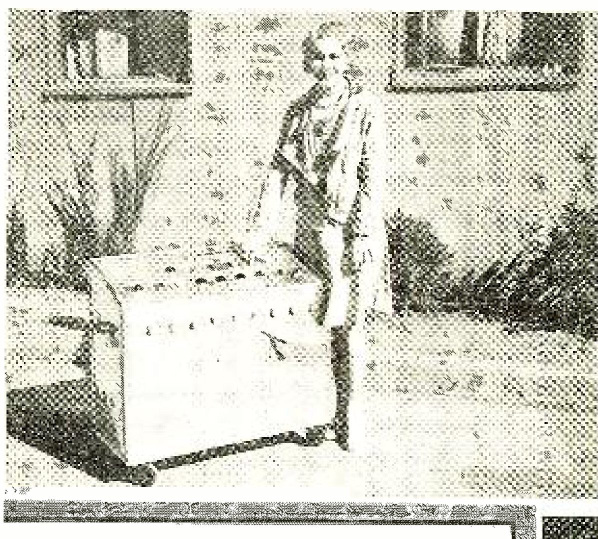
The Movies Come to

By Carl Dreher

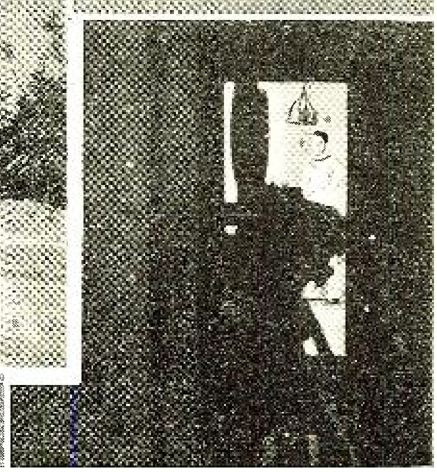
THE cliché about broadcasting and the talking movies being in their infancy has become tiresome even to headline writers, but it is largely true as far as the talkies are concerned. It is equally true that all such young though highly developed branches of technology rest on earlier discoveries and inventions, every industry being the descendant of older industries as well as a relative of coexisting ones. However, when such facilities are transferred to a new field, it is invariably necessary to adapt them to different conditions, and to supplement or ultimately replace them by additional equipment better suited for the object to be attained. This process is now taking place in the moving picture industry, and with unusual acceleration since economic and competitive conditions in this line call for the utmost speed in effecting whatever improvements are required or possible.

Some of these improvements are obvious enough, and yet exceedingly important. Microphone suspensions are an example. In broadcast practice microphones were originally arranged on fixed stands or pedestals. Later these were made adjustable to different heights. When the movies became important customers of the microphone manufacturers, the stands were found inapplicable in most cases, since the most common sound movie pick-up is overhead. So the microphones were slung by means of ropes and tackle from the gridirons and catwalks usually found on the stages, or from specially constructed frames of wood or iron pipe. Once the microphone position was set, the action had to center around it, or around a number of microphones suitably placed. The next scene was shot with a different microphone placing, and sometimes the moving of the transmitters resulted in costly delays.

Now, in most of the western studios, microphone booms are in use which swing the transmitter almost instantly to any desired position. A device of this kind is manufactured by the Mole-Richardson Company of Hollywood, California. It consists of a pedestal of pipe iron supporting a boom. A handle at a convenient height swings this boom about a horizontal axis at the top of the pedestal, which is about 10 feet high. The pedestal itself rotates easily. The boom is adjustable in length between 10 and 20 feet by means of a windlass. The base of the mechanism is on castors. It may be rolled to any convenient point, after which a microphone, suspended from the end of the boom, may be hung at any height between 5 feet and 20 feet above the floor, swung laterally, or extended 10 feet beyond the initial position. The boom is counterweighted and all these operations are performed with ease and speed. Using such a device, the action may be fol-

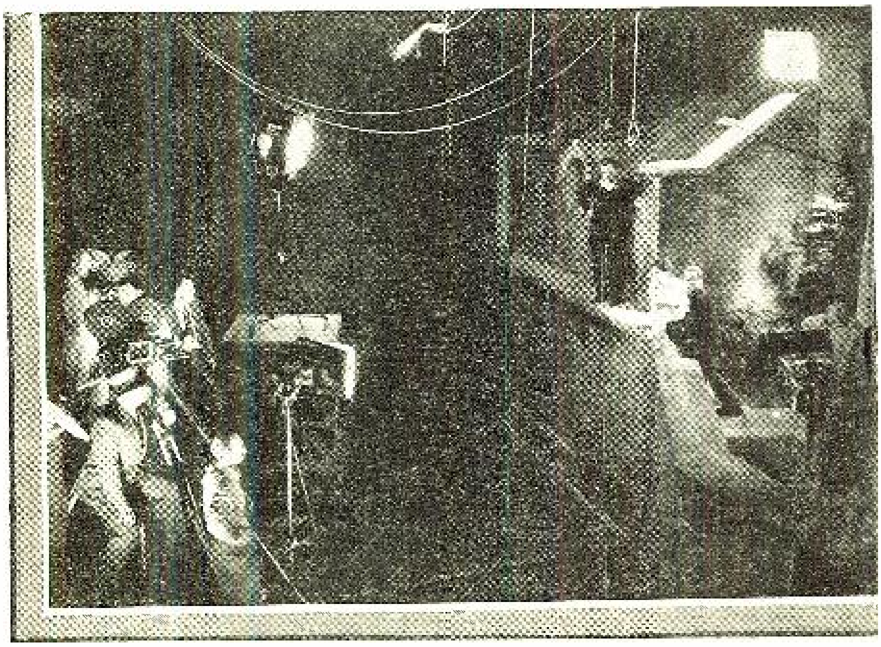


Portable unit for controlling six cameras, two recorders, markers and signals simultaneously



Looking out, from the inside of a sound-proof "tank"

¶ Realistic effects are brought about in recording by the clever use of sound distortion, the appropriate setting of volume levels and the removal of background hiss.



The making of a talkie. The microphone is just above the players

Life

¶ No matter how good the quality of reproduction is otherwise, when noise accompanies the rendition it destroys the illusion of reality. It constantly reminds the audience that it is listening to a mechanism and not to human beings.

¶ The development of equipment and technique for re-recording is perhaps the most important technical problem of the sound motion picture industry today. It makes possible the addition of sound effects or music after a picture already has been "shot."

¶ Automatic volume control is already familiar in broadcast reception and in the future it is likely to become a very important part of broadcast, public address and movie transmission systems.

lowed by a sound man on the stage. This simple mechanism, costing a few hundred dollars per unit, speeds up production remarkably and, by making the microphone movable during a "take," improves both action and quality of the recorded sound. Furthermore, it tends to reduce the number of microphones on a set, since one is usually sufficient.

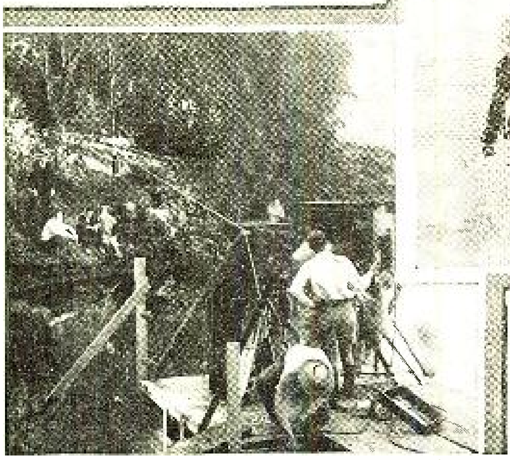
Preventing Microphonic Howls

This development also illustrates how one improvement introduces another. When the microphone is moved rapidly during a take, by means of the boom, microphonic noises are likely to result, unless the vacuum tubes have been designed anti-microphonically and the tube sockets, transformers, etc., of the microphone amplifier are properly protected against mechanical vibration. This involves no insuperable problems, since anti-microphonic precautions are a well-known element in broadcast and short-wave receiver design. However, microphone suspensions, tubes and amplifiers which are adequate for stationary pick-up must be redesigned for use with a boom. This illustrates the reciprocal process by which technical improvements are effected.

Further Microphone Improvements Due

The microphone itself is the critical element in all systems of sound recording and reproduction, and while it has already undergone considerable improvement, it is no doubt capable of further refinement. The original high-quality transmitters used in broadcasting were of the push-pull carbon type. The internal noises of this form of transmitter were too great for the exacting conditions of dialogue pick-up in sound motion picture work, and it had other disadvantages: it could not be tilted to the most favorable angle, nor moved rapidly during a scene, without noise. The electrostatic or condenser transmitter, with its lower internal noise level and freedom of rotation and movement, then came into extensive use in moving picture work. The present types are too large to be readily concealed, and one future development will be in the direction of decreasing

"Shooting" from a distance. The "mike" is suspended above the principals



Above: The camera, in sound-proof housing, and the microphone, supported by an adjustable boom, are mounted on a truck to facilitate recording

A night "shot" on the water in "Love Comes Along"

the size without loss in quality. If this cannot be accomplished with the condenser microphone, some other type of pick-up will be likely to supplant it. With the advent of wide film and the concomitant increase in the average camera field, the use of concealed or "prop" microphones will have to be more frequently resorted to, and small size will become a great advantage. There is no reason why dimensions as small as three or four inches should not be attained. Extensive work is also being done in directional microphone development and promising results have been secured.

The Camera Must Be Quiet

Before the advent of talking pictures, movie cameras were fairly noisy, and nobody cared. The first sound productions were made with the cameras enclosed in more or less soundproof booths and shooting through glass. The cameraman, sweating in his booth, was handicapped, not only by his physical discomfort, but by the difficulty of "panning," *i.e.*, moving the camera rapidly during a take to change the point of view for dramatic effect, and by a tendency for the glass in front of the lens to reflect light and interfere with the photographing. So camera hats or "blimps" of wood, rubber, felt and metal were devised which fitted over the mechanism and reduced the noise to an allowable level. With the camera back on its tripod, motion picture photography regained most of its original flexibility and effectiveness. In the meantime the camera manufacturers were busy, and, by careful redesign of their product, involving such devices as substitution of fibre for metal gears, they reduced the noise at the source to a point where an open camera might be used within ten feet of a microphone under normal conditions of pick-up, without objectionable interference.

Ousting the Hiss

Silencing the camera is only one aspect of the constant fight which the sound movie technician, in common with the broadcaster and the radio engineer, must wage against noise. The process of pick-up and amplification, as well as the record base itself, contributes to the disturbances which are constantly threatening to interfere with high quality reproduction. This "ground noise" takes the form of "needle scratch" in disc reproduction and somewhat similar crackling and hissing sounds in sound-on-film reproduction. Always present, it varies from an imperceptible level to a highly objectionable disturbance. Its control is more important than many sound movie critics and technicians realize. No matter how good the quality of reproduction is otherwise, when noise accompanies the rendition it plays its part in what the psychologists call the "fringe of consciousness" of the auditors and destroys the illusion of reality. It constantly reminds the audience that they are listening to a mechanism and not to human beings.

The lines of attack are: (1) Rejection of noisy tubes and microphones, leaky audio leads, etc.; (2) improvements in record materials and processing; (3) technical expedients to limit the amplitude of reproduction approximately to that of the intelligence-bearing portion of the record; (4) filters and networks to drop out non-essential noise-bearing frequencies; (5) maintenance, during recording, of a reasonably high level of modulation, although by no means of a dead level of loudness which would destroy dramatic effects.

On the Level

The last point brings up the advisability of controlling volume automatically during recording, since it is very difficult for the average operator to gauge his levels properly from scene to scene, and he is constantly between the Scylla of under-modulation and the Charybdis of over-shooting. Automatic gain control is already familiar in broadcast reception and is likely to become so in broadcast, public address, and sound movie transmission. The problems are not quite the same. In reception the object is to smooth out variations in radio-frequency field strength to give a constant audio output. In transmission and recording the requirement is to compress audio amplitude variations too great for the medium into a compass which will not exceed the physical limits set by the equipment, while retaining the differences in level required for dramatic effect. In other words, it may be necessary to raise a whisper to render it audible and intelligible in reproduction, and to reduce a shouted command to prevent it from tearing the equipment apart, but the whisper must remain a whisper and the shout must remain a shout. Automatic gain control, in which the amplification is adjusted by variations of grid bias through the input energy itself, is (*Continued on page 753*)

Section of main stage at the RCA Gramercy Studios. The black box suspended over the top of the set contains the microphone amplifier. From it is suspended the "mike." Sounds picked up by the microphone are transmitted by wire to recording booth "B" at the left, where they are again amplified and recorded on film. Large sections of sound-deadening cloth are placed before the booth, and in the right foreground, to keep extraneous noises from the "mike"

Construction and Circuit Details for

A Compact FIVE-TUBE Auto Radio Receiver

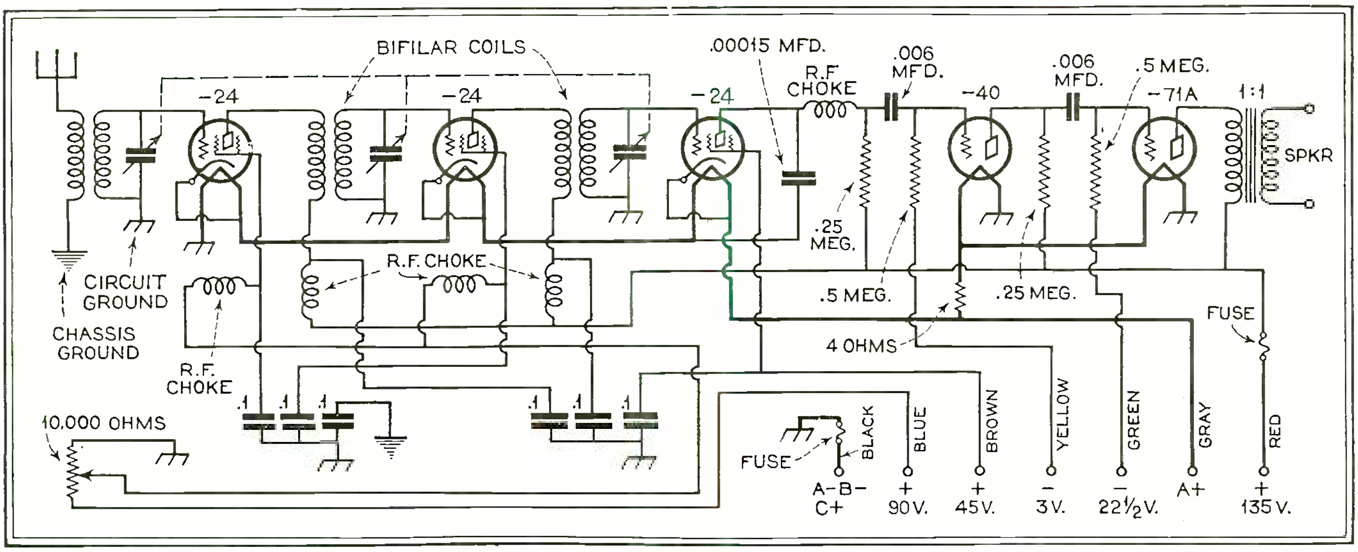


Fig. 2—Three —24 type tubes, a high mu —40 tube and a —71A are those which are employed in the S-M auto radio receiver. Circuit connections illustrating the special by-passing and r.f. choking features are shown

By McMurdo Silver

DUE to increasing popularity of a portable type receiver for installation in automobiles, the design of such a set has been undertaken by the S-M laboratory. While most of the circuit and mechanical design considerations are the same for a receiver of this type as for a conventional broadcast receiver, certain unique considerations must be kept in view in order to evolve a product suitable for this new use of radio receivers:

1, High overall amplification in order to produce satisfactory signals from the small antenna necessary; 2, special power supply considerations in order to give economical operation; 3, choice of tubes with special consideration for ruggedness and microphonism; 4, weight consideration; 5, suitable dust protection for the delicate parts comprising a radio receiver.

Antenna Space at a Premium

There is no great amount of space available in a motor car for an antenna installation; it is the present trend to utilize a small plate or a screen built into the roof structure of closed cars in such a manner as to be as satisfactory as possible. Due to the metal paneling in the sides and doors of the car, this produces an antenna of fairly high capacity to the car chassis (or ground) but very small effective height. This necessarily implies a small input to the receiver, especially when the machine is driving down streets lined on either side with steel buildings where the field strength from broadcasting stations is necessarily low. This makes it necessary that the highest gain practicable be (*Continued on page* 758)

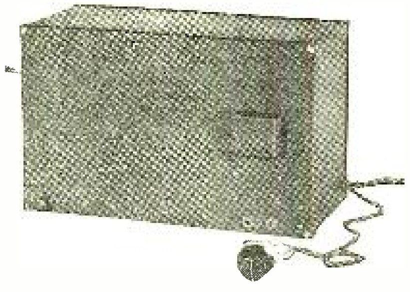


Fig. 3—Enclosed in a dustproof metal case, which also provides shielding against intercoupling between stages, the auto radio receiver is compact, thus lending itself to easy installation

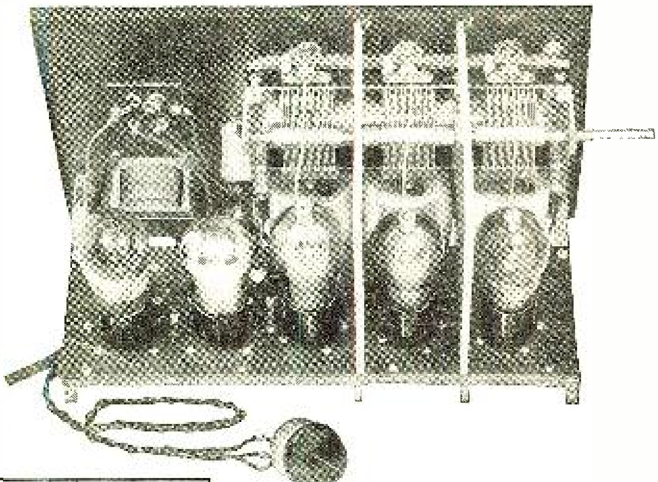


Fig. 4—A rear view of the S.-M. auto radio receiver showing the tubes mounted in cushion sockets for minimizing microphonic noises due to vibration

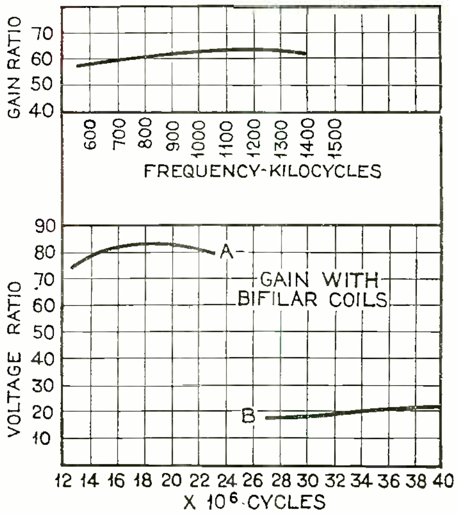
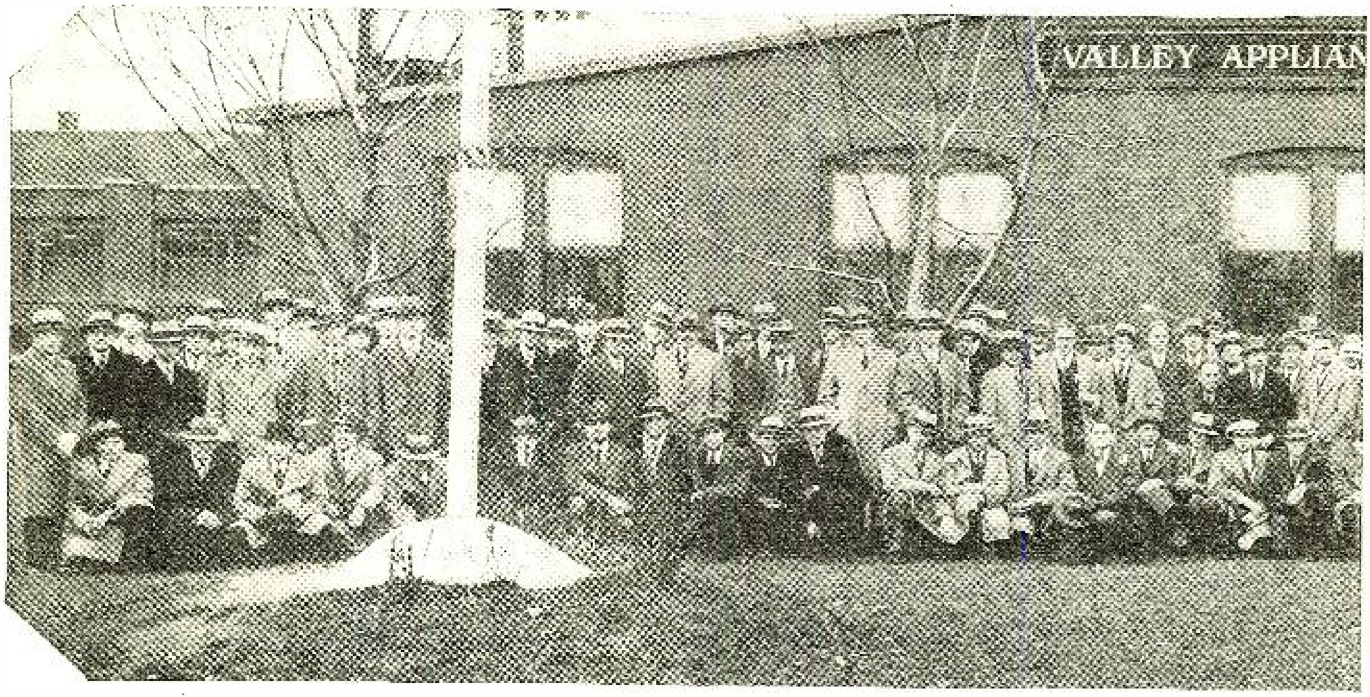


Fig. 1—Using three coils of the type described in the text, a relatively high order of "gain" is obtained, as shown by the curves to the left



Delegates who visited the Valley Appliance factory during the Eastern Great

A Sea-Going Desk Telephone

EVEN when he embarks on a sea voyage, the busy executive cannot escape the ring of his telephone bell, for at last the telephone has invaded the ocean liner.

Tests just concluded by the American Telephone and Telegraph Company between its radio telephone station at Deal Beach, N. J., and the steamship *Leviathan* some two hundred miles at sea, again call our attention to the fact that it is possible, from a standpoint of engineering, to enable passengers on ocean liners to communicate with almost any part of the world by telephone.

The conversations reported to have taken place between the *Leviathan* and various telephones in different parts of the country were rather inane in character, but their importance as conversations is minimized in significance by comparison with their importance as indicating a trend in a new service. A great many people will imagine that as a result of the successful tests, it is going to be possible for all steamships to be equipped with similar systems so that ocean travelers may be in constant touch with their offices and their homes.

Unfortunately, in the present state of development of the radio art, such a possibility is very remote. In order to bring about a system of this character it would be necessary for each of the vessels desiring to communicate in this fashion to have at least two distinct wavelengths. Each one of these wavelengths would cover a band. This band would have to be approximately as wide as the band used by a broadcasting station. Therefore, the number of stations it would be possible to operate by properly distributing all of the bands available would be very limited.

However, a recent report from England indicates that a flier or a radio engineer in the British Royal Air Forces has developed a radio communication system which will enable us to employ twenty-five telephone stations on a channel ordinarily occupied by one. If a situation of this character is brought about, it may be that marine communication by radio telephone will be in somewhat restricted use in a short time. Unless some such entirely new fundamental system is found, radio telephony for marine use is not likely to become general.

An Antarctic Epic

The following few paragraphs have been submitted to us by Mr. Alfred M. Caddell, and they express our own ideas so completely that we are reproducing them without change, in the belief that they will be of real interest to every RADIO NEWS reader:

"My calculations indicate we have reached the vicinity of the South Pole. We are now flying high over the Pole."

Current

By Arthur

(Byrd at the South Pole direct to the New York *Times* radio station in New York City.)

Out of the void, seemingly, the above message was flashed to civilization on the morning of November 29, 1929, and new radio history was made. The airplane "Floyd Bennett," bearing Commander Byrd, Pilot Balchen, Photographer McKinley and Radio Operator June was at that very moment flying over the very "bottom" of the earth. History was being made and written instantly—thrilling history, live history, imperishable history.

To grasp the import of it all one must go back twenty years, because we are living at so rapid a pace that many achievements of this sort lose their real significance. Who, twenty years ago, would have regarded as feasible the transmission, even electrically, of a message from the South Pole? Does this 1,600-mile flight to the Pole and return in less than twenty-four hours, and its report flashed instantly to the world by radio, contain any hint of the speed at which science is progressing? If so—if the achievements of the last twenty years may be taken as a criterion of progress to be expected within the next two decades—then indeed the thought is staggering.

In the July, 1929, issue of RADIO NEWS the story of the radio communication facilities which had been set up in the office of the New York *Times* and Commander Byrd's exploration base at Little America, Antarctica, was told. For practically a year, daily communication has been maintained over a distance of 8,000 miles by short-wave radio. Step by step the *Times* published the progress of the expedition as the news unfolded and was flashed over the intervening seas and continents by radio. Every day the wives and friends of the men engaged on this expedition received word from the exploration base and sent back cheering messages in return. No agonizing suspense as in the days of former polar expeditions, no wondering if the hardy pioneers were alive or dead. A truly scientific expedition it is, one which is destined to go down in history as an endeavor worthy of the highest acclaim.

Compared to the reporting of polar expeditions and discoveries of twenty years ago, however, one is forced to wonder if, after all, we are sufficiently appreciative of the great advance that radio has ushered in. When Amundsen sledged by dog team to the South Pole, several months elapsed before the

Lakes Division of the Institute of Radio Engineers recently held at Rochester

Comment

H. Lynch

news of his discovery reached the civilized world. And while an anxious world awaited even a single word from Scott, he and his party had long since perished on the icy polar wastes. It required 153 days for Peary to make known his discovery of the North Pole, only to find upon his return to the outposts of civilization that Dr. Cook had already been credited with discovering the Pole. Had it been possible for Admiral Peary to have flashed his discovery instantly as did Commander Byrd, the world would have been spared such a hoax.

On this polar expedition, radio has been subjected to a severe test, and it has come through with flying colors.

Brokers Afloat

It has been suggested that a number of ships in the merchant marine will follow the example of the *Leviathan* in providing stock market reports on regular schedules throughout the day for their passengers. After the capers which have been cut by the stock market during the latter part of October and early November, we wonder if a great many folks would care to have the stock market chasing them around while they are at sea—at sea physically, and possibly mentally.

Seriously, however, we believe that a service of this character would be extremely useful and it would be just one of those things which radio is doing which is destined to have a far-reaching influence on international industrial life.

Owls

We have received a number of extremely interesting publicity releases from the public relations department of station KSAT, owned and operated by the Southern Air Transport Division of the Aviation Corporation. Among the interesting facts which these releases call to our attention are the following: The station operates on 241.8 meters, or 1240 kilocycles, and even though the station has been in operation but a short time, the call letters have already been changed from KTAT to KSAT.

The chief item of interest in connection with this station, however, has to do with a particular program called "Flying the Sunrise Trail." This program goes on the air over the broadcasting station every Monday, Wednesday and Friday night from midnight until six o'clock in the morning. Among the interesting observations in connection with this station, we find that the audience listening to these very late programs comprises newspaper men, filling station operators, café owners, night watchmen, policemen, and various types of individuals who work at night, as well as social gatherings which appreciate this form of late entertainment when most other stations are silent. We wonder if it is possible that reports of criminal acts in Texas and surrounding states would be reduced if policemen in that territory withdrew from the broadcasting audience during those hours.

Canned Programs

Several organizations are now providing special programs, recorded on phonograph records, or on films, which may be put on the air at any broadcasting station at any time.

As a result of new recording and reproducing systems, the old objection to the use of mechanical devices at radio stations is largely obviated. In fact, some of the new records are far superior, from the standpoint of pleasing results from our loud speaker, to programs provided by less mechanical but greatly inferior entertainers. The proper distribution of these "canned" programs is of great benefit to the listener-in as well as to the sponsor of the program itself. The programs can be put on the air in the particular localities it is desired to cover at the hours which will best suit those localities, thus rendering a doubly effective service. By this mechanical process, also, it is possible to derive more effective results from the standpoint of real broadcasting than we are likely to have from many programs in which the performers appear in person.

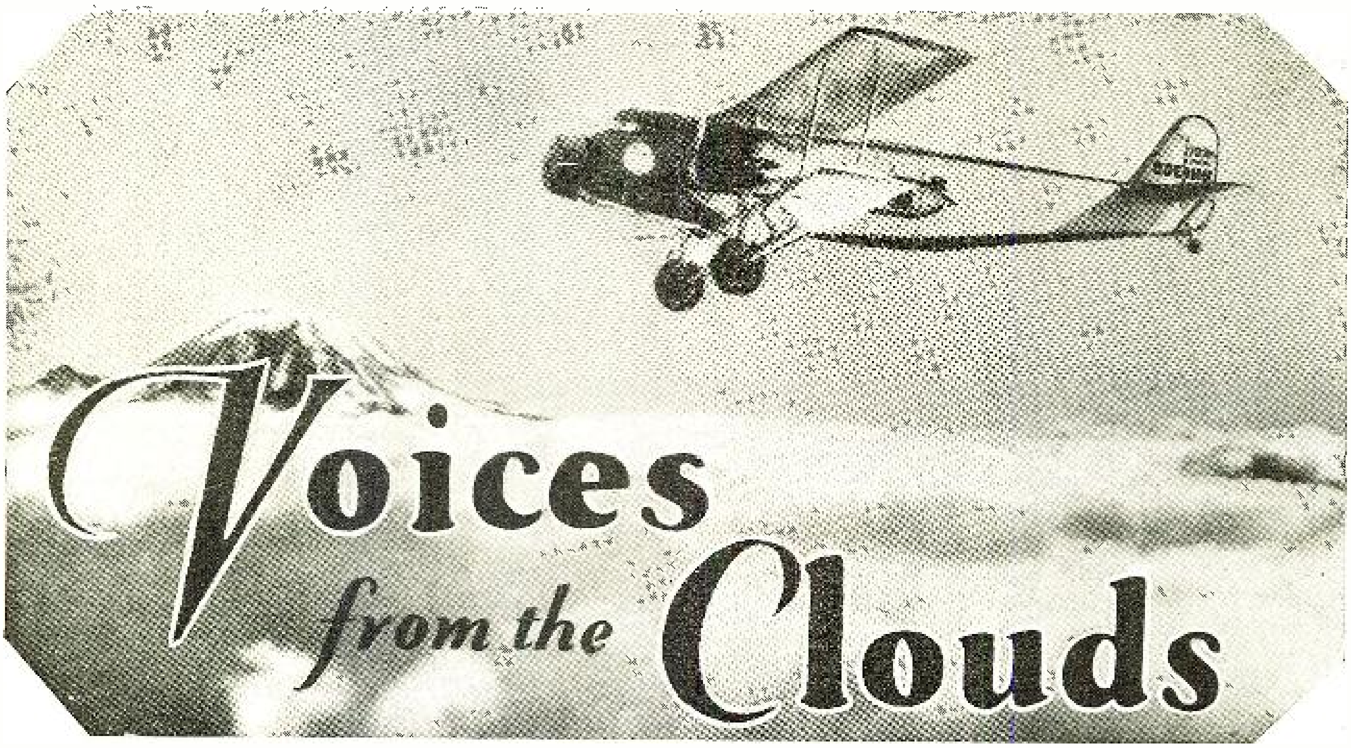
Soft Speakers

Every now and then some politician dashes into the limelight by calling attention to a campaign to reduce noise by eliminating loud speakers for private and public use. Several outbreaks of this character are going on in New York.

In connection with one of these cases, Alderman Joseph Clark Baldwin, 3d, who has made some interesting suggestions of this sort before, has made the following statement to the New York *Herald Tribune:* "There is need for some legislation along this line. The Noise Ordinance introduced last week is, of course, not in its complete form, but is merely something to aim at. A feasible ordinance will have to be drafted, this being only something to work on."

This Ordinance is by no means an attempt to curb radio reception. But, in a recent survey of a Sound Abatement

(*Continued on page* 740)



Plane-to-Ground Communication Now Carried on by Radiophone from an Elevation of 12,000 feet

By Robert Johnson

VOICE communication between a plane and the ground and between planes in flight has been brought to such a high degree of efficiency by the engineering personnel of Boeing System, operators of the Chicago-Oakland-San Francisco and Seattle-Los Angeles air mail-express and passenger routes, that Boeing pilots may now carry on conversation with ground operators from an altitude of 12.000 feet and as great a distance as 200 miles. Twelve ground transmitting and receiving stations along the transcontinental lines and seven along the Pacific Coast route have been established by Boeing System to keep its pilots constantly informed as to weather conditions and other matters pertinent to aviation over the two routes.

The development of an effective radiophone communication has resulted in a number of distinct advantages in the operation of mail, express and passenger planes and transports. Radiophone equipment adds much to the safety of flying; reduces the number of emergency landings due to uncertainty as to weather ahead; enables pilots to complete a greater number of trips on scheduled time; increases the payload of mail-express and passenger planes by reducing the amount of fuel formerly carried to give the pilot ample cruising radius when he is uncertain as to weather conditions; and is valuable in dispatching planes and giving flight instructions of pilots in the air.

The equipment in the plane weighs approximately 100 pounds, and is practically automatic in operation, requiring no adjusting on the part of the pilot, whose full attention may be directed to the operation of his plane.

Thorp Hiscock, Boeing radio engineer, with a number of associates, devoted a great deal of time and conquered many difficult obstacles in developing the radiophone. The first step was the selection of a wave length. A transmitter was set up and exploration was made of frequencies around 70 meters. A receiving set with a vertical antenna was installed in an automobile, and transmission from headquarters was made on schedules to the automobile, which traveled between 150 and 200 miles over varying terrain, halting at intervals of five miles to test reception. In this manner the entire distance was blocked off, and it was determined that 70 meters was satisfactory for point-to-point communication on the ground.

The next step was to equip a plane with radio apparatus and test the reception in the air. It was found that the 70-meter signal was effective only at an altitude of 1500 feet, and thus it was forced into the discard. A 50-meter signal was found to be satisfactory at all altitudes. Next it was necessary to confront the problem of night operations. Here the 50 meter frequency proved to be unsatisfactory because of erratic tendencies. 70 meters was again tested, without satisfactory results, following which the transmitter was re-tuned to 90 meters, where no difficulty was encountered in maintaining communication.

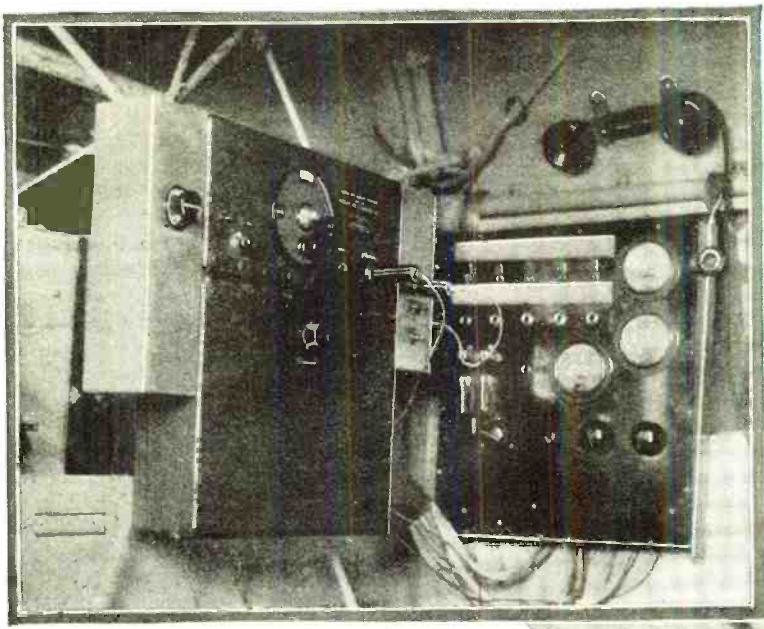
The use of high frequencies had been made possible by a proper preparation of the radio plane for reception. That short-wave telephony was possible in ground work was undeniable, but that it would be available for aircraft use was and is a debatable point. The discovery of the Boeing engineers was, however, that if the plane is properly bonded and shielded so that a sensitive receiver may be operated, no difficulty is experienced in obtaining two-way communication.

The bonding of the plane is not only essential from the standpoint of reducing static interference, but it is also necessary to insure the plane against possible fires during transmission. A loose piece of metal will pick up sufficient charge to develop a material spark.

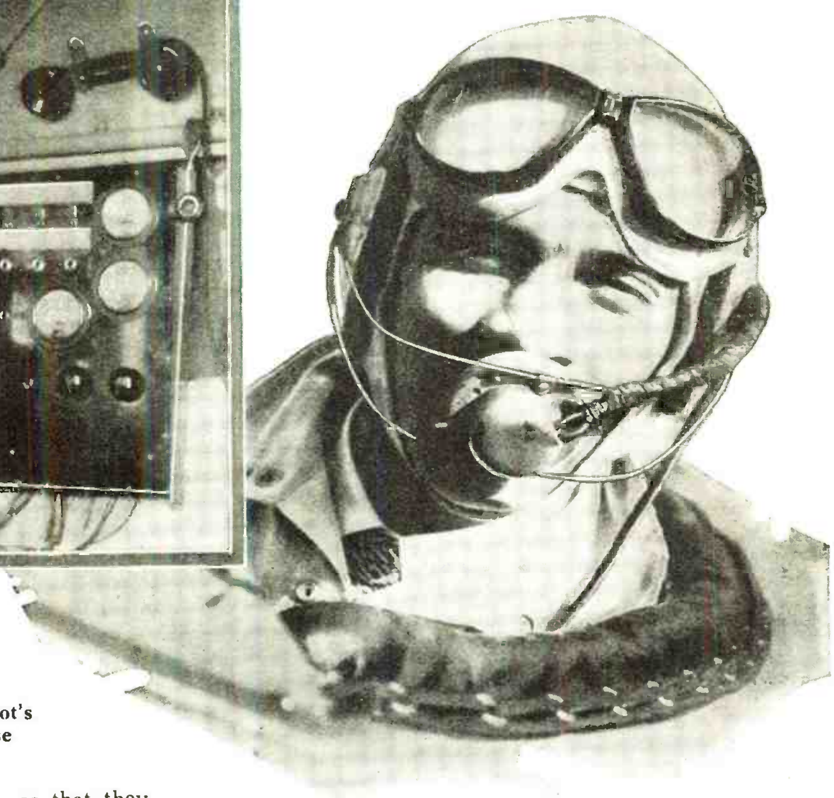
In the use of high frequencies, the static levels in these channels are as a rule rather low, and when a receiver operating at broadcast frequencies, or at longer wave lengths, is blocked by static, at the same time a 50 meter receiver may be functioning without difficulty.

In the bonding of the radio plane, a fuselage structure was equipped with an antenna and connected with a receiver. As every piece was added to the fuselage, it was tested for noise, and when noise developed it was bonded out. When the assemblage was completed, the plane was efficiently bonded.

Bonding is the connecting together of the metal framework,



Illustrating the radiophone installation in a transcontinental plane. The set weighs approximately 100 pounds



To the right, the microphone, attached to the pilot's helmet, leaves his hands free and ready for use

and, in fact, all of the metallic parts of a plane, so that they form one continuous electric circuit, leaving no unconnected gaps at any point within the structure.

Shielding of the ignition equipment, too, is essential before radio communication from or to a plane is possible. Were you to listen with a radio receiver in a plane whose motor had not been electrically shielded, you would hear nothing but a terrific storm of crashes similar to summer static in a broadcast receiver. These crashes originate at the make-and-break contacts in the distributor, the magneto and the spark that jumps the spark plug gap.

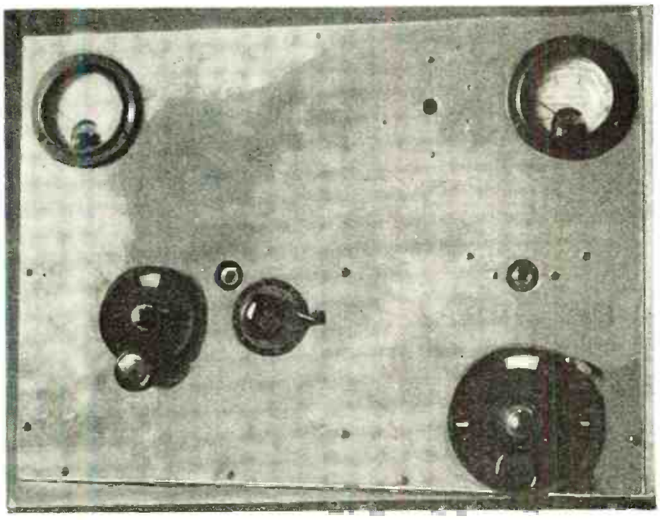
Interference of this character is overcome by encasing all of the spark plug leads in flexible copper armor, so that these noises will not escape and be picked up by the extremely sensitive radio receiver nearby. This covering, however, must be effected in the simplest manner possible, in order that it may not interfere mechanically with servicing of the planes. Interference from the ignition was effectively suppressed, and the plane was ready for undisturbed reception.

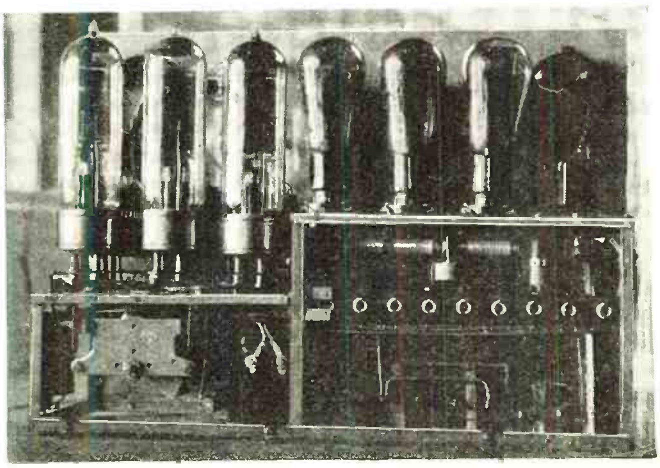
In the Boeing equipment, radio apparatus is mounted behind the pilot with remote-controls to the instrument board. A single throw of the switch can change transmission to reception. All that is required, then, is for the pilot to speak into a microphone mounted on his helmet directly in front of his lips. This arrangement permits complete freedom of the operator's hands at all times, except when throwing the switch to change from transmitting to receiving.

Soft rubber plugs, with phonettes attached, fit comfortably into the pilot's ears and are connected to the receiver with a fine silk cord. When transmitting, he simply speaks in a normal tone of voice, and when receiving, the voice he hears will be as distinct as if he were talking with someone across a table.

An adequate antenna for transmitting and receiving proved to be an eight-foot dural antenna mounted vertically on the top wing and stream-lined to reduce its resistance to wind. Power for the transmitter on the plane is taken from a double voltage generator on the engine. It also serves to charge the storage batteries and to operate the plane's landing lights.

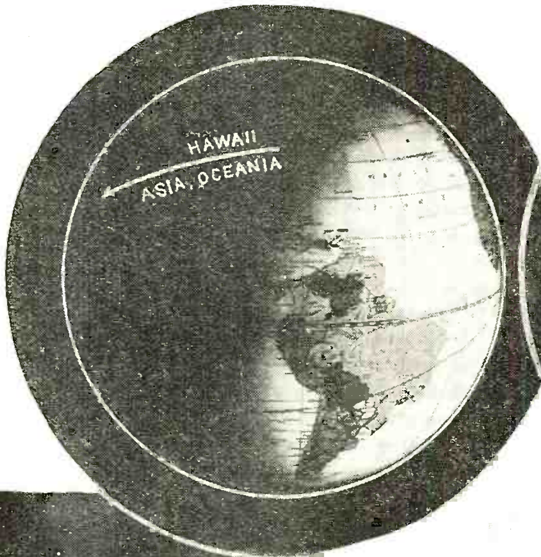
Boeing pilots are now talking from all elevations up to 12,000 feet with stations on the ground. The higher the plane is above the ground the more distinct, strangely enough, is plane-ground communication. It is possible to exchange conversations at elevations higher than 12,000 feet, but Boeing experimentation was stopped there inasmuch as that is the maximum flight elevation encountered on the two Boeing routes.

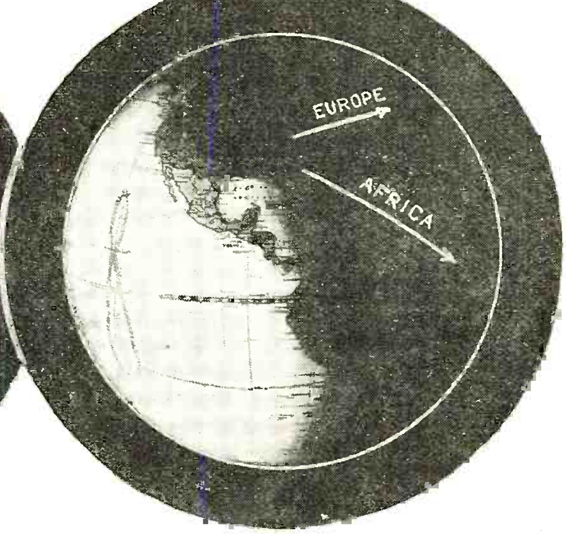




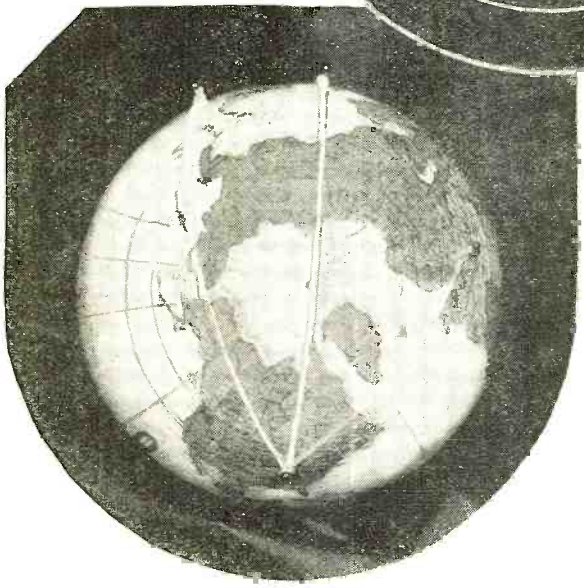
Above, a closeup of the plane radiophone set, and below it another view of the compact receiving and transmitting set of the Boeing planes

SUNRISE IN THE EASTERN U. S. Most favorable conditions for low-power communication with New Zealand and Australia. The earth's inclination corresponds to November or February





OVER THE TOP OF THE WORLD. If they follow the shortest (Great Circle) routes, signals from Chicago would shave Greenland to reach Central Europe, cut the Arctic Circle on the way to the Philippine Islands, and cross the North Pole on a direct line to India

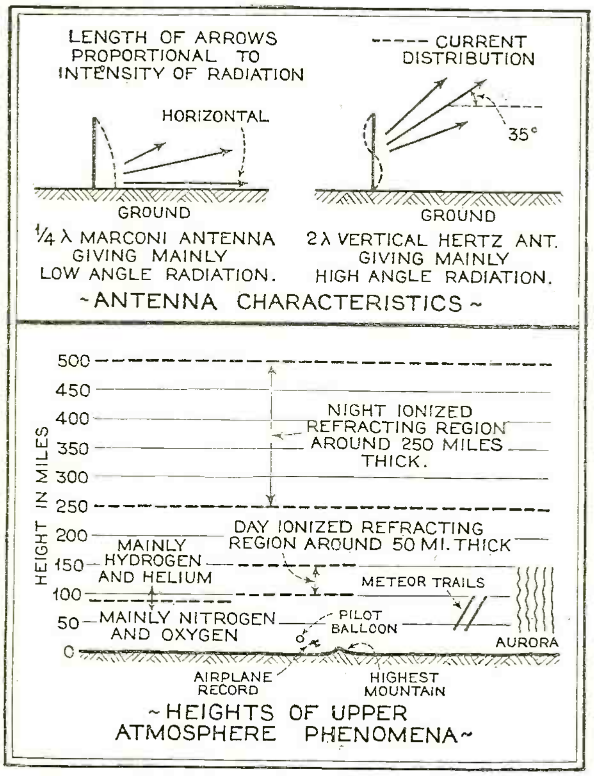


SUNSET IN THE EASTERN U. S. Most favorable conditions for low-power communication with Europe and Africa. The earth's inclination corresponds to November or February

MORE on Short-Wave

The First Complete, Authentic planation of Long-Distance

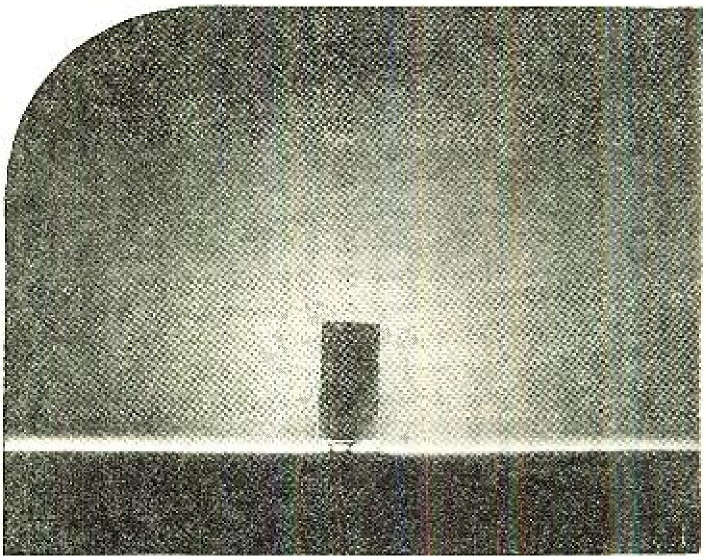
By Lieut. W.



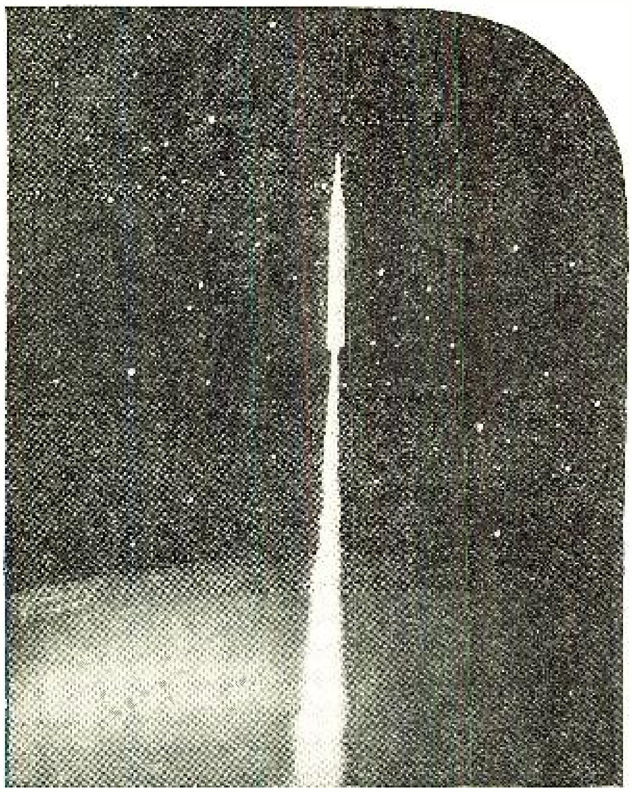
At the top, Fig. 1 shows the radiation characteristics of two types of antenna, while Fig. 2 (below) indicates the relative heights attained by man and those attained by the night and day ionized regions

IN the old days of long-wave supremacy an air of complacent finality pervaded radio transmission theory. This has, under the onslaught of the short waves with their worldwide range on low power, given way to a less comforting but more healthy uncertainty in which the radio engineer must consult the meteorologist and even the astronomer. The commercial companies seized quickly enough on the practical possibilities of the high-frequency El Dorado, with some possible benefit to mankind through the reduction of wireless rates; and for a time engineers were too preoccupied with what the short waves did to question how they did it. But now the tide has changed, and perhaps the greatest gift of the short waves to man will be in prodding him to further investigations outside the narrow ten-mile layer which he inhabits. Fortunately, the short waves provide a method as well as an incentive. If we set up a receiver near a powerful transmitter equipped to send a "jab" signal about 1/1000 of a second long, we can record, perhaps a thousandth of a second after the nearby shock has passed, an "echo" indicating that the wave has traveled some hundred miles up into the air, whence it was by some agency directed again downward towards the earth. And about one-seventh of a second later we may trace a second and much fainter echo, indicating that the wave has made in that brief fraction of time the complete circuit of the globe. How do these things happen?

In attempting here a readable and non-mathematical explanation, we shall have recourse to many illustrations and analogies. Radio waves are almost exactly like light waves except in size, and their performance on a large scale can often be visualized by studying the performance of light waves on a small scale. If our language seems



LIGHT FILAMENT ANALOGY OF A TRANSMITTING ANTENNA ABOVE CONDUCTING GROUND. The filament behind the screen radiates light in all directions. The "ground" absorbs some of the light, but reflects the rest of it to reinforce that coming directly from the filament



PROBABLE APPEARANCE OF THINGS IN THE IONIZED LAYER. The Goddard high-altitude rocket, only man-made contrivance capable of reaching these heights, zooming up from the earth dimly visible hundreds of miles below, gleams in the light of a blue-white sun, which blazes against a black sky filled with brilliant stars

LIGHT *Transmission*

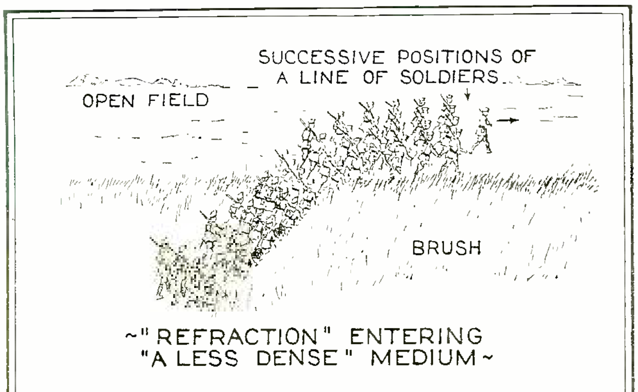
and Non-Mathematical Ex- Radio Transmission Theory

H. Wenstrom

at times a trifle abstruse, it is because the subject is more so: and if our facts and figures seem rather vague, it is because the foremost authorities of the present cannot yet find ground for exact agreement.

Antenna Radiation and Immediate Ground Reflection

Let us see first of all how the radio waves get away from the average antenna. We discussed at some length in a previous article the formation of the electromagnetic field about the antenna, and the fact that a part of this field speeds away in all directions. "In all directions" is not entirely correct, however, for the ground cuts off everything below the horizontal, absorbing some, reflecting some. As Morecroft has pointed out, an antenna over partly conducting earth is analogous to an incandescent filament over a partly reflecting surface. This is well shown in the photograph. The filament is behind the oblong pasteboard screen so that its glare will not fog the film, and the radiation of light into the surrounding smoky air can be clearly seen. The white paper "ground" cuts off practically all the downward radiation, reflecting a large percentage back up again into the air. If the horizontal surface were a mirror, we could see an inverted image of the filament below the real one; and in the same way if the ground below an antenna is a good conductor, there will be a well-defined virtual "image" of the antenna below the ground level. It is easily seen that if the ground is a good conductor (and hence a good reflector) the radiation is more efficient. For this reason big commercial stations are often



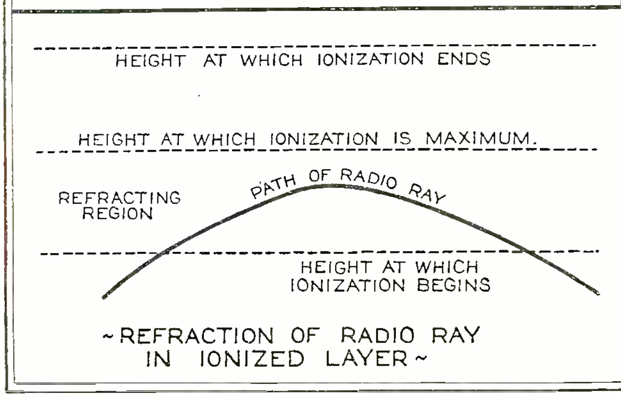
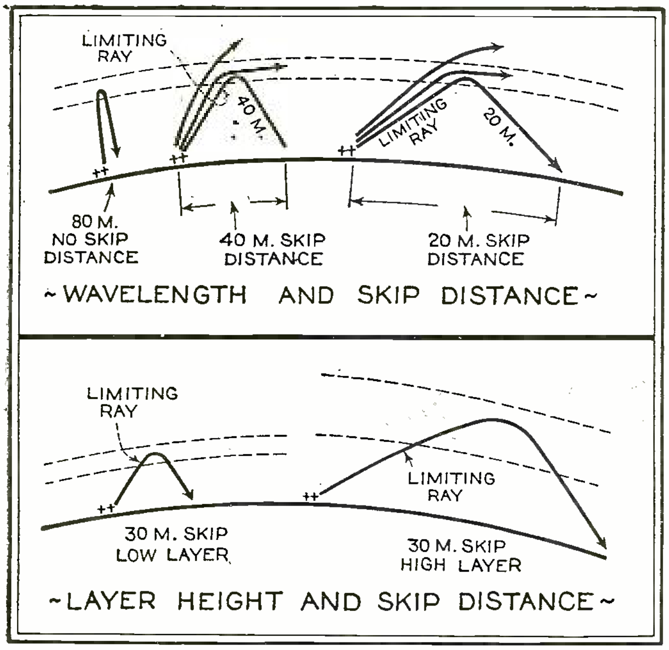


Fig. 3 (above) shows how the line changes direction to the right, because the soldiers on the left encounter the easier going first and for a short time walk faster than those on the right

Fig. 4 (below) illustrates how a radio ray is refracted due to the ionized layer.



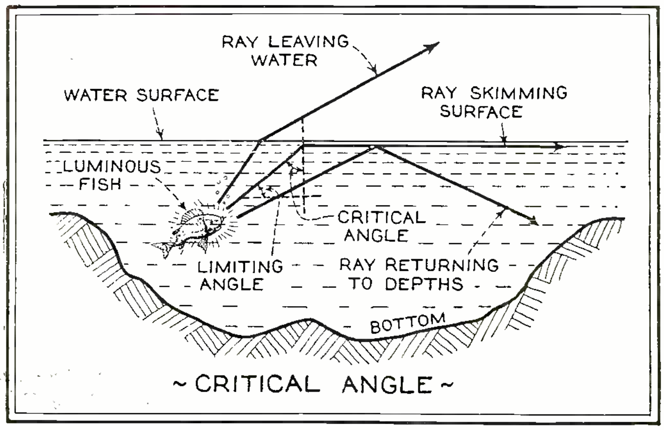


Fig. 5B (above, to the left)—For a given wavelength, as the layer rises, the skip distance increases

Fig. 5A (to the left)—For a given layer height (here pictured for a summer day), as the wavelength decreases, the skip distance increases

Fig. 5—A simple analogy depicting how rays of light from a luminous fish may, depending on the angle, be reflected from the surface or passed out into the air

located in salt marshes, and the ideal "ground" would be smooth sea water or large, flat metal serface. It might even be worth while to build such a surface, or to outline it with wires, beneath a short-wave transmitting antenna.

KNOWING the conditions under which you work is half the job. It is no less true in short-wave transmission than in every-day walks of life.

If you want to raise a station in Europe or Africa, your efforts will not be as successful if the attempt is made, let us say, at sunrise, as they will be if made at sunset. Similarly efforts to contact Australia will be more successful when the sun is just up than at sunset. Reasons for such phenomena are clearly described and explained in this noteworthy contribution by Lieut. Wenstrom.

The publication of this manuscript makes available, for the first time, as far as we know, a simple, non-technical application of the intricacies and vagaries of the theory and principles of short-wave transmission.

It is one thing to pound the key of a short-wave transmitter and hope to high heaven that your signals are "getting out." It is another thing to understand intelligently the limitations under which such work is accomplished.

If you are interested in the "how and why" of short-wave transmission, read this article.

THE EDITORS.

Even if the antenna is raised high above the earth, ground reflection and the "image" effect will still play some part in transmission. The present-day ceiling for an aircraft transmitter is less than eight miles, and this distance is small in comparison with long-range signal paths. Raising the transmitter in an airplane may, however, have an important effect on skip distance, as we shall see later.

Antenna Radiation Angles

We should recognize at this point that radiation patterns may differ widely for different types of antennæ—that is, one type of antenna may project most of its energy in a horizontal direction, while another may radiate chiefly at a steep angle. This is shown for two sample antennæ in Fig. 1. Horizontal radiation, and perhaps radiation for several degrees above the horizontal, may be absorbed by the earth. This absorption is less pronounced for short waves than for long ones; and therein, as we shall see, is the great advantage of short waves, that lower "rays" can be used.

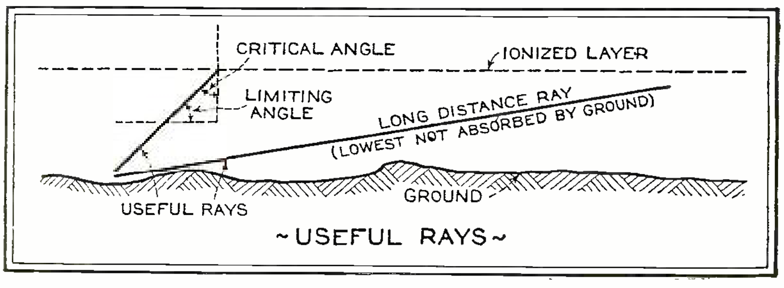
These effects are somewhat complicated by the fact that hills and buildings close to the transmitter may cast radio "shadows," and these shadows are sharper for short waves than for long. The same thing is true of light—the diffraction, or bending of light rays around a sharp edge, is greater for red than for violet. Even in sound the same principle holds. The sound of a cannon, fired on the opposite side of a hill or a large building, is muffled; the lower frequencies in the report, bending more easily around the obstruction than do the high ones, reach our ears in greater intensity.

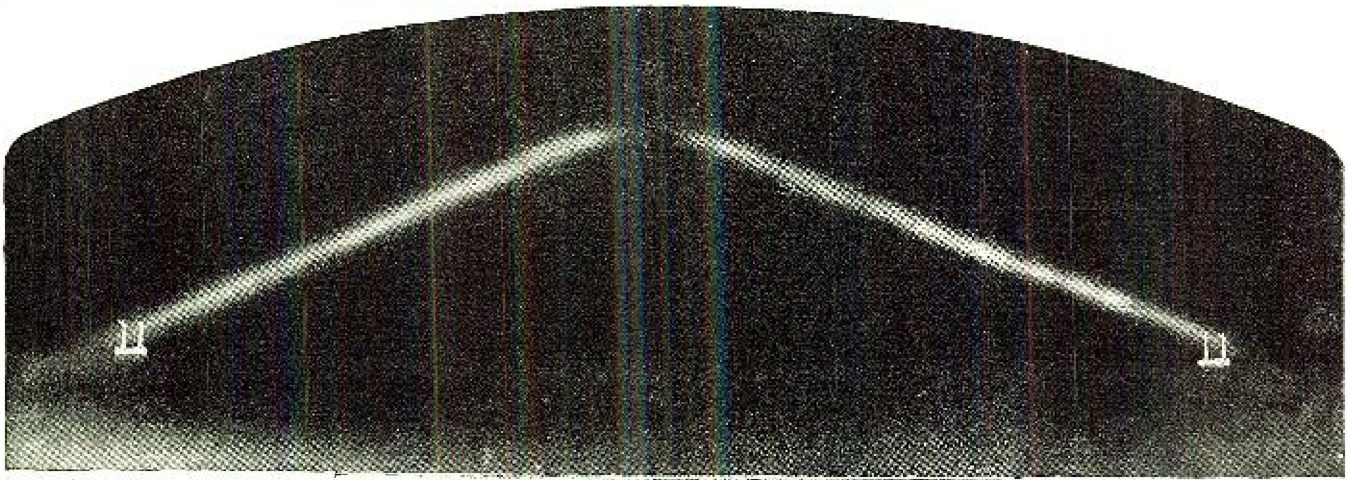
Before leaving the subject of antenna radiation angle, we might mention the possibilities of a horizontal parabolic reflector, arranged to throw a horizontal band of radio waves in a manner suggestive of a well-designed auto headlight. By moving the entire reflector system, it is possible to choose any maximum radiation angle at will. Such a reflector has been used by Meissner in Germany for 11-meter communication with Argentina.

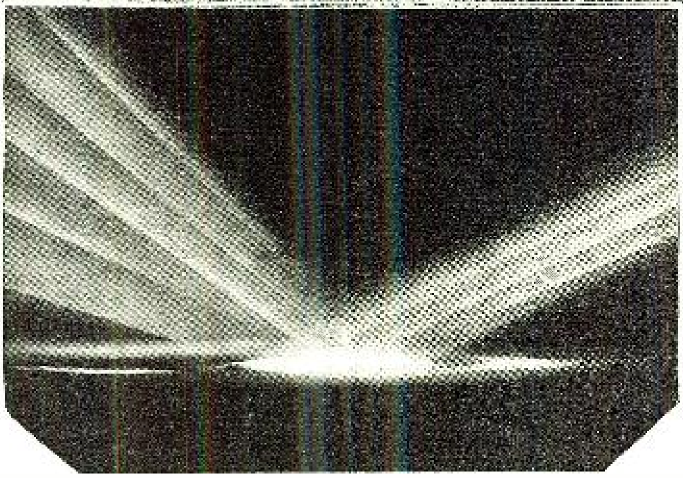
The Nature of the Ionized Region

The attempt to explain completely short-wave radio transmission has led to an intensive study of the nature of the earth's upper atmosphere. It was first thought that the upper air could act only as an absorber of radio waves, but as early as 1902 Kennelly, an American, and Heaviside, an En-

Fig. 6—All rays, between the limiting ray and the lowest ray not absorbed, return to earth







LIGHT BEAM ANALOGY OF GROUND-REFLECTED RADIO RAYS. When radio rays sloping downward from the ionized layer strike the ground, they are partly absorbed and partly reflected (generally with some diffusion)

LIGHT BEAM ANALOGY OF IONIZED LAYER EQUIVALENT REFLECTION. The light rays represent radio rays leaving the transmitter at high angle, to be "reflected" by the ionized layer down again to a distant receiver

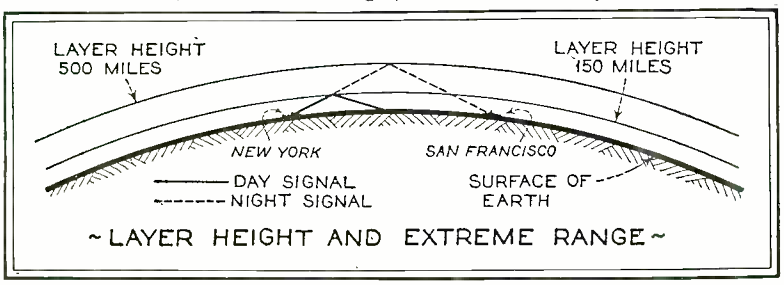
glishman, independently suggested that some reflective or refractive effect must be assumed to explain long-distance communication beyond the bulge of the earth. Since then the term "Kennelly-Heaviside Layer" has been used rather loosely by many writers to designate, sometimes a wide region, sometimes a definite surface or "shell." At the start we must realize that anything like a shell hundreds of miles above the earth's surface is the most monstrous impossibility, as extravagant as the solid sphere which the ancients believed to turn with the stars. There is absolutely nothing at these heights which would not be considered a very good vacuum at the earth's surface, and even at 30 miles, pressure has fallen to 1/1000 of its surface value.

Our knowledge of the upper atmosphere is far from final, because it has been arrived at largely by indirect means. The highest that a sounding balloon carrying meteorological instruments has ever ascended is about 20 miles—scarcely a beginning. But there are some indications of the height and nature of the upper air that anyone can notice. If we pass over the scattering of short light waves that makes the blue sky, or the transmission of long ones that makes the red sunset, the most common effect is the persistence of twilight after sunset and its appearance at dawn. This twilight is caused by the sun shining on the air high overhead, and the fact that it lasts about an hour indicates that the atmosphere up to a height of about forty miles is dense enough to scatter light. This gets us far above the range of the sounding balloon; other indications can carry us higher.

On clear, moonless nights we have all noticed "shooting stars" or meteors coursing swiftly across the heavens. They are specks of iron or rock, mostly smaller than pinheads, which approach the earth with velocities ranging from ten to fifty miles a second. They come originally from the break-up of comets by the sun's radiation pressure, and the comets themselves perhaps came from the Orion nebulous regions when the solar system was passing through them six or eight million years ago. Due to their high velocities, these meteors begin to glow with frictional heat in the rarefied gases a hundred or more miles above the ground, and they usually burn out above fifty miles. The prominent hydrogen and helium lines in their spectra indicate that the upper atmosphere consists largely of these gases. The photograph shows a meteor, and the pulsing light near the center of the trail apparently indicates successive explosions as the surface layers are enormously heated, vaporized and stripped away. As we shall see, radio signals themselves now furnish some of the best experimental evidence about the atmospheric heights.

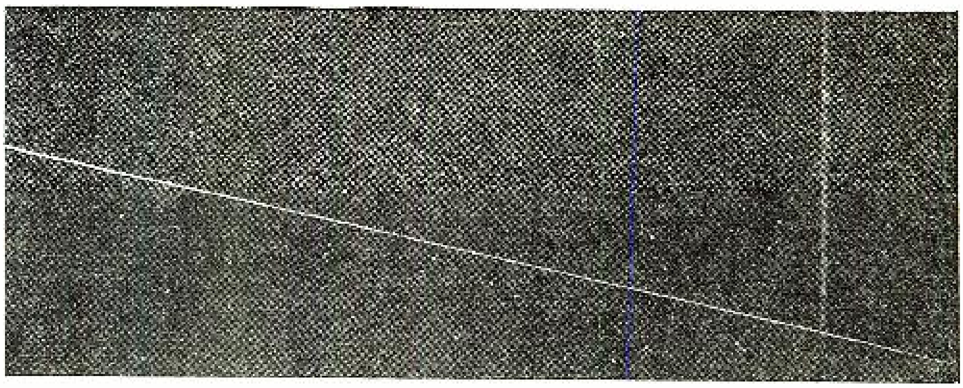
All these determinations are of course reachd indirectly, but they are in fair agreement. The only man-made device which gives much promise of carrying instruments to these heights is the Goddard rocket. A hypothetical observer rising with one of these would notice many strange phenomena. The pressure diminishes rapidly, the blue sky changes to violet, between 50 and 80 miles up the familiar nitrogen and oxygen give way to hydrogen and helium. The violet sky fades to black, planets and stars appear despite the sun, which has become bluer and more intense. Finally, at 500 miles, as pictured in the photograph, the sun shines brilliantly on the rocket and its trail, the sky is completely black and the stars very brilliant, and far below appears the dim bulge of the sunlit earth.

Fig. 7 shows why it is possible to transmit on 40 meters between New York and San Francisco at night, but not in the daytime



Having achieved a reasonable picture of the upper atmosphere, let us inquire more fully into the behavior of high-flung radio waves. When a diffuse gas is subjected to certain radiations, electrons are knocked out of some of its atoms, and wander about by themselves or attach themselves to complete atoms. The gas therefore contains three unusual things: free electrons, positive ions (atoms which have lost electrons), and negative ions (atoms which have picked up extra electrons); and under these conditions it is said to be ionized. It is the ionization of the upper air that makes possible the return to earth of upflung radio signals. The ionization, as we go upward, begins at about 20 or 30 miles, increases up to about 100 or

150 miles or possibly more, and thereafter does not increase and may decrease. The major cause of this ionization is the ultra-violet light from the sun, which of course strikes only the daylit hemisphere. In addition, this stupendous energy-machine, of which we hope to say more in a later article, throws out at inconceivable speeds myriads of actual electrons (β particles) and many ions (α particles). These particles do not continue, like the ultra-violet, straight toward the daylit side of the earth, but many of them follow the lines of force of the earth's field and converge at the magnetic poles, whence they may migrate equatorward to some extent. The concentration of this form of ionization has striking visual proof in the aurora borealis and aurora australis, brilliant and colorful displays of diffused light which seems to radiate from the magnetic poles. But as a matter of fact the green (oxygen) line of the aurora is always present in the night sky even at the equator, and demands a supplementary explanation of night ionization. The probable cause is cosmic radiation—electro-magnetic waves about one ten-millionth as long as visible light waves—that appear to originate from the destruction of atoms in the great suns that we call the stars. In general, we can say that the ionized region is somewhat more intense and extends somewhat lower in the daytime, and is less intense and higher at night. It is also more intense and lower in summer than in winter.



Photograph courtesy Harvard College Observatory

An actual photograph of a meteor trail. The meteor is coursing across the starlit heavens on a moonless night. Note the broken appearance of the center of the trail, probably caused by repeated explosions of the meteor's outer surface.

Refraction in the Ionized Region

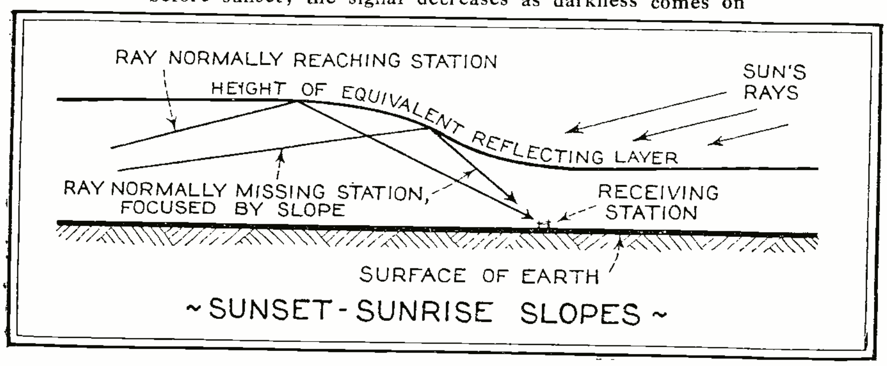
We have said that ionization denotes the presence of electrons and two kinds of ions; in short-wave radio transmission the ions scarcely count, and the important thing is the number of free electrons per unit of space—the electron density. The effect of increasing electron density is to reduce the dielectric constant of space and, as the velocity of a radio wave is inversely proportional to this dielectric constant, to increase velocity above that in empty space. In other words, a radio "ray" (or beam reduced to negligible thinness for convenience of discussion) is entering a "less dense" or "lighter" medium when it enters an electron bank, just as a light ray enters a less dense medium in passing from water to air or from glass to air. Now a ray entering a less dense medium at an oblique angle will be bent out of its straight course, or refracted. This effect can best be visualized by the homely example of Fig. 3. A line of soldiers is moving slowly through some brush and high grass, and suddenly comes out obliquely into an open field where each soldier can walk faster. The soldiers on the left of the line, having the advantage of open ground first, will tend to get ahead of the others, and in an effort to straighten out the whole line will change direction somewhat to the right. The radio ray, entering a region of increasing electron density as shown in Fig. 4, behaves in exactly similar fashion; and having left the earth's surface on an upward slope, is bent downward again towards the ground. Any one ray is actually refracted into four different rays, but in the interests of simplicity we shall only consider one of these. You may ask, "How can one be so definite about something quite invisible so far above the ground?" The answer is that the general hypothesis is borne out by repeated experiments under several different methods, and the evidence is steadily accumulating.

Some years ago it was thought that the radio rays were reflected from the under surface of a fairly definite ionized (conducting) "layer," and this may occasionally occur. In the great majority of cases, however, the ray is refracted (bent traversing different mediums) rather than reflected (made to rebound by a surface that will neither absorb nor transmit it). Nevertheless, we often find it more convenient to discuss the phenomena and represent them graphically on a reflection basis. By "refracting layer" we mean the region where the ray begins to bend and where it starts downward. By "equivalent reflecting layer" we mean a hypothetical reflecting surface which would give the same downward-directing results as a given refracting layer. Sometimes we shall speak of one, sometimes of the other. It is only necessary to remember that the actual summit of a ray is, in general for short waves, about three-fourths as high as the "equivalent reflecting layer." The third photograph shows a light beam analogy of equivalent reflection. The light beam slopes upward from one of the miniature stations on the ground, strikes the "layer," and is reflected downward to the other ground station.

Height and Extent of the Refracting Layer

When we speak of layer height and changes in that height, we do not mean that any definite and tangible thing has physically moved up or down. Rather do we mean that changes in the ionized region have made the particular layer which is refracting certain radio rays a higher one or a lower one. As a matter of fact, the effective layer height varies slightly with the inclination of a given ray; and varies considerably with wavelength, being perhaps twice as high on 20 meters as on 80 meters. But the great variations of layer height come with summer and winter, day and night. It is lower in summer, higher in winter; lower in the daytime, higher at night; intermediate for fall and spring, early morning and late afternoon; lowest on a summer day, highest on a winter night. The effective height under these various conditions is probably somewhat as follows: Summer day, 50-100 miles; summer night, 150-220 miles; fall or spring day, 80-150 miles; fall or spring night, 200-300 miles; winter day, 100-170 miles; winter night, 300-500 miles. Over the poles the layer is probably very low in summer due to perpetual daylight, and very high in the winter of continued darkness. As for the effects of layer height, a low layer discriminates against long waves in favor of short and ultra-short ones, while a high layer favors all waves that it bends down at all. Just how this works we shall see later. Below the refracting layer there may be an absorbing layer, very important for waves (*Continued on page 736*)

Fig. 8—Possible "focusing" of scattered rays on a receiving station. This theory explains strong signal of the British Chelmsford phone station in eastern U. S. just before sunset; the signal decreases as darkness comes on



Vaughn De Leath

The VOICE of FIRESTONE

Introducing Vaughn De Leath and Franklyn Baur, Two Well-Known Radio Personalities

By P. H. W. Dixon

Franklyn Baur

THE Voice of Firestone stands high among the radio presentations of the National Broadcasting Company, and high in the estimation of its listeners. It features two of the outstanding personalities of the air—Vaughn De Leath and Franklyn Baur.

Miss De Leath and Baur have several things in common. Both have been before microphones almost from the time when radio was born. (Miss De Leath was the first woman ever to sing in a broadcast program.) Both are limited by contract to one broadcast a week. Both are at the top of radio's ladder of fame.

Vaughn De Leath was born in Mount Pulaski, Illinois, and made her début there as an entertainer. She was just three years old when she first faced the footlights in a home-talent minstrel show.

She directed an orchestra when she was twelve years old. When thirteen, she sent out to thirteen different publishers thirteen copies of a song she had written. She sold the song to the first bidder, although there were several other offers. Recently she has had published another song, "Old Glory, I Salute You," that she first made popular on the air and that was written when she was twelve years old. Not long ago she found it in an old trunk and tried it out on the air—with success.

She was graduated from Mills College in California, going from there directly onto the concert stage. She did her share of starving in those early days of her musical career, she says.

After coming to New York, in 1919, she began to taste success when it was discovered that her voice was excellent for phonograph records. In January, 1920, she did something she had never done before, and something no other woman had done at that time. She sang before a microphone.

The event is important enough to be told in some detail. The studio was a little room in the tower of the Pulitzer Building in Park Row—a room reached by climbing three flights of winding stairs. There wasn't space enough for a piano, so an accordion was used. Dr. Lee DeForest was in complete charge of the broadcasting, which was still very much in the experimental stage. The microphone had a horn on it—a horn originally designed for a 1904 model.

Since then Miss De Leath has been definitely associated with radio broadcasting. She sang for WJZ when that station was the only one east of Pittsburgh. In 1923 she managed and directed station WDT. On occasion she even did her own announcing. During the early days of radio tests her voice was picked up at seven European listening points at the same time.

Although she is primarily a radio artist, she still makes phonograph records which are popular in Europe as well as in the United States. She writes both the words and music to songs, and is the author of a number of popular compositions. Her semi-classical compositions may be found in any modern library.

Franklyn Baur, the tenor Voice of Firestone, made his début as an entertainer somewhat later in life than Miss De Leath. He was eight years old before he tucked a violin under his chin and took his bows at public gatherings. With no insistence on the part of his family he studied violin for six years. Then he gave up the violin and devoted two years to studying piano. It was not until he was sixteen, however, that he discovered his singing voice.

When he was eighteen, Baur heard that the Park Avenue Baptist Church of New York was looking for a soloist. He applied for the job. So did more than one hundred professional singers. Baur was selected.

Concerts followed, and then he went abroad to sing. He was heard by the Prince of Wales, who commended him publicly. Homesick, he returned to America and began making phonograph records. Scouts from the radio studios discovered him, and he went on the air. One of his early radio appearances was as tenor with the Shannon Four in an Eveready program series. He was also featured in programs which are now part of radio history. Florenz Ziegfeld heard him and sent for him. The result was that Baur was featured in the Ziegfeld Follies of 1927. But he left the Follies the next year to return to radio.

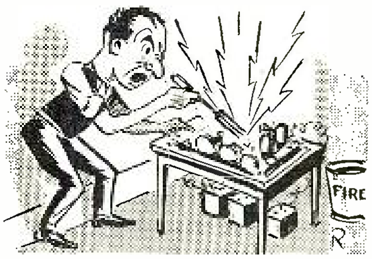
Although he is a familiar and well-known person to radio audiences, Baur is only twenty-six years old.

TRAPPING the

Illustrations by
J. P. Ronan

In Which a Noted Radio ... of His Experiences in ... of Hum Elimination

I HAVE a friend who is a very eminent lawyer, a patent lawyer. He has spent the best part of his life with patent development in the electrical industry. He has recently taken a prominent part in an important patent suit relating to electric radio sets, during the course of which about two thousand engineers and electrical experts have expressed their views and explanations of the particular kinds of hum in those electric radio receivers which were the subject of this legal controversy.

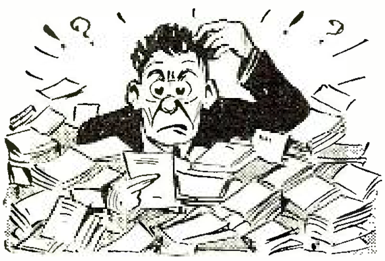


"—prod and poke this terrible thing to see why it hummed"

A week or two ago my friend said to me, "Miessner, what is all this commotion about hum in these a.c. sets—what makes them hum? Tell me in a few words——"

About fifty separate and assorted kinds of hum started swimming across my subconscious view, singly and in various combinations and permutations before the last questioning rise in inflection of his voice denoted the end of his query. I staggered, mentally, under the weight of this awful load. "Why indeed," thought I, "why should they hum, anyway? Why should the earth revolve? Why should a chicken cross the road? Why should certain lines in nebular spectra be due to transitions in OIII, NII, OII, and SII, occurring in violations of Loparte's rule? Why in a word or two should any exceedingly complex thing be so?"

I regained my composure presently and began an explanation which must have sounded by its beginning as if it would take at least two minutes to finish, when my friend interrupted me with just a trace of impatience, "No, no, no! Tell me, in a sentence or two, why should they hum anyway?"



"I alone have about 2,000 pages of note-book records"

Needless to say, I could not give him an answer that would meet my own critical judgment. When I had looked perplexed and embarrassed long enough to satisfy him, the smile he then displayed told me he had had his little joke at my expense.

Your editor also has asked me to tell you about hum in electric sets, but seriously, and without the humor of my friend, he has given me not a sentence or two, but as many sentences as may be necessary to tell it.

About fourteen years have elapsed since alternating current was first used on a vacuum tube. The hum in those days was so apparent, so strongly and persistently apparent, that only the stoutest hearts and bravest souls dared prod and poke this terrible thing to see why it hummed!

To learn why the use of alternating current instead of direct current makes a set hum, and to design it so that it will not hum, at least to an objectionable degree, has taken all these years, and perhaps the story is not yet finished. I say, as a fact that no one dare deny, that if all the theories, patents, notebook records of inventors and researchers on a.c. operation were laid end to end they would reach at least as far as Betelguese and two-thirds of the way back! I, alone, have about two thousand pages of notebook records on this subject, counting thousands of measurements, curves, oscillograms, theories, etc., and this, I am sure, is only a minute fraction of the total. The hum problem holds considerable fascination in spite of its droning monotony. But it has not the fascination of the nugget or the diamond under tons of rock or clay; it holds not the lure of the Holy Grail, or the Elixir of Life; these are always in the offing to beckon us forward and encourage us onward.

"—drag each one out by the ears"

Hum, like the convict's chains, we have always had with us, an asthmatic hindrance to our voice, the Brewster's millions we must somehow get rid of to achieve our goal; the needle scratch which has always marred the beauty of our electrical phonographic reproduction. Not how to achieve it, but how to get rid of it, and have, without this disadvantage, all the other wonderful advantages of a.c. operation, is the problem. That,

THE most complicated storage battery receiver of earlier broadcasting days involved fewer problems in design than the simplest of modern a.c. receivers. With the advent of the first a.c. tube, in commercial form, which could be operated from the light socket, came the necessity for solving problems which had not hitherto existed. Chief among these problems was the reduction of hum.

This has already been accomplished more or less satisfactorily, but it remained for Benjamin F. Miessner to make scientific analyses of hum phenomena, segregating them into as many different forms as possible. Then he studied them individually and in their relation to each other.

By
Benjamin F. Miessner

Engineer Outlines Some Attacking the Problem in A. C. Receivers

at least, was the problem. It has been modified, as all such problems are sooner or later in this commercial world, to read: "How can we accomplish this in the simplest, most practical and most inexpensive manner?"

How these problems have been and are being solved, therefore, is our subject. We propose to separate and assort all the varying causes of hum existing in such a complex aggregation as an a.c. radio receiver, drag each one out by the ears, set it down before you and tell you as much about it as may be considered useful or interesting.


"—were bottled up inside an evacuated tube"

I say "we" advisedly. I expect help, very generous help, in this undertaking. Perhaps my assistants will be generous enough to carry the whole of the burden and leave me to work and learn instead of talking about it—But enough of this, and now to work.

Radio in the beginning used batteries, that is, radio involving vacuum tubes. These vacuum tubes were designed for battery operation, which was no inconvenience in the laboratory, nor in the wireless signalling stations into which they quickly found their way. They persisted, in fact, into the broadcasting developments which followed and were for several years accepted as part and parcel of the receivers which they supplied with power. To use alternating current as a power source, instead of batteries, occurred to many, but the results of experiments were so discouraging that progress was slow. This applies not so much to the substitute of socket power for "B," and later, "C" batteries, which soon came into use, as to "A" batteries. Progress in this work was slow and difficult.

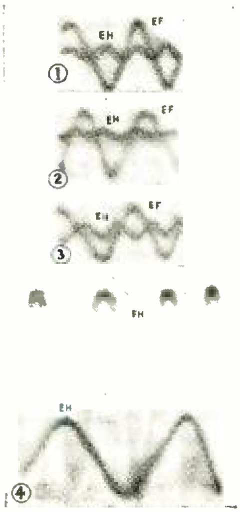


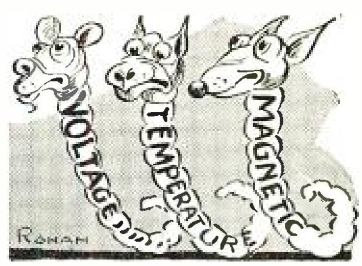
Fig. 1—Oscillogram of voltage effect hum of a -26 tube
Fig. 2—Plate of -26 tube temperature effect hum
Fig. 3—Striking example of magnetic effect hum using a -26 tube
Fig. 4—This -99 tube showed a strong temperature effect hum

Of course, as hindsight is much easier than foresight, it is not so difficult now to understand what goes on inside a vacuum tube, whose filament is heated by alternating current, as it was some years ago.

We knew that alternating instead of direct current heating power in a tube caused a loud hum which interfered to a more or less objectionable degree, depending upon how much amplification followed this tube. Theories aplenty suggested themselves, all likely enough it then appeared, but the question was, which were right and which were wrong? With plenty of facts to fit the theories, this question would not have been so difficult. But facts were scarce. And when we stop to reflect that these facts, or at least the causes of the hum we were seeking, were bottled up inside an evacuated tube, and that the forces and actions inside it are invisible and intangible, incapable of affecting any of our sensory equipment directly, we realize that our facts must be procured in round-about ways, pieced together, and then tried upon the theory.

We do not know yet with great accuracy all that goes on in a tube under this condition but several of the suspected and most important hum causes have been very definitely identified and the nature of their effects determined. These three are Voltage, Temperature and Magnetic effects.

These effects are present, always, in a tube whether its filament be energized by direct or alternating current. With direct current they are fixed and unchanging and so can do no harm by introducing disturbing noises; with alternating current, however, they are constantly varying, and at a frequency well within the frequency range the tube is used to amplify, so that an unwanted signal, the hum, is introduced and amplified along with the desired signal.

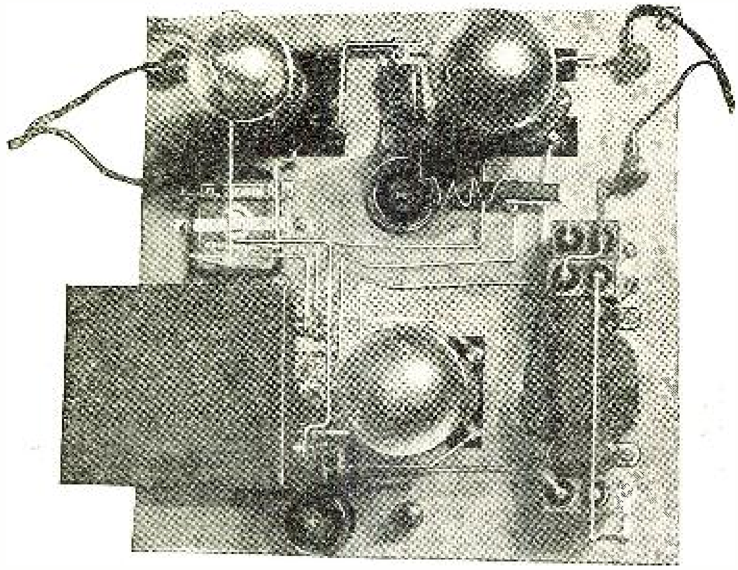


The Three Mighty Hum Dragons

The voltage effect is due to the alternating voltage variation along the filament from one end to the other, which causes an increase in the plate current of the tube for each increase in the filament voltage. This increase in (*Continued on page* 769)

These analyses involved, first, the designing of highly specialized laboratory equipment with which hundreds of oscillograms were made. Then the real work began. Like the diagnostician seeking clews to maladies revealed only by X-ray photos, Mr. Miessner devoted years to the study of these pictures of wave forms. His efforts have not been in vain, for there is probably no one who knows more about what takes place in vacuum tube circuits than Mr. Miessner.

This is the first of a series of articles on his important system which saves the radio manufacturers more than $1,000,000 a year. This series is an exclusive RADIO NEWS feature.



Top view of a compact three-tube power amplifier-power supply device of the direct-coupled type, showing layout of the parts. The circuit is shown in Fig. 1

The Amplifier

New direct-coupled audio few cycles to over 3,000,000 and requires no interstage

By Edward H. Loftin

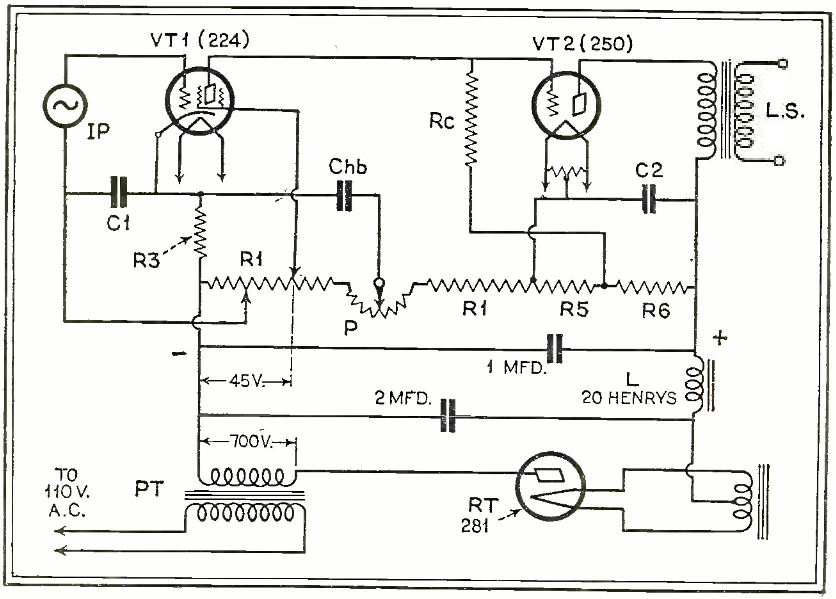


Fig. 1—Here is the direct-coupled audio amplifier and power supply circuit with values of parts employed as follows: VT1, -24 tube; VT2, -50 tube; R1, 5,000 ohms; R3, 25,000 ohms; R5, 100,000 ohms; R6, 300,000 ohms; Rc, 1/4 megohm; P, 400 ohms; Chb, .1 mfd.; C1 and C2, 1 mfd.

IN beginning the second of our series of articles covering a.c. operation of direct-coupled cascaded tube systems we deem it desirable to first include a brief statement of the problem as we view it so far as audio amplification and detection-amplification are concerned.

In any audio amplifier or detector-amplifier the following characteristics require attention: 1, frequency discrimination; 2, wave-form distortion; 3, hum, if a.c.-operated; 4, reasonable gain from the tubes used; 5, cost; 6, manufacturing tolerances.

In a.c. operation of direct-coupled cascaded tube systems the characteristics depend upon or are influenced by the following features:

1. Maintaining the operation of all tubes at the midpoint of their operating or output current curves, or what may be termed stabilizing against "drift" tending to arise from (a) changing tubes (they are not all alike), (b) change of constants or conditions due to (a') aging of resistors, (b') temperature coefficient effects in resistors, (c') line voltage modifications, (d') grid emission from tubes, (e') gas current in output tubes, (f') manufacturing tolerances.

2. Feedback phenomena at audio frequencies; 3, the hum problem; 4, motorboating; 5, trigger action; 6, maximum gain of tube; 7, providing current for auxiliaries, such as speaker field, and 8, increase to very high gain, such as that required by photo-electric cell operation.

Since the direct-coupled cascaded system is usable as a most effective detector-audio amplifier, it is well to keep in mind the following desirable features of which the system is capable in addition to those listed above:

1. Low grid bias for weak carrier currents and high grid bias for strong carrier currents, automatically self-adjusting.

2. Supply of potentials for the radio-frequency tubes sufficiently filtered to prevent modulation hum.

For those of our readers who may wish to construct an a.c.-operated direct-coupled amplifier we shall outline the

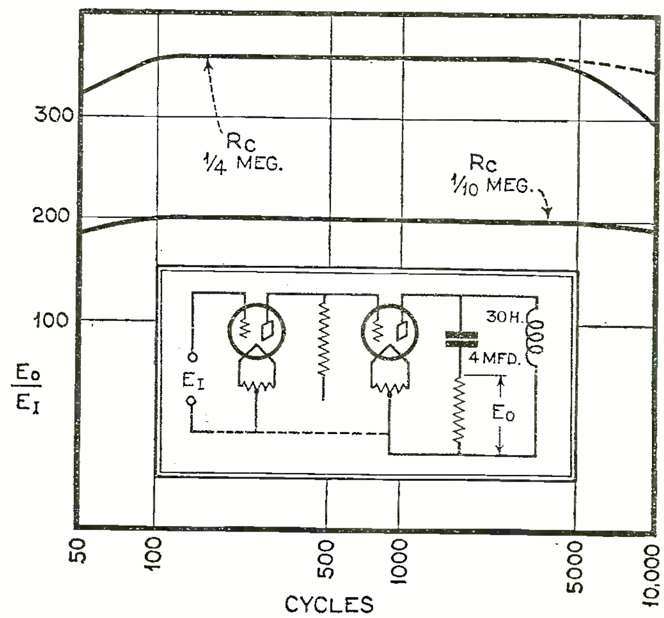
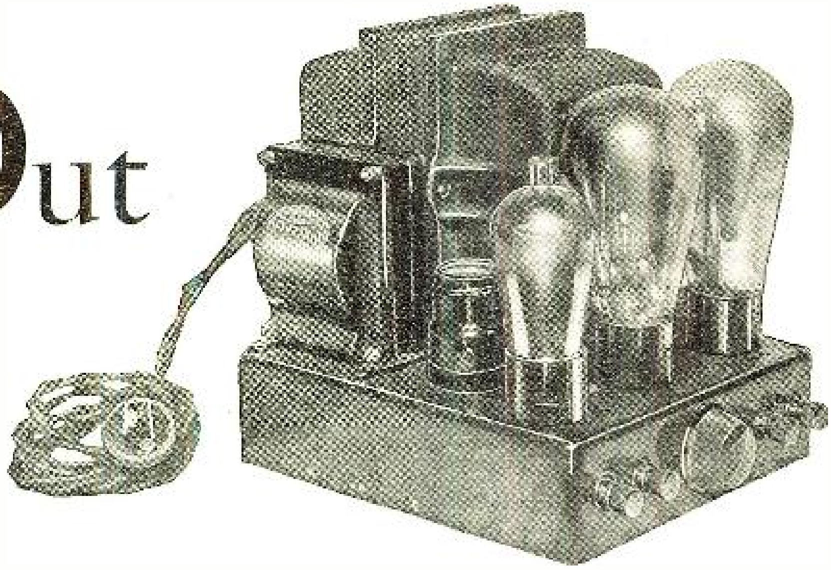


Fig. 2—Two curves which illustrate the direct-coupled amplifier's flat, equal frequency response over a band of from 50 to 10,000 cycles. The insert circuit shows the output system employed in obtaining these curves

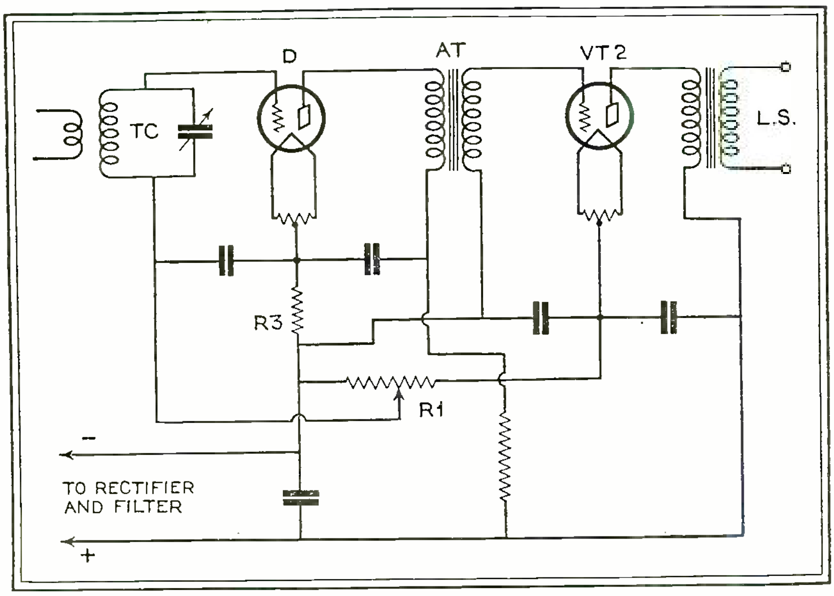
Steps Out

circuit covers range of
—is of simple design
coupling apparatus

and S. Young White



Transformer, tubes, resistances and condensers, all compactly arranged . . . and there you have the Loftin-White direct-coupled amplifier



¶ Truly embracing a new amplification theory, the Loftin-White direct-coupled amplifiers undoubtedly will bring about a revision of accepted amplifier principles.

¶ Utilizing only two tubes, and a rectifier in the power supply unit, tremendous amplification, combined with a signal frequency response which is amazingly flat over a wide frequency range, is obtainable with the direct-coupled system.

¶ Compactness and simplicity of construction, almost beyond description, characterize these new amplifiers which bid fair to exert a deciding influence over future receiver design.

THE EDITORS.

details of a system which we have found to give highly satisfactory audio amplification and detection-amplification results. The system is diagramatically shown in Fig. 1.

Forget Former Conceptions on Audio Amplifier Theory

In preparation for following our discussion of direct-coupled systems we suggest that the reader relax from his current conceptions and practical knowledge of tube and circuit characteristics and operation effects familiar in other systems for the reason that there are many occurrences and effects in direct-coupled systems which materially broaden our appreciation of tube and circuit operation and which, at first, may seem radical and perhaps questionable. We have only adjusted ourselves to these attributes through repeated verification of the results accompanied by persistent analyses for the causes.

The Circuit's Constants

Fig. 3—The sensitive handling of weak signals and the powerful handling of strong signals in the so-called power-detection circuits is aided materially by the adaptation of the drift-corrector and automatic bias arrangement as shown in the above circuit

Fig. 1 is a simple 2-tube system comprising a -24 screen grid tube (having a mu of about 400) as input and a -50 power amplifier as output, supplied from a single-wave -81 rectifier. The power transformer PT should deliver about 700 volts to the -81 rectifier. The filter comprises a single section having condensers of 2 microfarads and 1 microfarad spanning a choke having about 20 henries under load, connected as shown.

The potential developed by the filter is about 650 volts at 50 milliamperes. 400 volts of this being applied across the plate impedance of the 250 output tube through selecting the resistance of the arm R1 (about 5,000 ohms) to develop a potential of 250 volts at 50 milliamperes. A condenser, C2, of about 1 microfarad is needed to form a local signal circuit in the output circuit including association of any suitable loud speaker as indicated.

A coupling resistance, Rc, of ¼ megohm, capable of standing the small current of 750 microamperes, is suggested for the present Fig. 1, though in later articles of the series we will discuss wide variations in results securable through changing the value of Rc all the way to megohms. We also suggest 25,000 ohms as the value of bias resistance R3, but in later articles will comment on changes of value at this point. Filter condenser C1 should have a value of (*Continued on page* 763)

RADIO CORPORATION
OF AMERICA
233 Broadway
New York

Office of the President.

Mr. Austin C. Lescarboura,
Croton-on-Hudson,
New York.

Dear Mr. Lescarboura:

The need for trained men in commercial radio fields has never been greater than it is today. This need has been constantly growing with the increasing uses to which radio is being put.

Broadcast station operation, ship to shore communication, talking movies and public address equipment are demanding men qualified to fill positions of importance.

In the service field alone there are countless openings for men who appreciate the advantage of practical experience following a thorough school training.

Because of the rapid growth of the radio and allied industries calling for qualified men the Radio Institute, Incorporated, already offering a correspondence course, has greatly increased its facilities, by establishing schools in various centers throughout the country, to supply this demand.

Sincerely yours,

(*signed*) J. G. HARBORD

More Men

Trained men are needed for land, operation. Advancement is rapid

By Austin C.

THE openings for trained men in the radio industry far exceed the available supply. This is due, in part, to the tremendous growth of the talking movie, public address, aviation and broadcast operating fields, in consequence of which there is an unprecedented demand for men qualified to install, operate and service all types of apparatus employed in radio communication and speech-amplifying systems. There is need in the field, too, for service men, of ability, by broadcast receiver manufacturers.

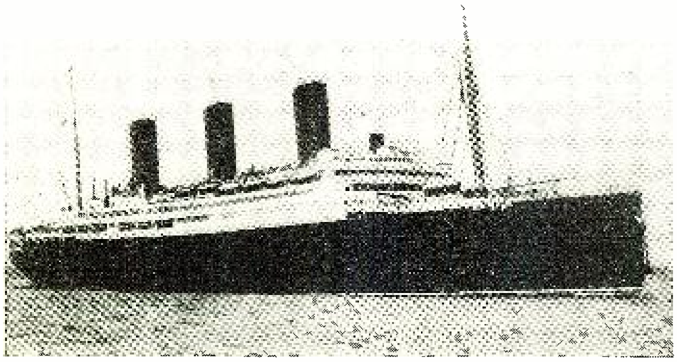
In view of this situation, RADIO NEWS *has commissioned Austin C. Lescarboura, formerly editor of* The Scientific American, *to survey the entire field and get the facts from leading executives in the industry, manufacturers, dealers and radio schools, and present his findings in a series of articles, of which this is the first.*

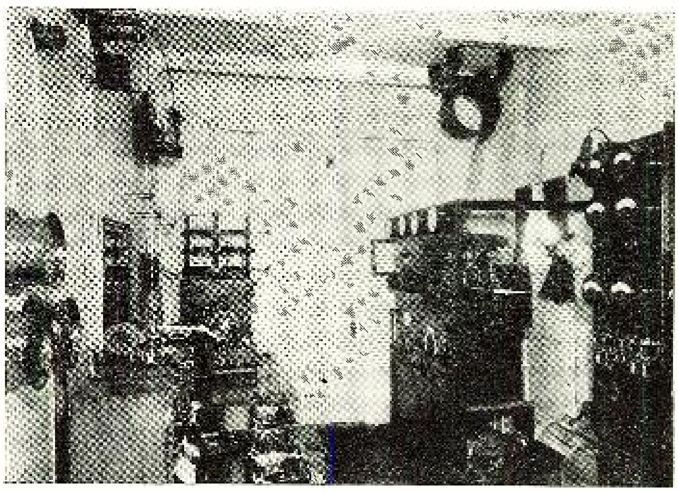
THE EDITORS.

NEVER before has there been such need for radio men as there is today. And, although this situation might at first seem strange, it is simply the logical result of circumstances incidental to the development of this new art.

The success of radio invites more radio. It is, indeed, a young field, large and growing larger with rapid strides. It is not handicapped by mouldy traditions—the man who delivers the goods is the man who succeeds. Without an overwhelming tradition to exercise restraint, it is kept in no straight and narrow path. Radio can and has branched out into other fields. Hence the constantly increasing demand for men with training, vision and aptitude.

In the early days of radio, trained men were in demand to develop new devices, tubes, transmitters, circuits, microphones, radio technique, factory methods, etc. Obsolescence was rapid; development made it so. Each manufacturer or radio concern wanted to get the jump on his competitors. Trained men were few. There being no tradition, no past experience, the men had, for the most part, to develop themselves. They worked on the trial and error method, not very



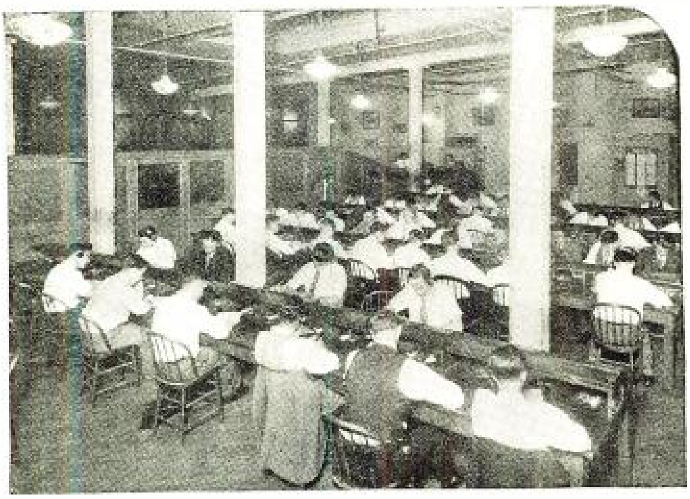


Above: S.S. *Berengaria*, a floating palace, where the radio operators have excellent living accommodations. Right: The radio cabin. Operators require training and experience to handle this elaborate installation

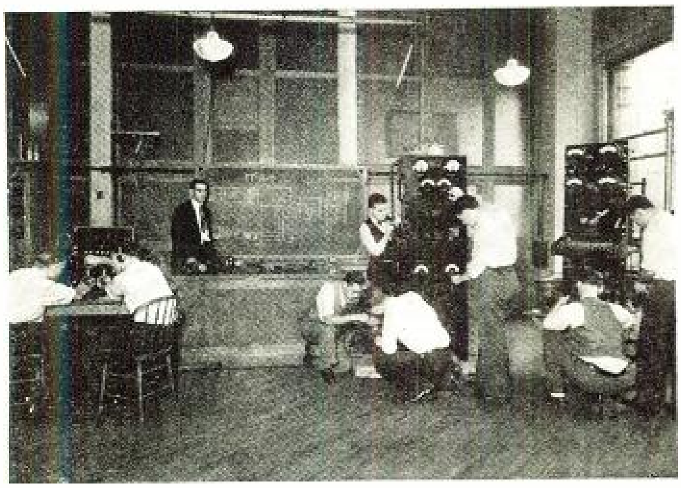
for Radio

ship and broadcast station and the pay excellent.

Lescarboura



Above: Where hundreds of students have learned to "pound brass." Below: A school where students learn by doing



efficient, but productive of great development by reason of the calibre of men who entered the field in those days and by mere force of numbers. From this mass of trial and error grew the developments. But unlike other fields, it was not always easy to say that one way was better than another.

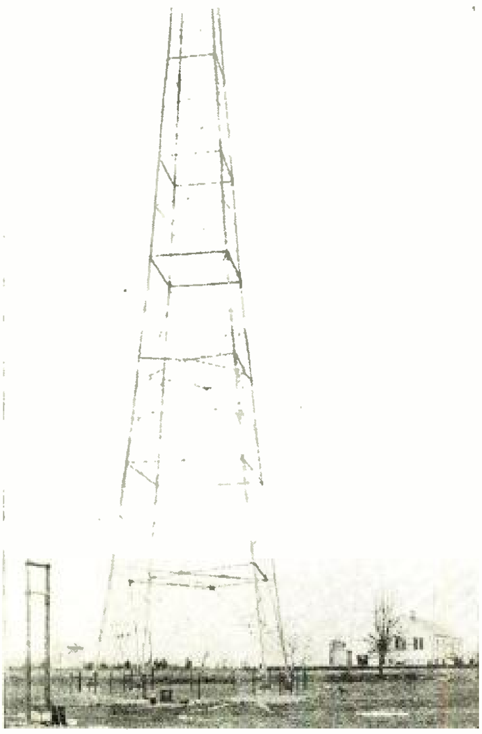
The fact of the matter is that many similar methods are equally good, depending on other conditions. So, from the early developments, there emerged numberless ideas, devices and circuits. Men were still in demand for experimental work. And, in addition, men were needed to care for, handle, and repair this mass of material that the experimenters developed. And as these things grew, the need for more men grew; not only more men, but better trained men, to handle the ever-growing quantity of new devices.

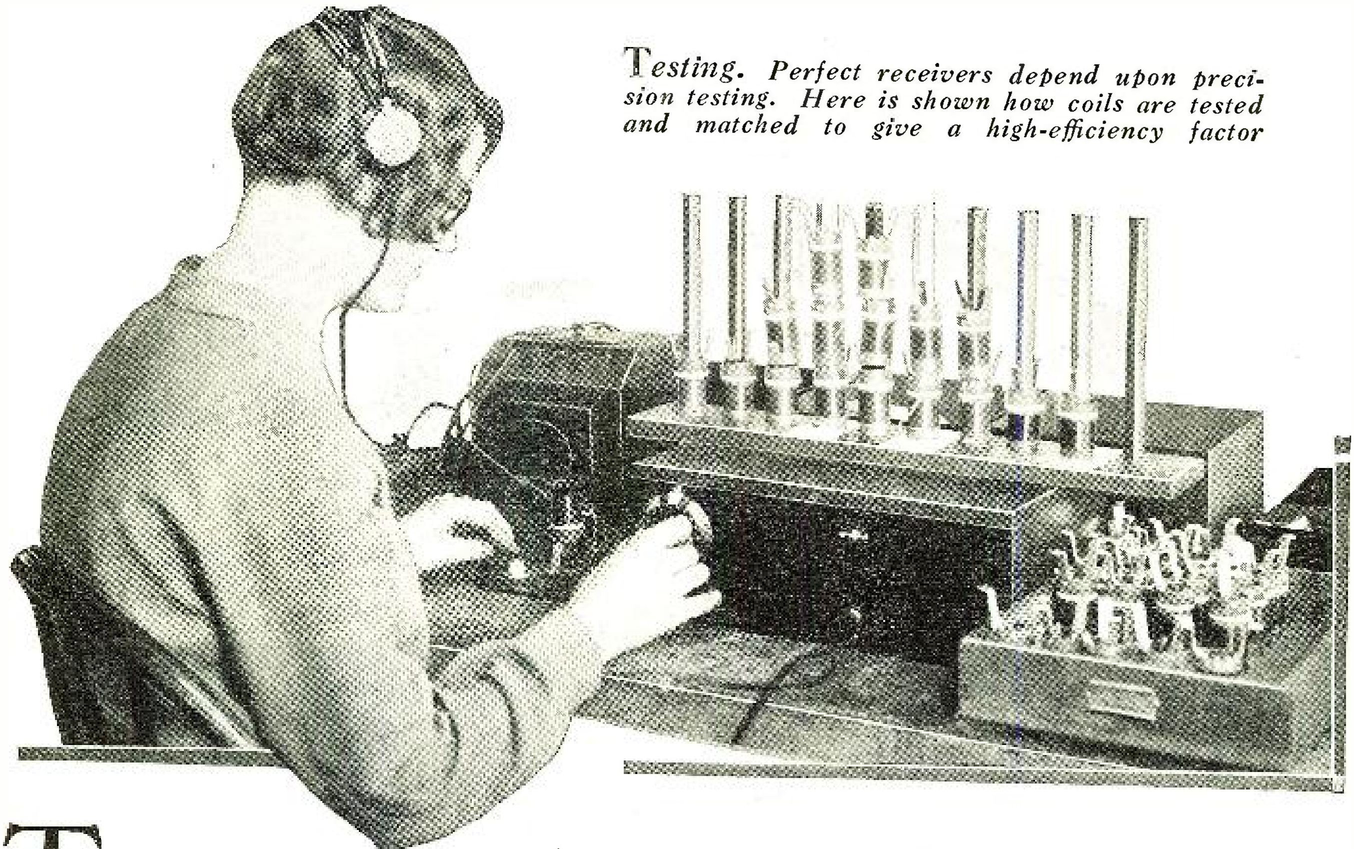
Then came the era of mass production. Fortunately for the radio manufacturer, sets were the rage. People bought right and left. And radio was still young enough so that each six months or so new vital developments came to the attention of manufacturers, who incorporated them in their products and sold new sets to owners who had purchased the "latest" radio receiver only a few months before. The rapid rate of obsolescence played into the manufacturers' hands. Why bother with servicemen? Before the radio gets out of commission, a new one will be on the market. Servicemen became the weak link in the radio chain. Trained men for the laboratory, yes. But mass production largely did away with them in the plant. What with precision machinery, skilled girl operators took the place of trained radio men. Operations were specialized; the factory worker no longer needed to know radio.

And the rapid development of new sets put the serviceman out of business. Instead of repairing the old set, a new one was bought. The development of new receivers was so rapid and radical that the serviceman could not hope to learn all of the intricacies of the new model before a still newer one appeared on the market. Discouraged, servicemen of high calibre began leaving the field. Auto mechanics, house electricians and men in other none-too-closely related fields took up the work of servicing. They were untrained. The manufacturers did not bother to give them information concerning their products. So the serviceman became a hack worker.

That has largely been the case almost up to the present time. Within the past twelve months, radio manufacturers have begun to see the end of their golden road to fortune in the field of improved sets every few months. Not that intrinsic improvements have stopped for all time, but the important elements of radio technique, manufacture, and parts have reached a point where they are fairly stable. Repeat sales can no longer be made purely on the basis of some feature in the new set. People are beginning to consider the service they got with the old set, in deciding whether or not to buy a new one. And manufacturers have learned that their repeat (*Continued on page 754*)

WJZ, inside and out. A most interesting place to work under almost ideal conditions, and usually under high pressure





Testing. Perfect receivers depend upon precision testing. Here is shown how coils are tested and matched to give a high-efficiency factor

Tips on R. F. Transformer Design

Selectivity and Distance-Getting Ability of the Shield-Grid Receiver Depend Largely on Coil Diameter, Coupling and Shielding

TO the average set buyer such insignificant parts as the tuned radio-frequency transformers (which appear to be merely a number of turns of wire on a bakelite form) are looked on with indifference if they are given any thought at all. However, these coils are the heart of the radio-frequency amplifier, for on their design depends not only the selectivity but also the distance-getting ability of the receiver.

Before the introduction of the screen-grid tube with its high amplification factor and its low internal capacity it was only possible to obtain a gain (amplification) of about 15 at the most from a tuned radio-frequency transformer together with its associated vacuum tube. And when this carefully designed transformer was used in a multiple stage radio-frequency amplifier the feedback through the vacuum tubes was so great as to preclude its commercial use unless extreme care was taken to neutralize the tube capacity. Thus the screen-grid tube was a logical development. The addition of the screen or second grid not only shielded the plate so that the grid-to-plate capacity was minimized but also raised the amplification of the tube from the ordinary value of about 8 to 400 or higher. Unfortunately for the designer, the plate resistance was increased at the same time to such a large value that it is practically impossible to design a transformer which will, at broadcast frequencies, allow the full realization of gain which may theoretically be derived from the tube. However, it is possible to obtain an amplification of from 20 to 40 with a well-designed radio-frequency transformer used in conjunction with the a.c. screen-grid tube.

In designing a multiple stage radio-frequency amplifier there are two definite problems which must be solved. First, the exact design of the radio-frequency transformer itself and second, the method of sufficiently isolating the individual stages so that the finished amplifier will not oscillate. The solution of the first problem was taken up in some detail in the June, 1929, Radio News and it suffices here to recapitulate the salient facts. The secondary of the tuned radio-frequency transformer shown in Fig. 1 and marked L2 should have as low a radio-frequency resistance as possible. Of course, this ordinarily would mean that a three or four-inch diameter form was used for the winding and that the wire was about size 18. Commercially this is not possible and, in fact, when the question of shielding is considered, one inch and a quarter or an inch and a half coils are about as large as can be used without making a radio set a great deal too bulky. When a small form is used for winding the coil small wire must be also employed, for otherwise the length of the coil would be so great compared to its diameter that the radio-frequency resistance would be large. That is, the winding length of the coil should not be greater than its diameter or the leakage flux becomes large and the inductance for the length of the wire used is small. The radio-frequency resistance of any type of coil may be decreased somewhat by space winding. The amount of this spacing is usually determined by experiment and may be as great as the diameter of the wire used.

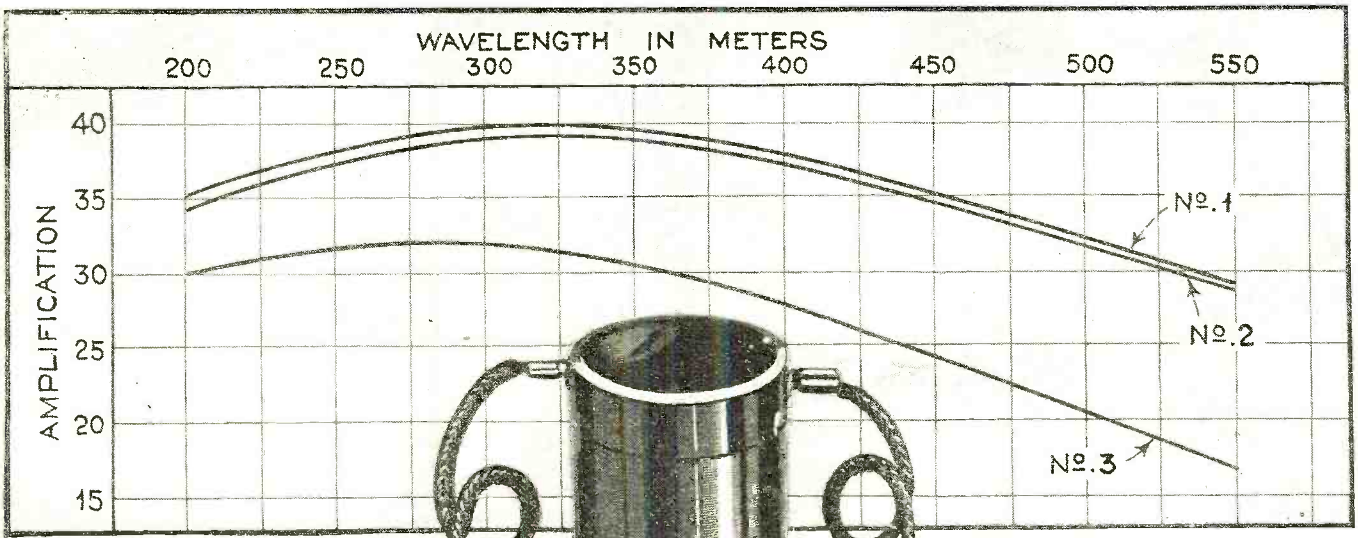
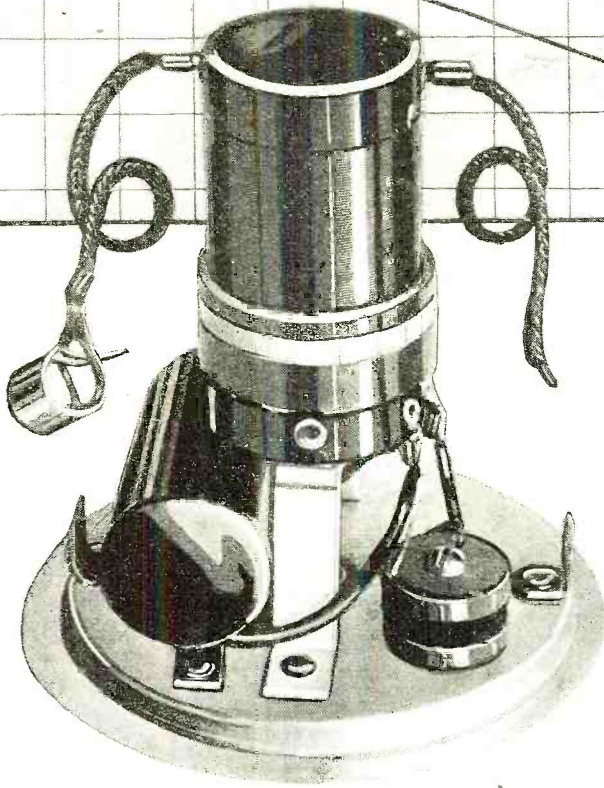


Fig. 3—The amplification curves obtained with 1, no shielding; 2, a 3-inch copper, brass or aluminum shield can, and 3, a 3-inch iron shield can. The latter shows a surprisingly high amplification factor, especially at the higher frequencies (lower wavelengths)



By

Glenn H. Browning

and

James Millen

In the case of the MB-29 considerable experimental data was collected on this point. It was found for a 1¼″ coil that No. 30 enamel wire spaced 66 turns to the inch gave about as low resistance as could be obtained when the question of shielding was taken into consideration. For the information of those readers who are technically inclined the data in Fig. 2 is given. R/Lω is the factor of merit of a coil, for it gives the radio-frequency resistance per unit of inductance at a given frequency. (R is the resistance of the coil, L is the inductance, and ω is two pi times the frequency.)

Curve 1 indicates the value of R/Lω of a three-inch coil wound with No. 18 wire, while curve 2 shows the value obtainable with an inch and a quarter coil wound with No. 30 wire and spaced 66 turns to the inch. Curve 3 is for an inch and a quarter coil with a spacing of 88 turns per inch. As will be noted, there is a surprisingly small difference between the three-inch coil and the inch and a quarter one, though the shape of the curve in the former is better as the fraction R/Lω is smaller at the longer wavelengths. The spacing of 66 turns per inch is preferable, provided the inductance of the coil does not have to be so large as to make the length of the coil great compared to the diameter.

After the size of the secondary of the transformer has been determined the next thing to ascertain is the size of the primary winding. In the case of an r.f. transformer for the screen-grid tube, the size of this primary is limited. If too large an inductance is employed the capacity inherent in the tube itself between the screen-grid and the plate (this capacity is directly across the primary of the transformer, as may be seen by referring to Fig. 1) tunes the primary circuit to some point in the broadcast band. However, the (*Continued on page 752*)

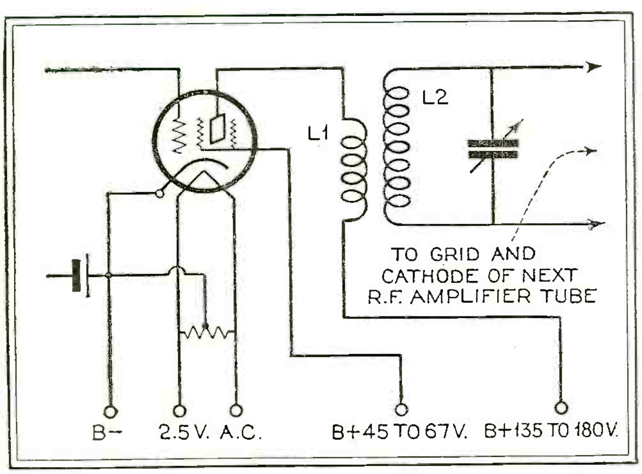


Fig. 1—A typical radio-frequency amplifier circuit which employs the screen-grid tube. Note that no shielding, bypass or isolation features are shown

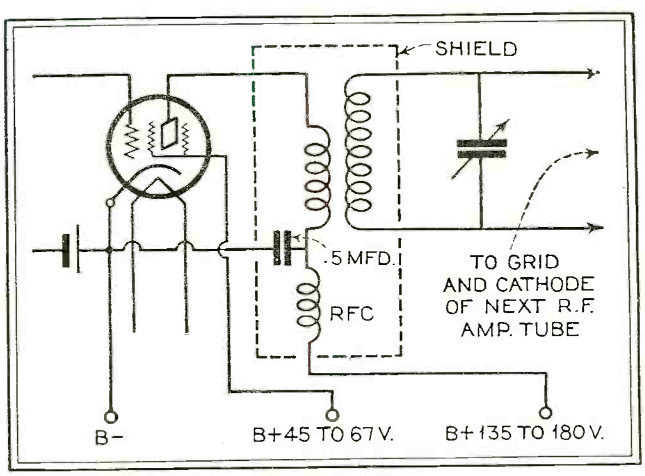
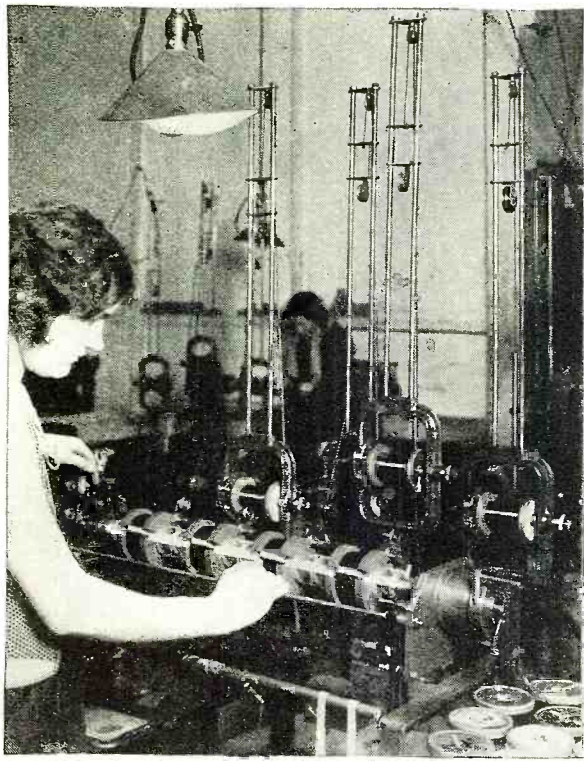


Fig. 4—Maximum gain from a screen-grid r.f. amplifier can only be realized when proper bypassing and shielding precautions have been observed as shown here



Above, left: Close-up of one of the coil-winders. In making coils, Valley does everything but cast the ingots, draw and enamel the wire. Above, right: The longest speaker assembly line in the world. Here precision parts made in the Valley Plant are assembled into the complete chassis unit, tested, given final inspection. Thousands of chassis go over these lines every day

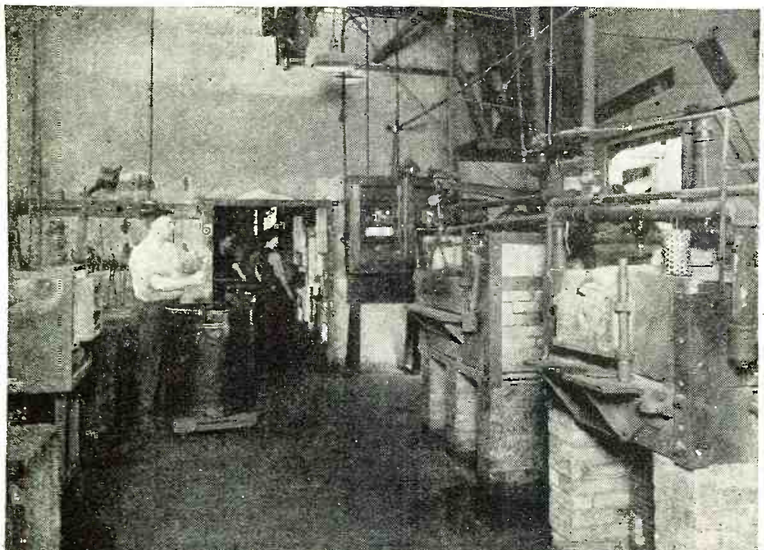
A Million

A pictorial story of what the is doing in the loud speaker in different parts of the reaping a harvest

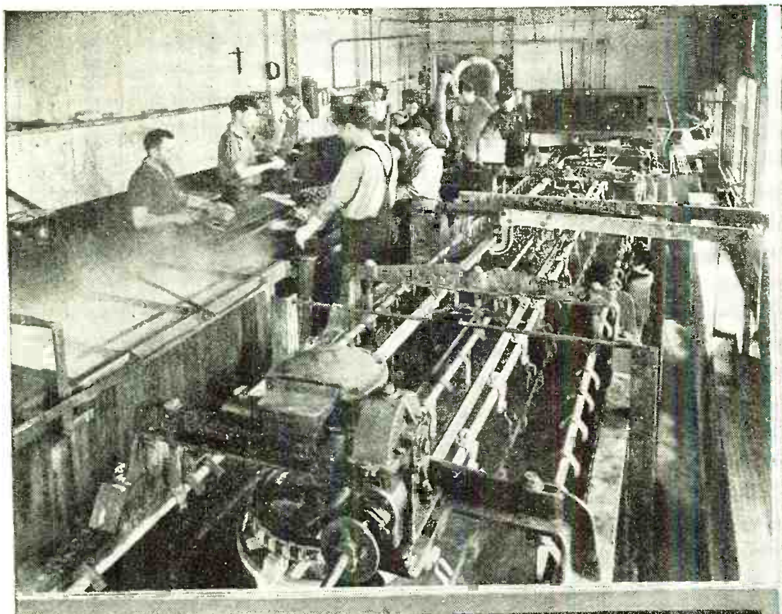
ROCHESTER, New York, is the home of the Valley Appliance Company, an organization devoted entirely to the manufacture of radio loud speakers and special parts of all descriptions used in the production of radio receivers.

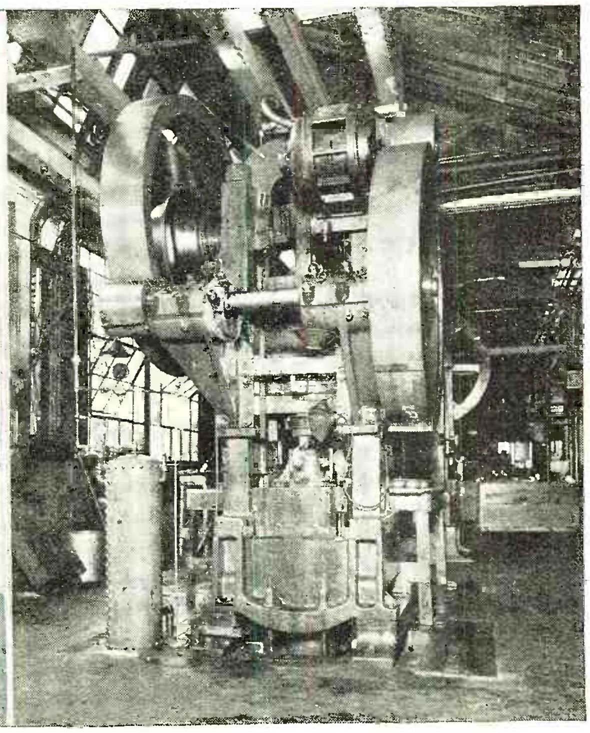
The entire factory covers 86,000 square feet of floor area, and when production is in full swing six hundred people are employed there. Its capacity is 5,000 reproducers, as well as two carloads of miscellaneous parts, a day.

The plant and equipment together are valued



Above: Heat Treating and Annealing Department. Over 400,000 speaker magnets have been treated in this battery of furnaces. Tools are tempered here, alloy products annealed. Exact temperatures are maintained by Leeds-Northrup controls. Right: View of Cone Assembly Department, where cone parts are made ready for final assembly and testing





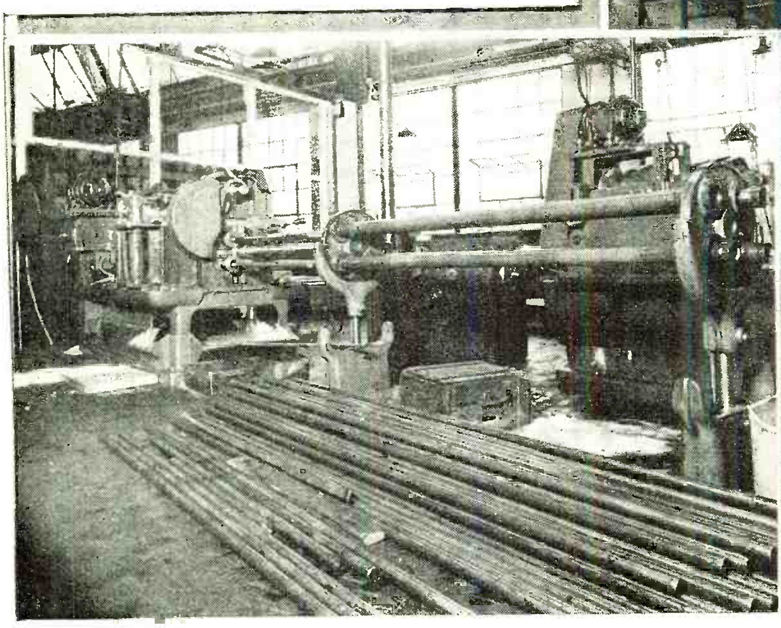
Parts a Day

Valley Appliance Company world. Other organizations country are likewise by similar methods.

Above, left: Section of Plating Department, showing automatic plating equipment. Cadmium nickel and silver plating is done here. Above, right: A battery of these big presses makes possible economical speaker design, stamping from heaviest sheets those metal parts ordinarily cast or completed by the assembly of several sections

at approximately $1,000,000, including $348,000 worth of modern labor-saving machinery installed within the last three years.

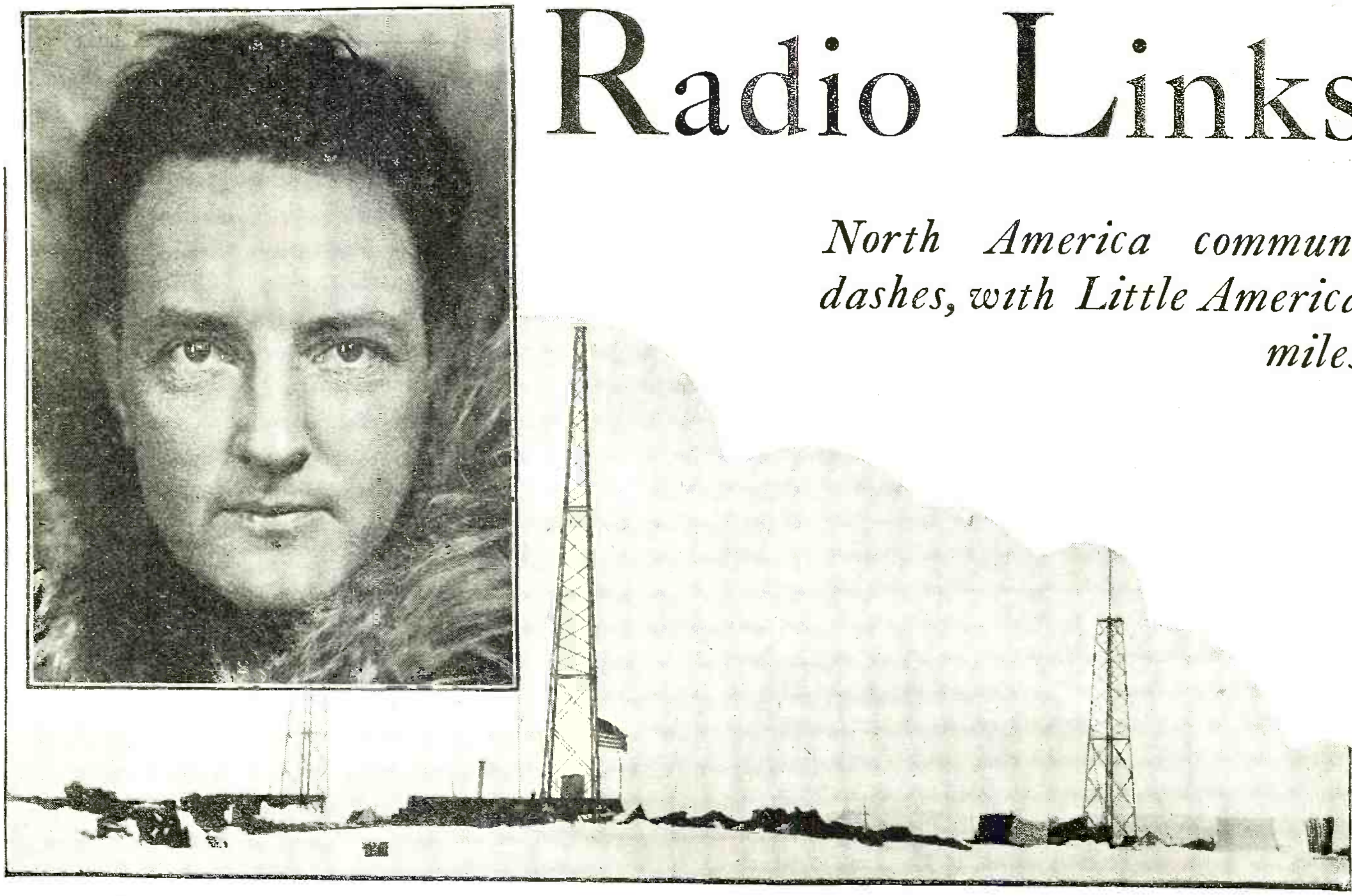
The public at large rarely hears about organizations of this character, of which there are a number scattered throughout the country. Nevertheless, they play a most important part in the radio world, since their production is utilized by manufacturers of receiving sets who do not build their own reproducers, or other components which are available from an outside source.



Above: A section of the Cone-Spraying Department, where the cones are waterproofed prior to assembly into complete reproducers. Left: One of a group of large automatic screw machines that complete a sequence of metal-cutting operations, to the closest tolerances, with almost human ingenuity

Radio Links

North America communi
dashes, with Little America
miles



Upper left: Commander Richard E. Byrd

Above: The Byrd base camp at Little America, Antarctica, showing the radio towers through which the party maintains communication with the outside world

By Orrin E. Dunlap, Jr.

THERE is a young man sitting in a room on the third floor of a New York skyscraper, in the heart of the busy Times Square district, frequently termed "the crossroads of the world." His ears are capped by round black cases. Apparently he has heard something intelligible, but there is not a sound in the room, and nothing but a black box in front of him on the table. His hand reaches out across the table to a small brass rod with a dark knob on the end. His fingers touch it lightly. On the seventeenth floor, high above the Broadway theatre crowds, in a darkened room, a glow not as bright as moonlight issues from several glass tubes arrayed on a wooden rack. There is no great electrical crash or thunderous noise. Not a soul is in the room. The uncanny glimmer is suddenly cut off—the room is in total darkness. The man seventeen floors below has picked up a pencil and writes:

"Listen for plane 'Stars and Stripes' at 3:15 A. M."

Again the glass bulbs glow as they do when called upon to speak an electrical dot-and-dash language. The man in New York replies "OK."

Ten thousand miles away, secluded in the land of Little America at the Bay of Whales, Antarctica, 2,400 miles from the nearest point of civilization, while an airplane is being prepared to go aloft with Commander Richard E. Byrd, over the trackless, uncharted wastes, a man in New York knows exactly what is taking place, and has just arranged to keep a rendezvous with the aviator at 3:15 A. M.

The hands of the big clock in the Paramount tower point to the hour. New York is as much asleep as it will be at 3:14 A. M. The youth moves forward in his chair and picks up his pencil, confident that he will hear something come from that black box in front of him.

He writes: "Plane is about to leave the ice. Stand by."

Then he touches a dial on the panel of the box. The knob moves so slowly that it is imperceptible to the eye, but a slight turn means much in the realm of kilocycles. Just a breadth of a hair on that dial shifts his contact from the *City of New York*, Byrd's base ship anchored to the ice in the Bay of Whales, to the airplane's small radio transmitter now aloft over the Antarctic wastes.

Above: Captain Ashley McKinley, Aerial Surveyor of the expedition, who made photographs during the flight to the South Pole

There is the characteristic 240-cycle note in the headphones. The operator smiles. He eavesdrops as the aviator adjusts his transmitter so that the dots and dashes that would evolve when he touched his key would carry to their intended destination. Once or twice the operator in Times Square taps his key and grins as if someone at the other end of a telephone had told him something pleasant. In the Antarctic the plane's operator knows that he is in direct communication with the New

the Americas

cates nightly, by dots and in the Antarctic 10,000 away

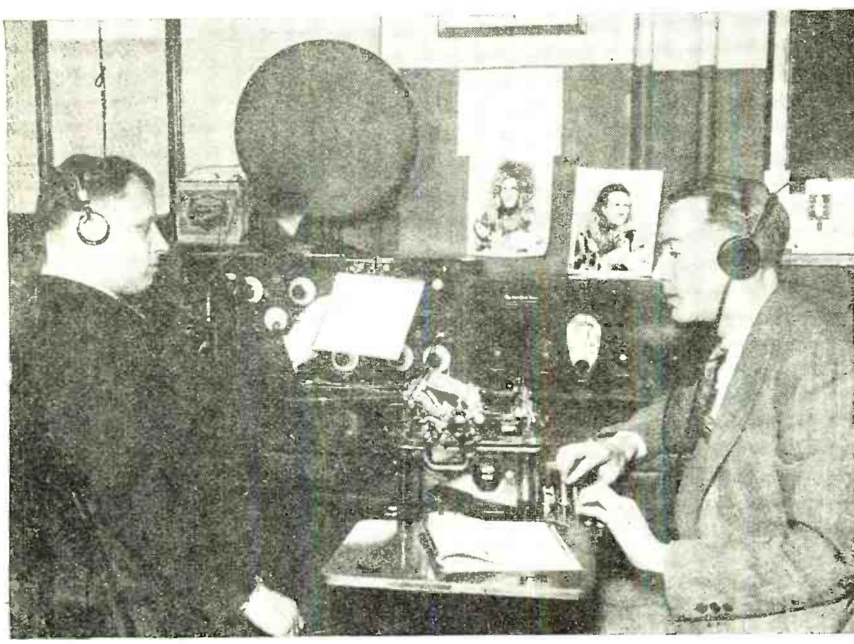
York *Times.* A man sailing 3,000 feet above the ice in the South Polar regions announces that a world's record is being established. Never before has a man in an airplane in flight communicated back and forth with a friend 10,000 miles away—across the Antarctic ice, a stretch of the Pacific, South America, the Equator, to North America and the United States—up from the home of the relentless blizzard, through summer warmth, only to find New York in the grasp of winter, yet mild by comparison with the scene beneath the plane. And all this done in the twinkle of an eye—at the speed of light, 186,000 miles a second!

Far below the radio room of the *Times* roar the mighty presses printing the daily news to be ready at the doors and on the newsstands when New Yorkers awake. Later that operator was to hear a flash from the bottom of the world—a scoop for the presses to rush into print that Byrd, the first man to fly over the North Pole, had encircled the imaginary pinnacle at the other end of the earth!

Upper right: Harold I. June, Radio Operator on the Byrd plane

Bernt Balchen, Chief Pilot, who piloted the huge tri-motored monoplane on the history-making flight over the South Pole

May, 1926, marks the time that radio was linked forever with exploration leading into uncharted, pathless regions. It was then that Commander Byrd and his companion, the late Floyd Bennett, in their plane the "Josephine Ford," sped down an icy runway at Spitzbergen, bound for the North Pole! Historic dots and dashes transmitted on a 44-meter wavelength flashed, "We have reached the Pole and are now returning with bad oil leak, but expect to be able to reach Spitzbergen."



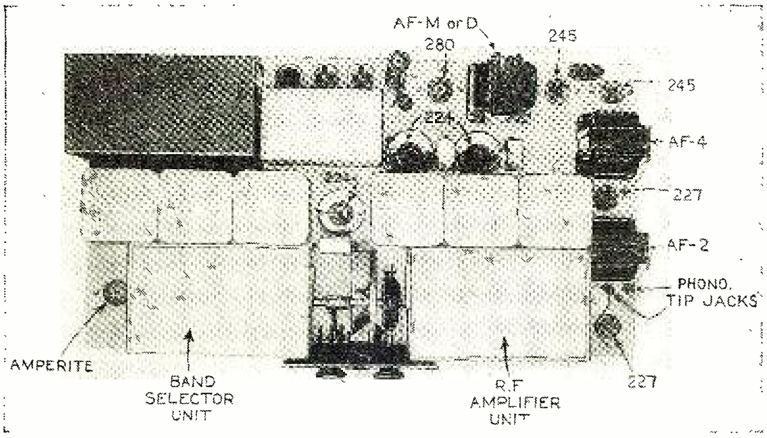
Below: Radio room in the New York Times Building, where communication with the Antarctic is carried on

And they did! It was a triumph for aviation; an achievement for radio; glory for exploration.

The big monoplane had scarcely landed when the dirigible "Norge" slipped out of its hangar at Spitzbergen, the big blunt nose pointed northward, bound on a flight across the top of the globe with Alaska as the destination. Radio messages broadcast from a wire dangling 300 feet below the airship gave the world a running story of the eventful cruise above the ice, into a bleak region where there were apparently no signs of life. Seventy-one hours later the "Norge" came to earth at Teller, Alaska, where Roald Amundsen, Riiser Larsen, Lincoln Ellsworth and Umberto Nobile, with a brave crew told the story of a dangerous trip across the top of the world, which on more than one occasion was threatened with death and disaster.

The South Pole was all that remained at the ends of the earth for an aviator to look down upon. So Commander Byrd called together a band of explorers, aviators and scientists for a sojourn in the Antarctic, 10,000 miles distant from the Statue of Liberty, but only one-twentieth of a second away by radio. Thanksgiving night the little black box in New York, tuned to Little America's wave, detected the code disclosing that (*Continued on page* 761)

A High Quality



With the exception of the audio transformers and sockets the Hi-Q 30 is completely unit-assembled. All wiring is made underneath the chassis base

Given a Good Radio Be Satisfactory Only Its Audio Channel With Fidelity An Amplifier is

By Leslie G. Biles

THE articles published thus far, in the two preceding issues of RADIO NEWS, have dealt chiefly with an exposition of the general constructional features which distinguished the Hi-Q 30 receiver from its predecessors and a semi-technical analysis of the function of the tuner end of this receiver to separate the job of selecting an incoming signal from that of amplifying it.

This article carries on from that point and goes into the details concerning the features of the audio channel and power supply employed, and in a brief way outlines some of the constructional and wiring hints which should be observed in constructing the receiver.

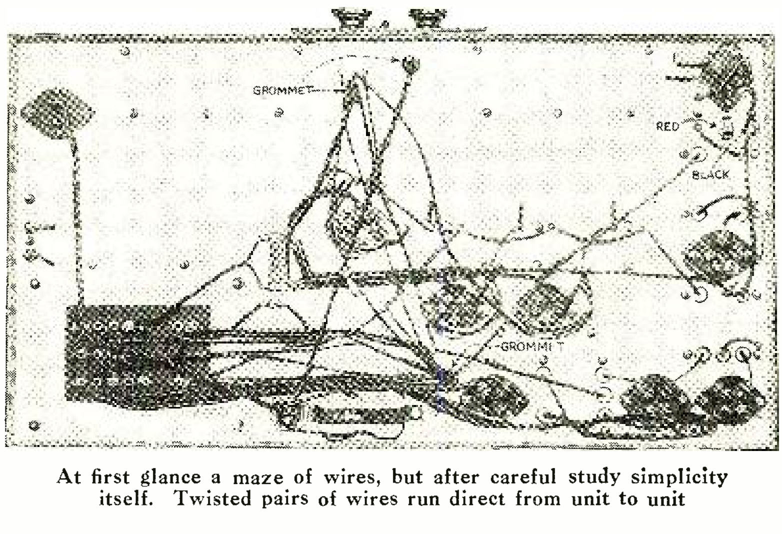
Matching of Coils and Condensers Makes for Accuracy

As stated previously, the higher the sensitivity of a radio receiver, the greater its selectivity should be, especially when operated in congested locations. This follows naturally when it is considered that the ability to tune out a strong local station by a change of one or two degrees in the dial setting is of no particular benefit unless the receiver is sensitive enough to then bring in a weak distant signal with good volume. Conversely it is of no advantage to own a receiver of tremendous sensitivity unless it also possesses sufficient selectivity to tune out locals and other powerful signals in favor of the weak distant signal desired. The sensitivity of the Hi-Q 30 has been made very great by the use of three efficient stages of radio-frequency amplification using the a.c. screen-grid tubes. Inasmuch as the receiver is truly "one dial" control, the one dial tuning all six circuits simultaneously, great care has been taken in the design and construction of the tuning inductances, in both the filter (preselecting) and amplifier units. The filter tuning coils and the radio-frequency transformer secondaries are wound on threaded bakelite forms and the six coils of each set are matched to each other with an accuracy of better than ¼ per cent. The two triple-gang tuning condensers are also accurately matched with each other in addition to having their individual sections matched. This matching is important for both selectivity and sensitivity. Since the distributed capacities of the six tuned circuits differ widely from each other, a supplementary adjustable capacity is connected across each main tuning condenser. These supplementary capacities are adjusted so as to bring the minimum or inherent capacities of the individual circuits to exactly the same value. Thereafter, since the inductances and individual tuning condenser sections are matched, the six circuits will be found to track throughout their entire tuning range.

High Gain Necessitates Use of Complete Shielding and Filtering

The radio-frequency transformers have high inductance primaries closely coupled to space-wound secondaries, thus insuring a high impedance load in the plate circuits of the screen-grid radio-frequency amplifier tubes. This insures a high r.f. gain over the whole broadcast frequency band. Although the amplification of these r.f. transformers increases rapidly with frequency, no steps were taken to prevent this condition, since it is a simple matter to control the amplification at any wavelength by properly adjusting the volume control. Under test a sample receiver had a measured sensitivity of 4½ microvolts per meter at the extreme lower end of the broadcast spectrum (550 kc.) and this increased to 1 microvolt at about 750 kc. Above 750 kc. the sensitivity increased still more, but could not be measured owing to the fact that the measuring equipment used was not calibrated above that point.

This tremendous r.f. gain makes complete shielding abso-



At first glance a maze of wires, but after careful study simplicity itself. Twisted pairs of wires run direct from unit to unit

Audio Channel

Amplifier a Receiver Will In so far As the Ability of to Amplify and Reproduce Is Concerned. Such Described in This Article

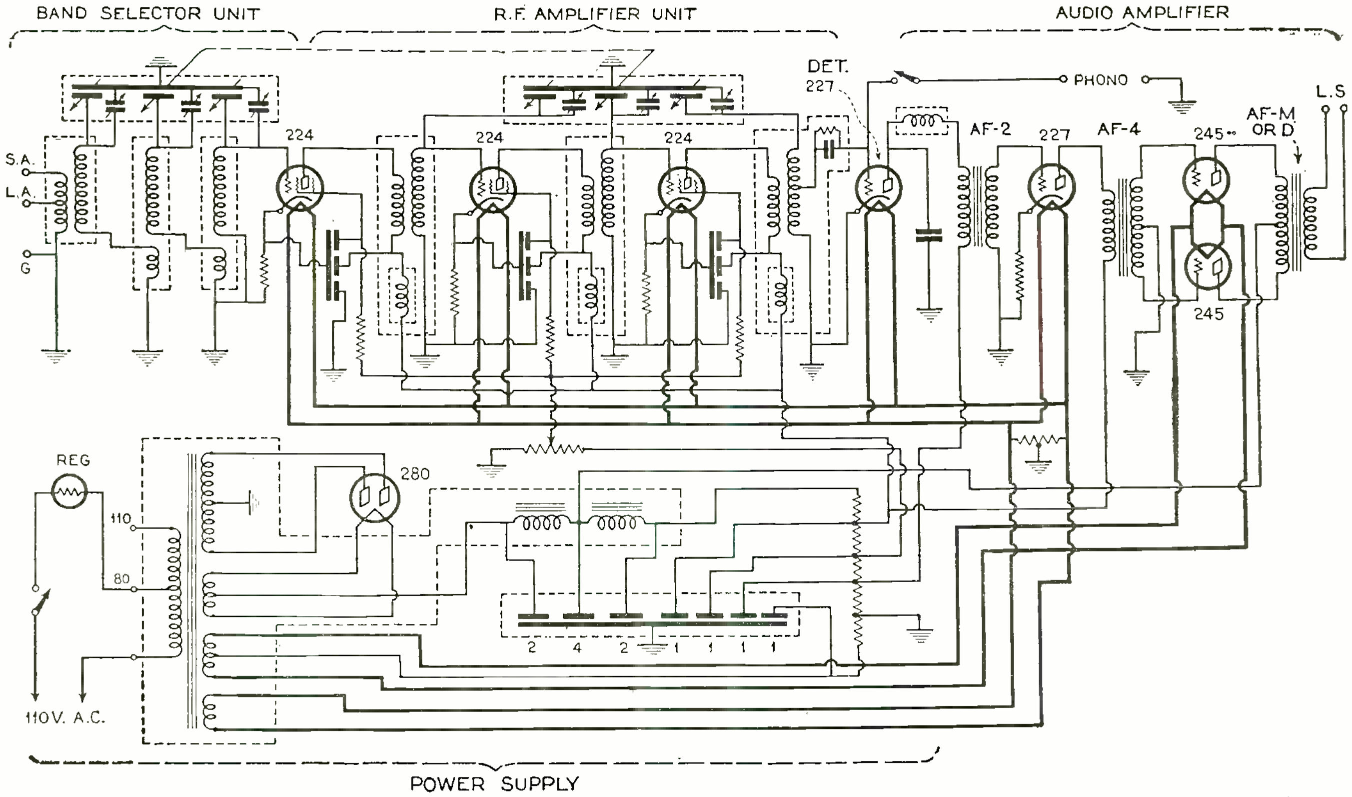
lutely necessary and accordingly this phase of the Hi-Q 30 design has received especially careful attention. The filter coils and r.f. transformers are shielded in individual copper cans (tinned on the outside) with soldered tops and bottoms. Each triple-gang tuning condenser is also shielded in an aluminum can and in the case of the second triple condenser, which tunes the three r.f. transformers. the shielding is carried still further, partitions being placed in this can to isolate each of the three condenser sections from the others. The screen-grid tubes are enclosed in specially designed two-piece aluminum shields which are removable to facilitate changing or inspecting tubes. The radio-frequency chokes used as isolating impedances in the plate circuits of the screen-grid tubes are mounted in the copper shields housing the radio-frequency transformers, but are shielded from same by their own aluminum cases. The r.f. choke coil used in the plate circuit of the detector is also shielded, since any feedback of r.f. energy from this point to the input of the receiver would be very undesirable.

Detector-Selectivity Improved by Modified Circuit

The standard grid-leak, grid-condenser detector has been used with slight modifications. As will be noticed in the circuit diagram, the lead to the grid condenser and leak is tapped off the secondary of the third r.f. transformer at a point roughly two-thirds from the filament end. By this scheme the damping effect on the tuned circuit caused by the low input resistance of the detector tube is reduced by more than half. thereby materially improving the selectivity of the circuit. At the same time greater voltages are built up in the circuit by reason of the reduced damping, therefore the voltage actually impressed on the detector grid is not reduced. Another quite important advantage of the tap is the reduction of the effective input capacity of the detector. While the input capacity of the tube is not actually reduced, its *effect on the tuned circuit* is reduced by over fifty per cent., thereby permitting the use of an equalizing capacity across this circuit as well as the others. The combination of .00025 mfd. grid condenser and one megohm grid leak introduces practically no distortion in the audio-frequency range.

The Audio Channel

The total amount of audio amplification is comparatively low, even though two stages are used. This enables the use of low-ratio a.f. transformers with large primaries, insuring good low note reproduction. The low overall a.f. amplification makes audio regeneration virtually impossible, besides reducing microphonic troubles to a minimum, and in addition reduces to a truly negligible amount the annoying a.c. hum generally associated with a.c. receivers. On the other hand, the audio gain is sufficient to insure maximum input to the push-pull power tubes long before the detector tube is overloaded. The first-stage transformer has a ratio of (*Continued on page* 756)



The complete circuit diagram of the Hi-Q 30. Note how it is composed of four distinct units: the band selector, r.f. amplifier, audio amplifier and power supply

¶ *Fifteen cities, realizing the invaluable part radio can play in the apprehension of lawbreakers, now have radio systems either in operation or under construction. This article outlines what has been done in some of these cities and what the police chiefs think about this new means of extending the arm of the law.*

(Below) Chief Jacob Graul of Cleveland, and (right) Chief Claude M. Worley of Indianapolis

William F. Russell, Chicago's Police Commissioner

Cops Don

Police Departments In 15 Cities Listen In Radio-Equipped Calls. Many Other Broadcast

By Ralph

¶ The total arrests made in Detroit by the crews of the radio-equipped automobiles as the direct result of orders given to them by radio has passed the 1,600 mark at an average time per arrest of 90 seconds.

¶ The patrolling cars have been given more than 32,000 messages by radio and of these 10,000 have been direct orders to head for the scene of some actual or reported crime. The arrests have included all sorts of criminals, from petty thieves to slayers.

¶ The police radio station, operating on a low wavelength, is able to confine its messages chiefly to those for whom it is intended—the crews of the radio-equipped police cars.

¶ Twenty-seven days after the Highland Park, Michigan, system was placed in operation, more than 5,000 messages had been given the cruisers. A number of important arrests have been made, four holdup men and four burglars have been captured in less than two weeks.

THE EDITORS

CRIME is being made more difficult and dangerous than ever before as the police use of radio spreads slowly but surely over the nation.

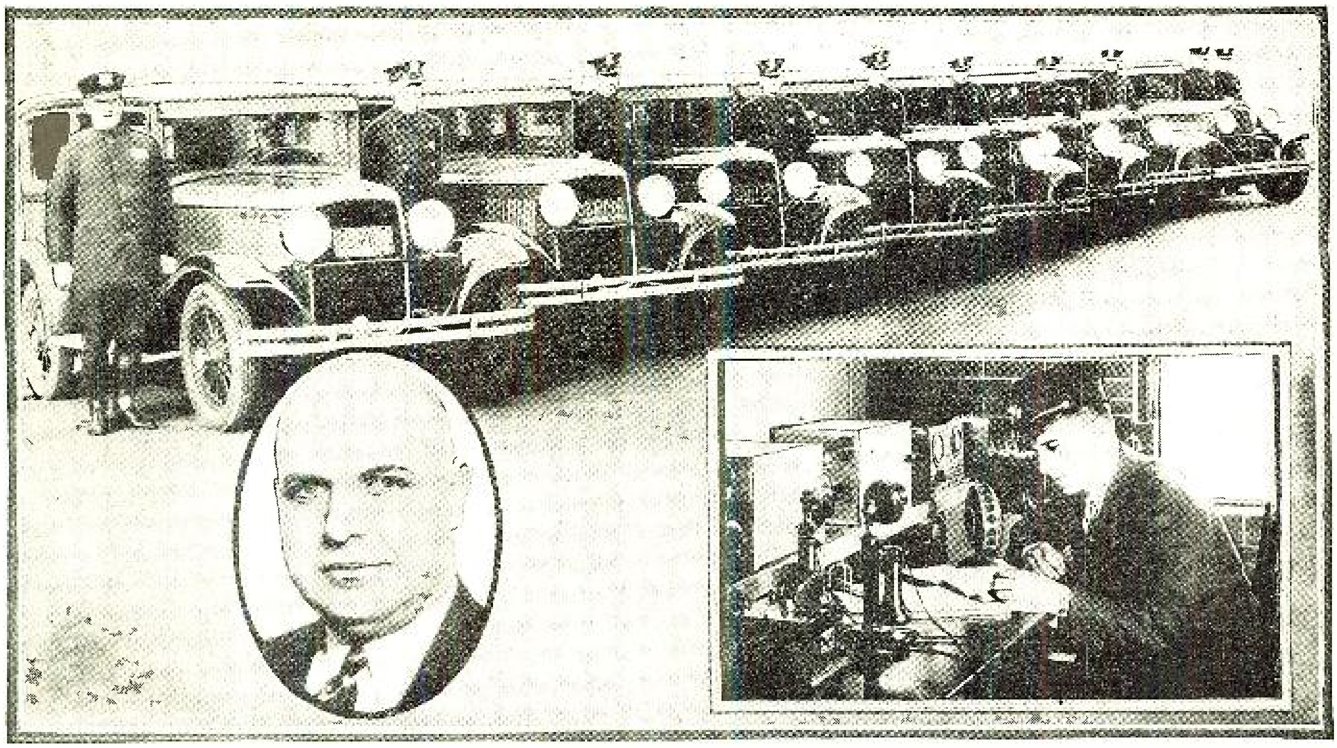
The underworld is face to face with the realization that the police have an unseen and powerful new weapon—a weapon whose speed is astounding and whose use is being hailed everywhere as one of the most important police developments in years.

The crook is being hemmed in on all sides by the ever-widening invisible network set to snare him. There are still loopholes, but the tightening of the net has begun.

It was only a few months ago that reports began to trickle out of Detroit to the effect that radio was proving an efficient police ally after years of experimentation. The reports spread and grew in significance. Other cities began sending inquiries and then representatives to investigate.

Where Detroit formerly stood alone in the municipal use of radio by the police, the dawn of the new year found fifteen police radio systems in as many cities in operation or near completion. More than half a dozen heads of other police departments were hoping 1930 would bring the funds necessary to enable them to employ radio as a crime-fighting ally.

The fifteen systems were those of Berkeley, Cal.; Buffalo, N. Y.; Beaumont, Texas; Chicago, Ill.; Cleveland, O.; Cincinnati, O.; Detroit, Mich.; Flint, Mich.; Highland Park, Mich.;



Chief William I. Cross of Highland Park, Michigan (in circular inset), his fleet of radio-equipped police automobiles, and an interior view of the radio station

eadphones

Flash Reports to Officers Who Automobiles for Emergency Municipalities Plan Nets

L. Peters

Indianapolis, Ind.; Miami, Fla.; New York; Pasadena, Cal.; Seattle, Wash., and Tulare, Cal.

Plans for Philadelphia's system are progressing. The police executives of Atlanta, G Grand Rapids, Mich.; Portland, Ore.; Youngstown, O., other points are looking ahead to the time when radio systems will be in operation in their respective communities.

From abroad come reports that the London and Berlin police have also added radio to their array of crime detection and prevention measures.

Meanwhile, the Detroit police have not been standing idle. The original force of nine radio-equipped automobiles has been increased to thirty-five, and further additions are contemplated. The boats of the Harbormaster's Division have also been equipped with receiving sets and loud speakers like those in the police cruisers and scout cars.

The total number of arrests made by the crews of the radio-equipped automobiles as the direct result of orders given to them by radio has passed the 1,600 mark, at an average time per arrest of 90 seconds.

The patrolling cars have been given more than 32,000 messages by radio, and of these 10,000 have been direct orders to head for the scene of some actual or reported crime. The arrests have included all sorts of criminals, from petty thieves to slayers.

Not content with leading the way and establishing an outstanding record of its own, the Detroit Police Department has assisted in the establishing of similar police radio systems elsewhere.

Lieut. Kenneth R. Cox, under whose direction Station WCK of the Detroit police established its record, was given a leave of absence so that he might go to Chicago and assist in the installation of a radio system there. A similar leave was granted to Robert Batts to go to Indianapolis. Information and the benefits of experience have been passed on to other departments also.

The Highland Park, Mich., Police Department offers one of the best examples existing of the efficiency of a "radio-motorized" police department. With the exception of one "beat" in the business section, all districts of this city—completely surrounded by Detroit—are covered by radio-equipped police cruisers and their crews. Nine cars are now equipped with radio and shortly the number will be raised to fifteen.

Chief William I. Cross points out that under the new system the citizens of Highland Park are getting "ten to one better protection than ever before." He explains that where formerly a foot patrolman was able to pass each house on his "beat" but once in three hours, that at present two patrolmen and a radio-equipped car are in the front and rear of every home every 15 minutes. An instant's notice enables one or more of the radio-equipped cars to reach a trouble point.

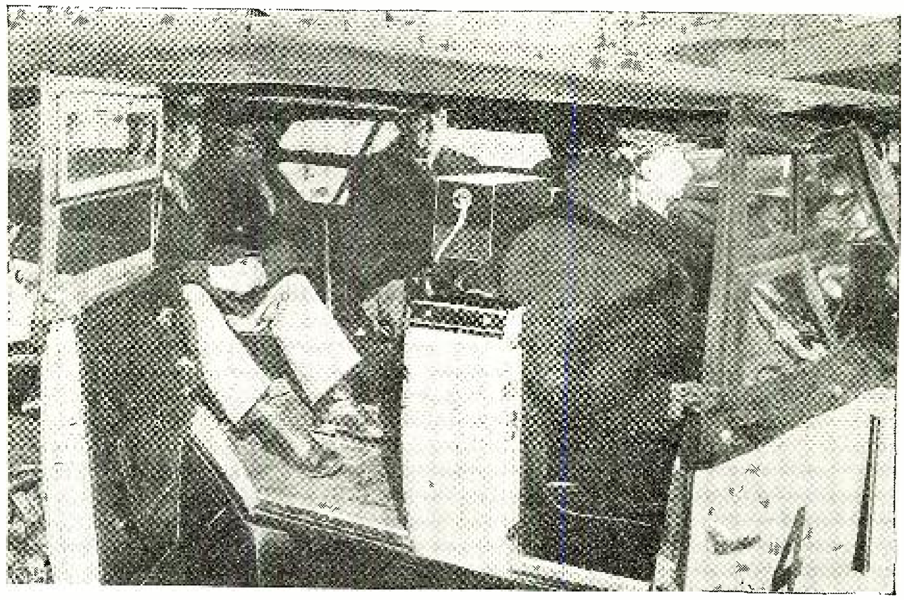
Detroit's police broadcasts are received by teletype and rebroadcast from the Highland Park station. Highland Park alarms, in the same manner, are rebroadcast by the Detroit station to the Detroit cruisers and scout cars.

The Highland Park system was placed in operation August 12th and twenty-seven days later more than 5,000 messages had been given the cruisers. A number of important arrests have been made, four hold-up men and four burglars having been captured in less than two weeks. Police records indicate crime has decreased 50% in the city since the radio system went into effect.

Chief Cross points out that not only does the system assist in the apprehension of criminals, but that it acts as a powerful crime preventative because of the constant threat of speedy capture to any lawbreaker.

Police radio was introduced in Chicago by the Chicago *Tribune*. The *Tribune* heads heard of the success being achieved in Detroit, and sent two men to investigate. On their return and report the *Tribune* offered a proposal to Commissioner William F. Russell that the newspaper outfit forty police squad cars at its own expense and broadcast police orders to them from the paper's station, WGN.

The offer was accepted, the cars equipped and the co-operative radio system placed in operation. It was an improvement, a decided one, over the older and slower type of automobile police work, but it had its bad points. These were that it was frequently necessary to break into a program in order to give an order to some police car, and second, that the orders were given out on the regular broadcast wave so that all the public listening in on a program heard them.



Radio-equipped squad car of the Chicago Police Department

Frequently the police were hindered or actually frustrated in their work by the "gallery" of persons that raced to the scene of a reported crime to see what transpired. This is not the case in Detroit, where the police radio station, operating on a low wavelength, is able to confine its messages chiefly to those for whom they are intended—the crews of the radio-equipped police cars. The receiving sets on the cars are tuned in on the radio station and locked in position.

Lieut. Cox was given a leave of absence in April and made a survey of the Chicago situation. He made a number of suggestions. These called for the construction of three police radio stations which could be operated independently or synchronized. He also recommended the equipping of nearly 300 police automobiles with radio receiving sets and loud speakers, the establishing of a central and dispatching point, and other provisions.

The Chicago system requires the services of eight operators to handle the incoming police calls and of three dispatchers to assign the various radio-equipped cars to those calls demanding immediate attention.

Broadcasting Room of the Cleveland Police

Cleveland's police radio system has been in operation since September 19, 1929. Less than two months after it began the crews of the six radio-equipped cars had made 87 arrests. The department has its own station, located in the Police Headquarters Building.

Provision was made for the use of radio as far back as 1925. The new Headquarters building was erected that year with space for transmitters, broadcasting room, workshop, etc. Steel antenna towers were erected on the roof. It took the efforts of the Cleveland Association for Criminal Justice, however, to bring radio actually into use by the Cleveland police.

The association became interested in the results being achieved in Detroit, and Miss Leona M. Esch, operating director of the association, went to Detroit for a first-hand study of the system. Before going, however, she had attended night school in order to learn the principles of radio.

She rode with the cruiser crews, spent considerable time in the radio station, obtained facts and figures, and returned to Cleveland, where she reported to the director of the association, made up of a number of the city's leading men, that in her belief police radio was one of the greatest police innovations in years.

The association then began its efforts to equip the police with radio. The suggestion found some city officials enthusiastic, some lukewarm and some hostile. Eventually, persistence and demonstrations of what radio could mean to the police turned the tide.

Chief of Police Jacob Graul, of Cleveland, is an enthusiastic supporter of radio's use by the police. In commenting on it, he said recently:

"Although our station has been in service only since September 19, 1929, it has proven itself a very valuable asset and the results have been very satisfactory.

"The best deterrent to crime is the certainty of arrest and punishment. Considering the short space of time in which the police may be notified of crimes committed, locations, etc., by radio, and reach the scenes, the possibility of apprehending the guilty persons has been greatly increased. We adhere to the statement that radio is still in its infancy, and believe that before long it will be even more prevalent in police work."

Chief Graul plans eventually to equip fully fifty police cars with radio.

The Indianapolis system, under the direction of Claude M. Worley, is fundamentally the same as that used in Detroit. One of the innovations enables the police chief or superintendent to sit at a desk and communicate directly with the crew of every radio-equipped car. The station and ten cars were placed in operation in December. The system eventually is to include thirty-five cars.

Other cities throughout the country have been considering the installing of radio equipment and further development of the growing network is anticipated by police officials during 1930.

Flying "Hams"

By J. V. Magee

A ONE-TIME amateur, now in charge of communications for the Transcontinental Air Transport, has applied the experience gained in hamdom to the problem of air communication. The claims for his transmitter are longer reliable range, less trouble and lighter weight than his company was able to find in any regular communication equipment—quite a compliment for amateur radio.—THE EDITORS.

E. W. PROCTOR

Chief Communications Engineer, T. A. T. Designer of the new aircraft transmitter built along "ham" lines

A NEW radio transmitter for use aboard the planes of the Transcontinental Air Transport coats-to-coast air-rail line which operates in connection with the Pennsylvania and Santa Fé railroads, was recently placed in operation.

The new transmitter was developed within the company by E. W. Proctor, communications engineer, and Daniel Givens, his assistant, and is believed to be the only intermediate-frequency voice transmitter to give entire satisfaction in airplane use. Radio receivers are in use on the T. A. T. planes and many other transport air lines.

For some time successful tests of the new transmitter have been carried on in scheduled operation. The longest test made provided clear two-way communication between a plane flying over the T. A. T. airport at Kingman, Arizona, and the T. A. T. radio station at the Clovis, New Mexico, airport, a distance of 617 miles. No transmission failure has been experienced since the new installation was first made on T. A. T. planes on August 20th.

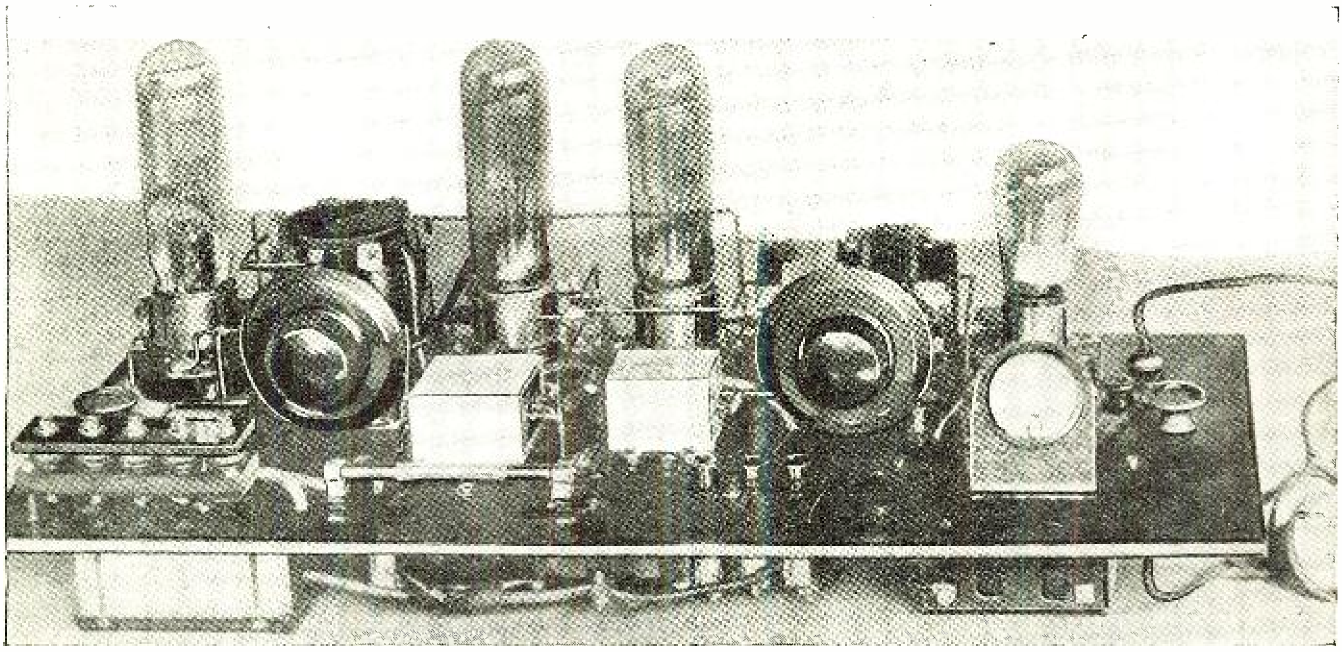
The new transmitter has been designed to eliminate all the difficulties which have been found in commercial sets with which T. A. T. planes have been equipped. It incorporates well-known radio circuits and principles, and is unique chiefly for its small size and great power. Its value for airplane communication is greatly enhanced by its light weight, which permits installation in the tail of the ship rather than in the passenger cabin. The complete transmitter, including all controls, tubes, dynamotor, antenna and microphone, weighs 87 pounds. The panel assembly shown weighs 30 pounds. The weight of the commercial equipment which it replaced was 185 pounds, and it had to be installed in the passenger cabin.

Because of its compact design, substitution of one transmitter for another can be made in less than five minutes.

The transmitter is mounted on a panel 12 by 27 inches, and consists of four tubes connected in a master-oscillator power amplifier circuit with an output rating of 100 watts. It utilizes an oscillator, power amplifier, and modulator, each of fifty watts, and a 7.5-watt speech-amplifier tube.

Only five connections are made to the transmitter; two high-voltage connections from the dynamotor, two to the tube filaments, from the ship's battery, and one to the microphone.

The dynamotor, having an output (*Continued on page* 751)



New 100-watt plane transmitter employs well-known "amateur" circuits, weighs less and does more than regular commercial units it replaces

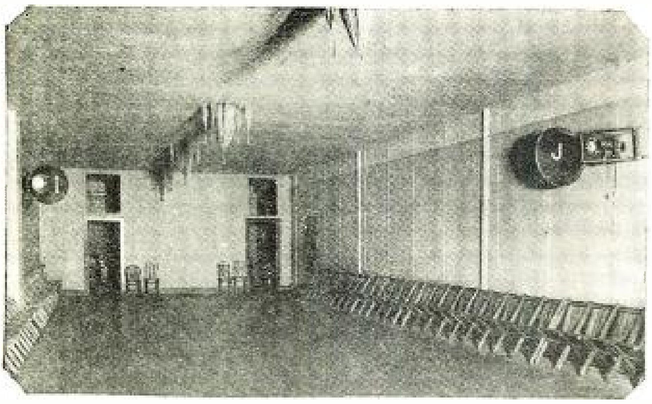


Fig. 2—An upstairs hall equipped with dynamic speakers and horn baffles for the reproduction of music from the main ballroom

On With *with the help of* Sound

Simple Installation Provides Four Dance Floors With Music from Orchestra, Phonograph or Radio

By

S. Gordon Taylor

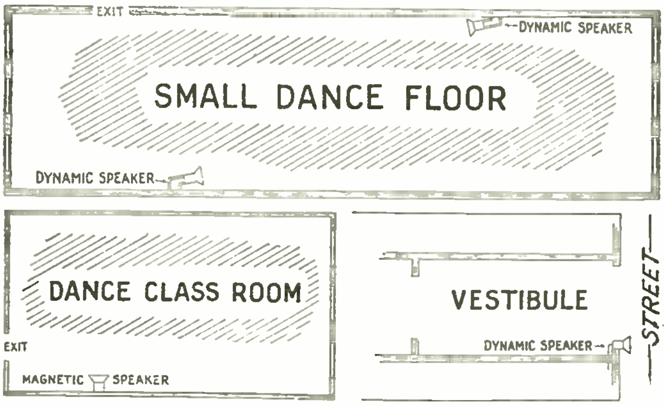


Fig. 4—Floor plan of two of the three halls constituting the Remey Dancing School, including the street entrance, where a dynamic speaker is mounted for publicity purposes

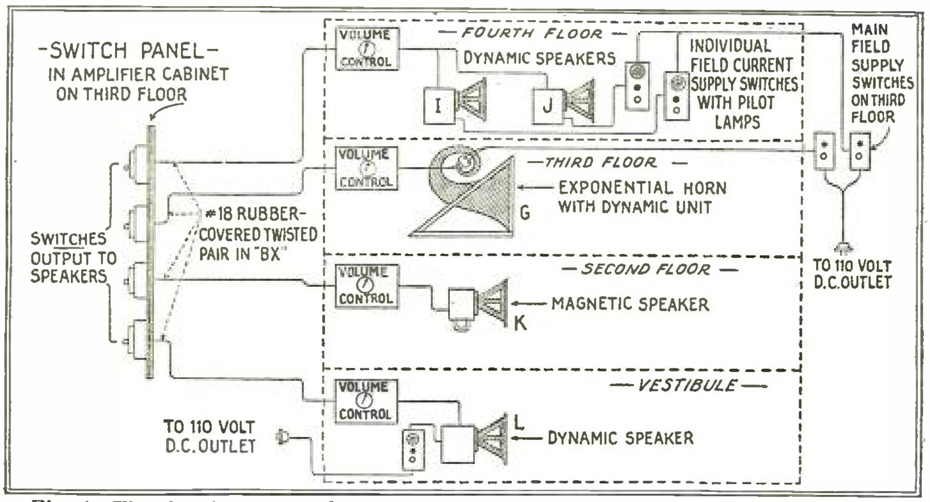


Fig. 6—The drawing above shows the wiring details for the complete loud speaker distribution system, together with its auxiliary volume control apparatus

THERE has been a demand among readers for a detailed description of a moderately sized sound amplifier installation—such a description as would be helpful to beginners in the installation field, in bringing out methods of procedure in making similar installations. To satisfy this demand, the installation recently made at the Remey Dancing School in New York City has been selected for description. It is sufficiently extensive to be definitely classed as a sound amplifier installation, yet it does not involve too many of the complications found in some of the really large installations.

Before going into the description of the equipment and layout, it will be well to explain the conditions which made an amplifier system desirable.

The Remey School had been in existence for many years, and during all that time it had been necessary to employ a regular orchestra for the main ballroom on the third floor, and extra musicians for the additional dance rooms located on the second and fourth floors. The second floor space is employed for instruction primarily, while the fourth floor space is used for the crowds that overflow the evening dances in the main ballroom, particularly on Saturday and Sunday evenings. This fourth floor space is also rented out during the week for private dances.

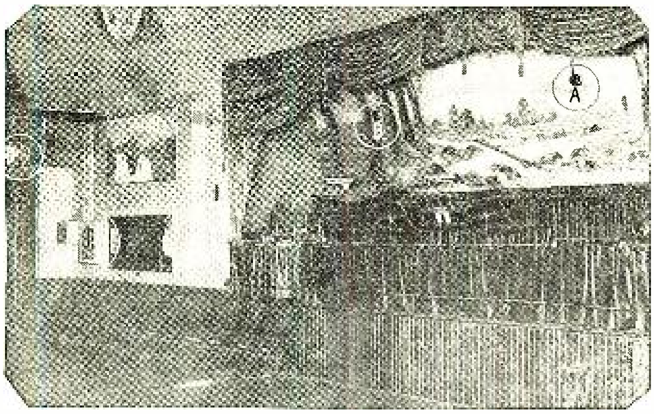
The expense of the extra musicians for the upper and lower floors was considerable, of course, but was made necessary by the fact that these floors were completely isolated from the main (third) floor, as far as the sound from the orchestra was concerned.

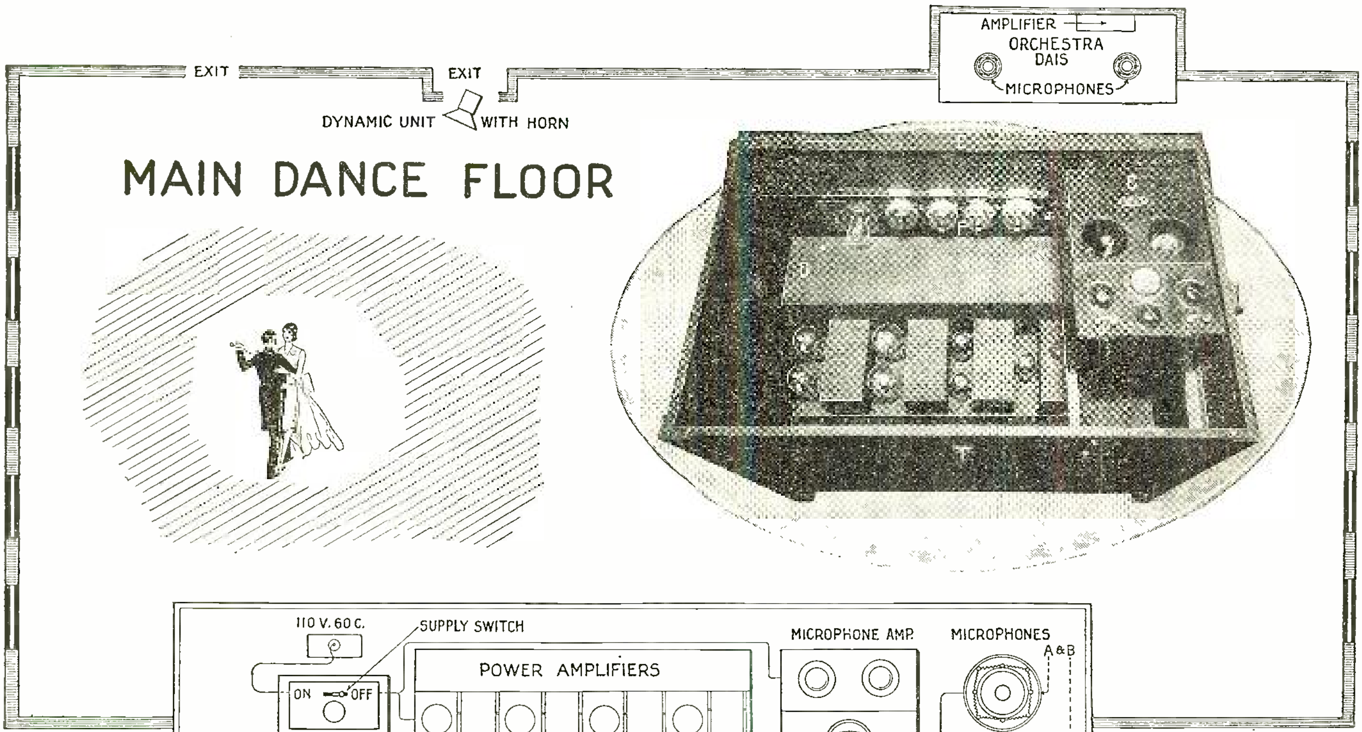
Then, too, there was another problem. The orchestra was mounted on a raised platform, set in a recess in one wall. The hall itself was long and narrow, with the result that the orchestra could scarcely be heard at one end of this hall, over the noise of the dancers.

Obviously the answer to both of these problems was the installation of an amplifier system which would carry the orchestra music to the "dead" end of the main hall, and also to the halls upstairs and down. After careful consideration it was decided to install microphones, amplifiers and speakers, which would permit the music from the orchestra to be distributed throughout the premises. Neither radio nor phonograph were considered necessary, but either can be added to the installation should such addition later appear necessary. Arrangements were therefore made with Mr. H. J. Pfeufer, of the National Amplifier Service Company, Inc., 152 West 42nd Street, New York City, to design and make the installation.

In discussing the equipment selected for this installation, frequent reference is made to the schematic diagrams shown in Figs. 5 and 6. The discussion will start with the microphones

the Dance AMPLIFIERS





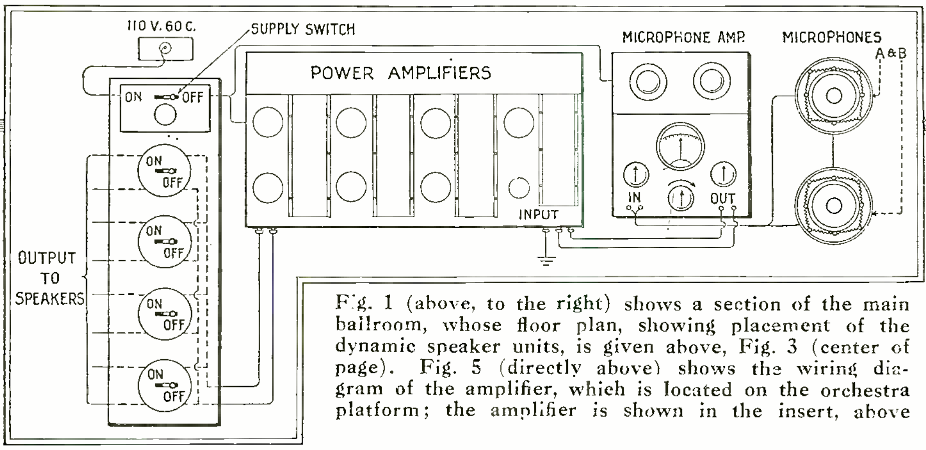


Fig. 1 (above, to the right) shows a section of the main ballroom, whose floor plan, showing placement of the dynamic speaker units, is given above, Fig. 3 (center of page). Fig. 5 (directly above) shows the wiring diagram of the amplifier, which is located on the orchestra platform; the amplifier is shown in the insert, above

and continue in logical order through to the loud speakers.

The shallowness of the orchestra dais makes it necessary to string the musicians out in a line, with the result that the orchestra is so widespread that one microphone would not have been sufficient to provide adequate pick-up, without accentuating the nearest instruments and neglecting those further away. Two microphones were therefore decided upon, located as shown at A and B in Fig. 1. These microphones are of the single button type, manufactured by Amplion.

The entire amplifier equipment is located on the orchestra platform, and is enclosed in a metal table stand, so arranged that it may be locked up when not in use. An inside view of this cabinet with the cover removed is shown in Fig. 3. This location of the amplifiers has the advantage that it is close to the microphones and therefore keeps the rather critical microphone leads short, with consequent less likelihood of picking up interference from lighting lines and other sources. Also, such attention as the amplifier may require in operation can be given by some member of the orchestra, although little attention is required, except perhaps an occasional readjustment of button current for the microphones.

Continuing the discussion of the individual items of equipment, the microphone amplifier comes next. This is also an Amplion product and is operated from the a.c. lines. It consists of a single stage, employing a 299 tube. The tube filament, plate and the microphone button currents are all obtained through a 380 type rectifier tube and suitable filter, incorporated in this amplifier unit, which is shown at C in Figs. 3 and 5. The input and output impedances of the unit are such as to match the microphone impedance with that of the power amplifier input.

The microphone amplifier has three controls mounted on its face. One is to regulate the button current, thus controlling the microphone sensitivity. The second controls the filament current, and the third the output volume. Thus complete control is obtained, and a meter is included in this amplifier as an aid in making adjustments.

The power amplifier, shown at D in Figs. 3 and 5, is a three-stage job, also by Amplion, and using Ferranti transformers and parts. As will be noted from the illustrations, the entire amplifier is mounted on a single base and is fully shielded. The first stage employs a single 327 tube, the second stage is push-pull, using two 326 tubes, and (*Continued on page 755*)

HOW *to* INSTALL *an* AUTO-RADIO RECEIVER

By Stuart C. Mahanay

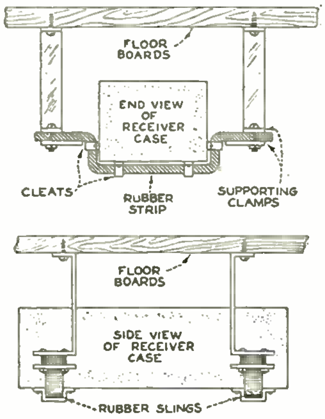


Fig. 1—Shock absorbers for mounting the set under the floor boards

RECENT issues of RADIO NEWS have described in some detail the problems which must be met and overcome in the construction of radio receivers for use in automobiles and motor boats. The selection of the type of receiver to be used and its construction present only a part of the job to be accomplished.

Once it is built the constructor must give thought to its location in the car. It is true too, that, where the set has not as yet been built, the amount of space available for it will exert a deciding influence on the type finally chosen.

It is with this in mind that the following article has been prepared. The information presented has been carefully compiled and is offered as an aid to those enthusiastic pioneering souls who are now finding an outlet for their energies in this newest of ventures in radio.

Tuning and Operating the Set

Assuming that the receiver has been built, the first item for consideration, in the car itself, is how and where the tuning controls are to be located. Naturally it is out of the question to consider that the tuning dial, volume control and "on-off" switch will be mounted directly on the receiver chassis. The bulkiness and the lack of a suitable place to locate a receiver, so as to be reasonably convenient for tuning, precludes this possibility in most cases. Therefore, we will assume that the tuning controls will have to be placed in one location, naturally the most accessible and convenient one, while the set itself is located elsewhere in the car.

Belt drive of the condenser shaft is a possibility, but the simplest method of control is a flexible shaft such as those used in dental drilling machinery and speedometers. In other words—a modified remote tuning control. Volume control of the receiver, together with the means for switching it "on" and "off" require only that the actual units necessary for these operations, namely the volume control variable resistance and battery switch, be connected with the circuit of the receiver by means of extra long shielded leads.

Usually it is found most convenient to locate the tuning controls directly on the dash or at the driver's left, on the side wall of the car. See Figs. 7 and 8. From either of these location the flexible shaft and leads go directly to the set.

The actual placing of the receiver depends largely upon the size and type of car in which it is to be installed. for instance, in a coupé or roadster, the logical place for the set and batteries would be in the compartment occupied by the rumble seat (Fig. 7). In a sedan or touring car having an unusually long hood, ample space for locating the receiver will be found directly forward of the dash, under the hood. In others, space may be found under the floor-boards (Fig. 4) or even under the seat. Still another place for the set is on the running board, where it may be placed in a metal box, strong enough to serve as a step if necessary.

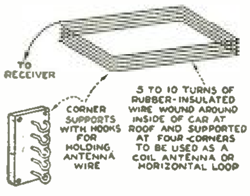


Fig. 6.—How to mount the coil antenna in the roof

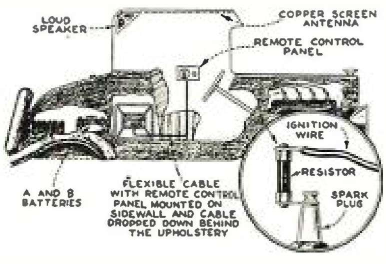


Fig. 7.—Showing the installation details for the set, batteries and tuning control. For eliminating spark-plug interference note the use of the resistors

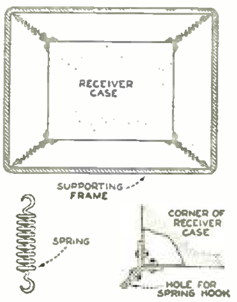


Fig. 2—Another method of shock-proofing the set

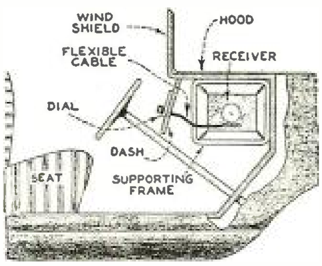


Fig. 8.—Mounting the set under the dash provides a short tuning control cable to the dash board

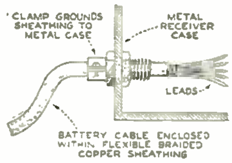


Fig. 3.—Use a clamp to ground the cable shield to the set's case

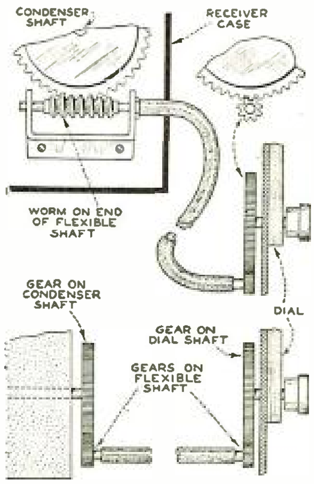


Fig. 9.—Some methods for gearing the tuning control to the condenser shaft are shown here

Shock-Proofing the Set

To take up the excessive vibration which will be visited

(*Continued on page 773*)

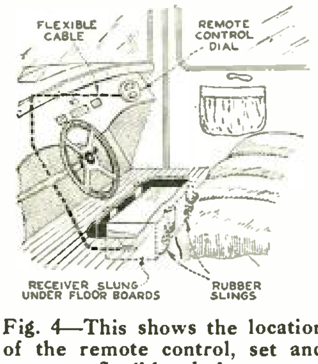


Fig. 4—This shows the location of the remote control, set and flexible shaft

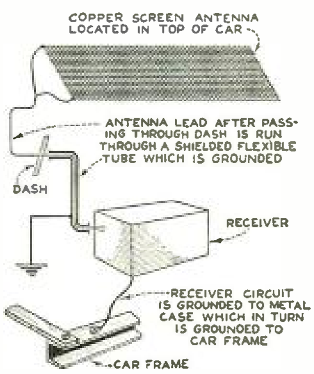
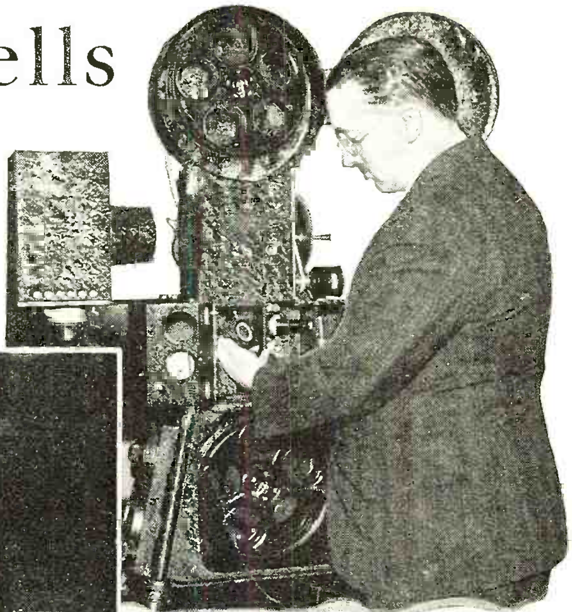


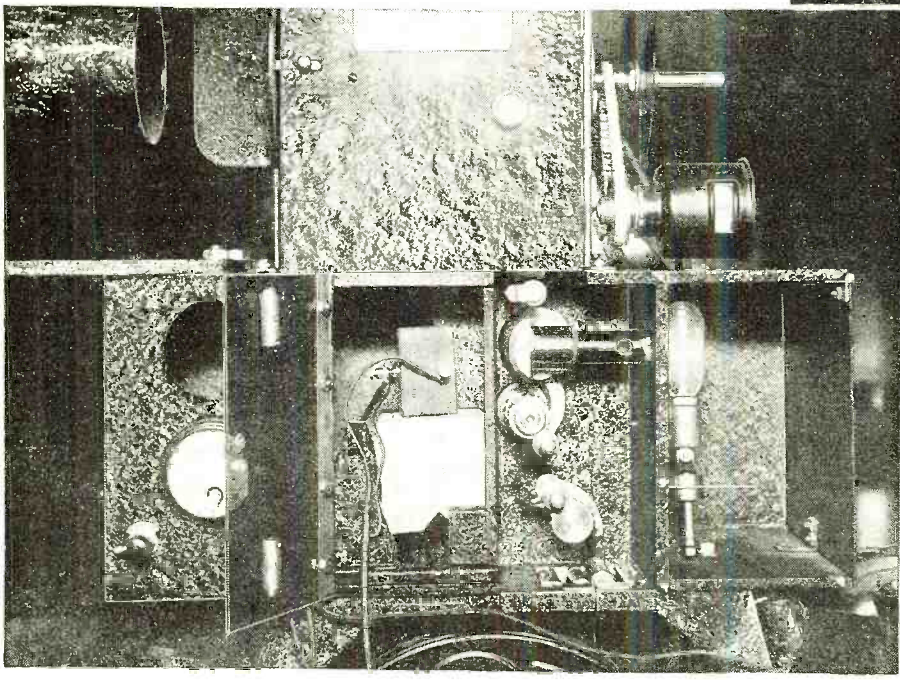
Fig. 5—Details of the antenna-ground system for an auto-radio installation

The shielded spark-plug which aids in eliminating ignition interference

Light-Sensitive Cells Make Talking Pictures Possible



Mr. Wein is holding the photo-voltaic cell which is used in the projection machine to convert light variations into electrical impulses



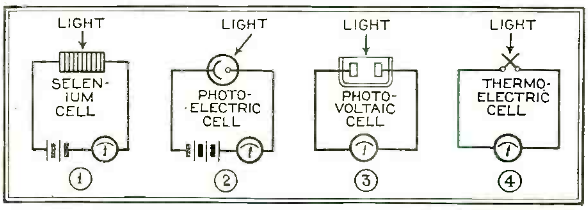
A close-up of a section of the projection machine showing, right to left, light source, optical system and light-sensitive cell

By John B. Brennan, Jr.

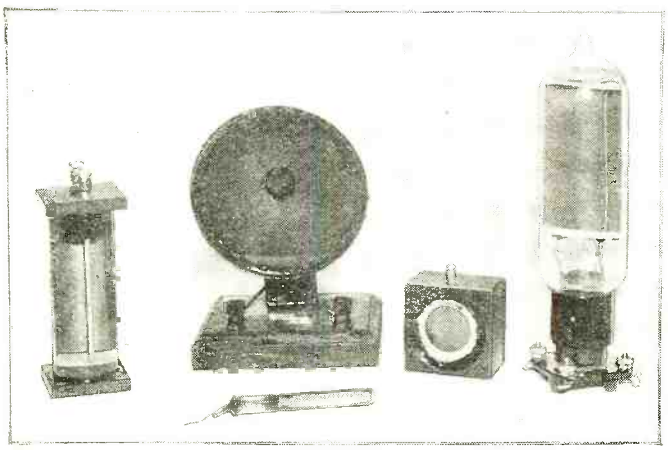
COMING into prominence recently, principally through the activities associated with the detection and elimination of the "smoke nuisance" and also by its application to television and talking moving pictures, the light-sensitive cell has become the center of much interest.

In the presentation of information of an authoritative nature on light-sensitive cells as used in amplifier circuits and the principles underlying their operation, Radio News magazine has had the hearty co-operation of Mr. Samuel Wein, now affiliated with the Radiovision Corporation and for the past 28 years intimately identified with the progress and developments in the light-sensitive field. For the information contained here Radio News is indebted to Mr. Wein.

A light-sensitive cell may be (*Continued on page* 750)



Circuits illustrating the four standard types of light-sensitive cells for converting variations of light into electrical current



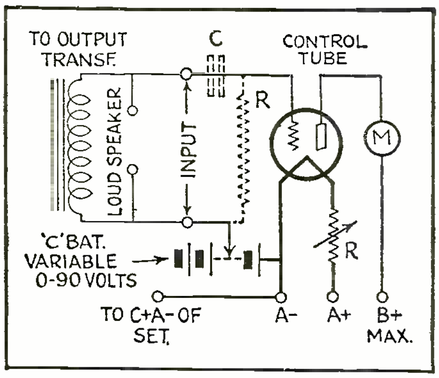
Above, to the right is shown the Eveready-Raytheon "foto-cell," while to the left are shown five different shapes and sizes of radiovision photo-voltaic cells

Mr. Wein is holding a cell which, when connected to a meter and exposed to light, shows a reading of several mils

Circuit Constants and Constructional Information on the Automatic Volume Control

By Charles Williamson*

EXPERIMENTERS and radio engineers are somewhat sketchily familiar with devices providing automatic control of volume intended for use with a type of receiver which has been until recently the commonest in American homes. This familiar sort of receiving set uses three or four 201-A type tubes, with a 171-A in the output stage operating a magnetic speaker. Experience has shown that before we can adapt an automatic control designed for this type of receiver to receiving sets of other types, we must go rather thoroughly into the question of what the control seeks to do and how it does it.



To determine the value of the constants for the circuit finally to be employed, it is just necessary to construct a simple vacuum tube voltmeter, whose circuit is given here

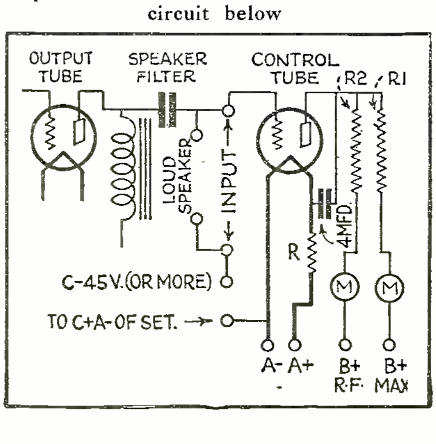
All volume controls, whether automatic or manual, may serve either of two different purposes: the first, to set the average volume of the incoming signals at a pleasing level; the second, to reduce the intensity of the loudest passages to a point where they are acceptable, and to bring up the intensity of the softest parts until they are satisfactorily audible. Any automatic control which depends for its action upon carrier intensity alone must needs serve the first purpose only, inasmuch as it remains unaffected by a.f. amplitudes. In this case the hand knob must be used to control undesired extremes of audio intensity.

On the other hand, the automatic volume control devised by the writer is operated by the a.f. output of the receiver. Hence its primary purpose is to control the extremes of audio intensity, bringing up the softest parts and limiting the loudest to a predetermined maximum. This leaves the usual hand knob to be set for average volume only. Thus, the automatic feature eliminates gross overload distortion, cuts down the intensity of heavy static crashes, and partly compensates for fading. As will be explained later, the medium range, from fairly soft to fairly loud, is left practically undisturbed, so that the proper musical contrasts will be preserved. Moreover, this type of volume control does its work without reducing the sensitiveness of the tuner to weak signals.

The article in the March issue had to be dogmatic about voltages, resistance, tube, etc., because it was a specific description of the automatic volume control as attached to a particular receiving set. In order to determine what the value of the constants should be when adapting it to some particular set, certain experimental data will be needed. The first thing to be measured is the maximum a.f. voltage we will allow to appear across the loud speaker. This will of course vary with the type of output tube used in the set. In order to measure it, we will construct a simple vacuum tube voltmeter. Inasmuch as this will be used later as a part of the finished automatic volume control, it involves no extra expense for materials or labor.

A fairly good 150 volt d.c. meter having a resistance of about 100 ohms per volt (a low range milliammeter may also be used), a small power tube with socket, and four or five small size 45 volt B batteries will make a serviceable vacuum tube voltmeter for our purpose. The connections are shown in Fig. 1. For A and B power we can use the sources belonging to the set. The grid must be biased off with the dry cell B batteries—until the voltmeter (which is here being used as a plate milliammeter) shows no current. If the tube is a 171-A with 180 volts supplied to the B+ terminal, this will probably occur in the neighborhood of minus 67½ volts grid bias.

Automatic control of the plate potential supplied to the r.f. amplifier of a receiver is obtained by the use of a control tube connected across the loud speaker terminal as shown in the circuit below



If the set has an output filter or transformer, the tube voltmeter may now be connected directly across the speaker as shown in Fig. 1. Note that the C+, A— terminal on the set is connected to the C+, A— terminal on the tube voltmeter, if this has separate sources of power supply. The speaker return *must* be removed from A— (if previously so connected) and left unconnected except to point X on the tube voltmeter.

If the set has no output device, or if the speaker is a dynamic type using a high ratio step-down transformer, we may provide the vacuum tube voltmeter with an input filter, shown dotted at C and R (Fig. 1). In this case the speaker return is *not* made to the vacuum tube voltmeter but left connected to B+ as usual.

Having connected the V.T. voltmeters to the set, tune the receiver to a strong local station, set its volume at the maximum desired. When the set is placed in operation, any a.f. voltages across the speaker will be indicated by "kicks" of the plate circuit meter. Now increase the negative grid bias on the tube voltmeter until the kicks of the plate circuit meter are just about eliminated. The amount of extra C bias thus required is equal to the peak a. f. voltage appearing across the speaker. It need not be determined any closer than the nearest 22½ volt tap on the set of B batteries used for grid bias as it is required only for the selection of the proper control tube to be used in the finished automatic volume control.

There is obviously room for considerable judgment in this experimental procedure. Some simple calculations will give us a good idea of the approximate voltages that may be expected. The maximum allowable output voltage of a tube is given by the equations

$$W = EI = \frac{E^2}{R}$$

therefore $E = \sqrt{WR}$

where W is the maximum undistorted power in watts that can be delivered to an external non-inductive resistance R, this resistance having a value in ohms equal to twice the plate a.c. resistance of the output tube.

In the case of a type 171-A tube with a load of 4000 ohms, this becomes

$$E = 0.7 \times 4000 = 52.9 \text{ volts.}$$

This being an RMS value, the peak voltage, E′, is given by

$$E' = \sqrt{2WR} = 52.9 \times 1.414 = 74.6 \text{ volts.}$$

*Carnegie Institute of Technology.

Table I gives the results of similar calculations for the six common output tubes. In the case of a push-pull circuit, the allowable voltages may be multiplied by about 2½.

TABLE I

Maximum Allowable Voltage Across Loud Speaker

Output Tube	120	112-A	171-A	210	245	250
$\sqrt{2WR}$ (volts)	52.5	60.5	74.6	175	116.3	198

For best results, the figures in the above table should be used only as a guide, being supplemented by the vacuum tube voltmeter measurements previously described. The table gives voltages which should not be exceeded if the output tube is not to be overloaded. But the speaker, the first audio tube, and the detector tube can give rise to objectionable overload distortion. Here the measured speaker voltages must decide. As soon as overload distortion is heard, the peak voltage should be observed, and noted as the value which must not be exceeded.

Now we are ready to change our vacuum tube voltmeter into the automatic volume control. It will be familiar to all that the volume control knob found on every broadcast receiver actuates a variable resistance of some kind. Hence in designing the automatic control we must make use of some arrangement in which the control tube functions as a variable resistance. If at any time the plate potential and current are simultaneously observed, a simple Ohm's Law calculation indicated by the equation

$$R = \frac{E}{I}$$

will give the plate-to-filament d.c. resistance. For a 171-A type tube this varies from 2600 ohms to several megohms, rising as the negative grid bias increases or as the plate voltage decreases. The fact that one terminal of this resistance must be at a high potential suggested its use as a control for either the plate or grid potential supplied to an r.f. tube. Circuit difficulties made the control of grid bias seem less desirable, inasmuch as it was desired to keep the device as simple as possible. Therefore it was decided to control the plate supply to an r.f. tube. The connections for this purpose are shown in Fig. 2. This also shows how the automatic volume control is connected to a receiver having an output filter.

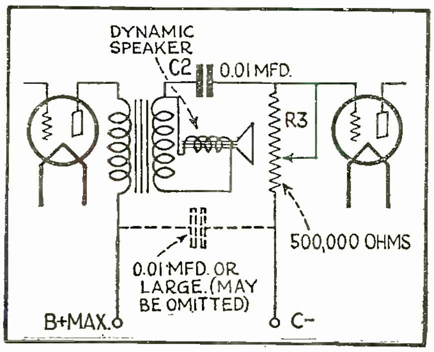
A large bypass condenser, two resistor mountings, and an assortment of fixed resistors are needed, and another meter will be helpful. A low-range milliammeter of 0-5 ma. range is preferable, but another voltmeter similar to the first will serve. The resistor marked R2 takes the place of a choke used in previous experiments. A value of 10,000 ohms will have about the same impedance to 60 cycle current as the choke, and of course will be cheaper and take up less space. Two variable resistance units of suitable range might serve in the place of the fixed resistors, but the experimenter would not then know very definitely what values of resistance were being used. The automatic volume control may use the same sources of A, B and C power as the receiver, and the filament may be heated by a.c. if desired.

We may now select the most suitable control tube. Under the simplest conditions, the speaker a.f. voltages are impressed directly on its grid. When this is the case, the grid should not be allowed to go positive. It will be seen from Fig. 2 that if it were to do so, grid currents would flow through the speaker in such a way as to add to the positive halves of the signal currents, thus producing distortion. This in fact can be easily heard by the experimenter. If peak voltages up to 67½ can be handled by the audio system, they can evidently be put on the grid of our 171-A control tube without modification. Should it be found that values of less than 20 volts will overload some part of the receiving set, a 112-A will be a better choice for control tube.

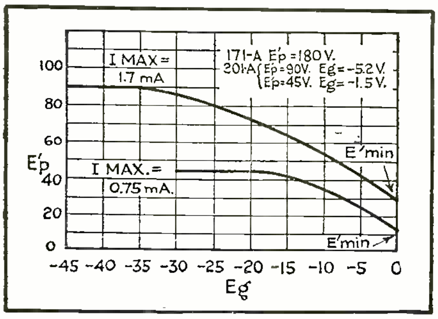
There are two conditions under which the above arrangement must be modified; the first, when the audio-frequency potentials are in excess of 67½ volts; the second, when the speaker or other output winding is at a high d.c. potential. To provide for the first condition, two possibilities present themselves. The grid of the control tube may be given additional negative bias, or the speaker voltages may be impressed on a potential divider, and any desired fraction tapped off for the use of the control tube. The first of these expedients is the cheaper, and will probably serve well enough if the speaker voltages do not exceed 135. For higher values, the "potentiometer" scheme is preferable; and it affords the added advantage that the amount of control exercised by the device can be set to any value preferred by the experimenter. Furthermore, we are no longer limited to the use of a type 171-A or 112-A tube; any tube that will exercise the desired amount of control may be used.

If the receiver uses a push-pull output choke or a dynamic speaker, the winding across which the high a.f. voltages appear will be at a high d.c. potential. In this case, at least one, and preferably two, stopping condensers are required, as well as a high resistance potentiometer. All of these must be able to withstand the high potentials involved. The connections are shown in Fig. 3. If it is desired to substitute other values for C2 and R3 than those shown, C2 should be increased as R3 is diminished.

The use of one or two stopping condensers, together with a high resistance potentiometer is shown in this circuit where the automatic volume control is connected to a receiver whose output employs an output push-pull choke or dynamic speaker



Now we can determine experimentally the value of R1 and the minimum bias to be used on the grid of the control tube. Turn on the receiving set with which the automatic volume control is to be used. Measure the normal plate current drawn by the tube or tubes to be controlled. Connect the automatic volume control to the receiving set, but remove the control tube from its socket, or else turn out its filament. Turn the receiver on fully, but do *not* tune it in to any station. Read the plate current drawn by the tube or tubes under control. Fixing R2 at about 10,000 ohms, change R1 until the plate current, as shown by both meters alike, has its normal value. Next insert—or turn on—the control tube, and bias off its grid until both meters read alike again. This is the minimum bias that should be used. Inasmuch as it may be minus 67½ volts or more, the standard —45 volt tap of the B eliminator may have to be boosted by the addition of a small-sized B battery. If the control tube is allowed to draw plate current in the absence of a signal, the value of R1 will have to be reduced, which will render the automatic control less effective.



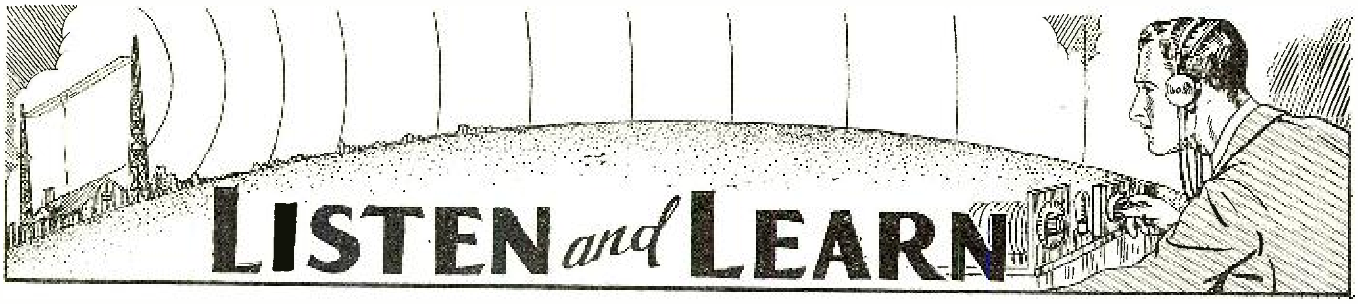
A typical curve plotted and obtained by means of a potentiometer control to indicate various values of peak voltage under the operating conditions as indicated

The maximum grid bias to be used on the control tube is that indicated in Table I, or less, as determined experimentally by the procedure outlined in the eighth paragraph of this article. If this maximum proves to be greatly in excess of the minimum bias required, the potentiometer connection of Fig. 3 is desirable. When this is used, the grid bias can be reduced to the minimum value, merely to prevent the tube drawing plate current in the absence of a signal; and the speaker voltages can be reduced to an appropriate value by setting the potentiometer knob. Furthermore, the grid of the control tube may now be allowed to go positive at times without bad effect.

An idea of the voltage regulation obtained under various circumstances can be had from Table II.

In this table, E max. shows the highest available plate voltage, I max. the highest plate current in milliamperes taken by the r.f. tube being controlled, R1 + R2

(*Continued on page 766*)



When Broadcast-Listening Palls, Speed up Your Code Receiving by Building This Simple Two-Tube, Long-Wave Set. Signals from Stations Throughout the World Transmitting at All Tones and Speeds Are Yours for the Listening

By John B. Brennan, Jr.

IN recent years such great strides have been made in the radio broadcasting field that the mere mention of the word radio gives rise to the supposition that the topic under consideration has to do purely with broadcast activities. This distorted viewpoint on the part of the listening public has been instrumental in preventing them from fully realizing that radio broadcasting plays but a small part in the world of radio activities.

Development of short-wave transmission has been recent enough still to be in the public's eye. but of the older long-wave transmission little or nothing is heard.

Surprising as it may seem, there are hundreds of stations located in every part of the globe which daily carry on communication with other stations thousands of miles removed from them. Their business is largely national and international, giving their transmission a decidedly interesting flavor.

Inquiries made to the Radio Inspector's Office of the Department of Commerce, the Radiomarine Corporation of America and other radio communication interests have elicited the information that while most transoceanic transmission takes place at an exceedingly high speed, say 80 words or more per minute. there are still enough stations, sending as slowly as 18 words and less per minute, which will interest the listener enough to "copy" them.

And thus we come to the business at hand.

Perhaps you don't know the code but want to, or you have a smattering of it and wish to brush up on your speed both in copying and in handling the key. Perhaps, after reading Lieutenant Wenstrom's articles on the fascination in short-waves you want to get into this work but lack a knowledge of the code. Well, there's no better way to learn than by listening.

Throwing together a key and buzzer so that you may practice sending is to be highly recommended. Fig. 1A shows the simple circuit for connecting a key, battery and buzzer. If you want a more elaborate outfit, the circuit shown in Fig. 1B should be used. Here the buzzer works continuously, being inductively coupled to the key-phone circuit by means of the telephone induction coil. The code characters are formed by operating the key and are heard in the phones. This arrangement more closely simulates actual receiving conditions.

Once you are more or less familiar with the code and want some good copying practice the long-wave receiver helps admirably. On the 600-meter band there are all the ships to listen to. Up higher, around 1600 to 2500 meters, are the coast stations, while beyond this are the real long-wave transoceanic stations.

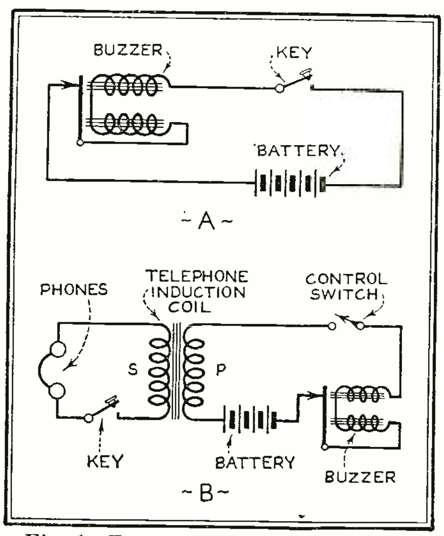


Fig. 1—Two methods of connecting together buzzer outfit for learning the code are shown in circuits above. "A" shows the buzzer operated directly by the key, while "B" shows continuous operation of the buzzer with keying done in the secondary circuit

Building a set for this work is simplicity itself. All you require is an assortment of plug-in honeycomb coils (see table 1), a .0005 mfd. variable condenser, a couple of sockets and tubes, fixed condensers, a transformer, binding posts, etc.

The layout of the parts on a baseboard is shown in Fig. 2. There's nothing elaborate about it, the condenser, rheostat and switch being mounted on pieces of bakelite panel and the other apparatus being firmly fastened to the baseboard. For further mounting details see Fig. 3.

The circuit connections are shown in Fig. 4. Tuning is accomplished by the condenser C1, while change from one wave-band to another is obtained by changing the honeycomb coil L. Control of oscillation is obtained by regulation of the rheostat R2.

How to Build the Two-Tube Long-Wave Receiver

First, obtain the parts as listed in the Parts List. When these have been got together they should be inspected thoroughly for loose nuts and bolts. It is much better to tighten such loosened

Table 1

~ TUNING RANGES ~
(WITH .0005 MFD. CONDENSER)

HONEYCOMB COIL	WAVE-BAND COVERED
100 TURNS	500 TO 900 METERS
150 TURNS	700 TO 1450 METERS
200 TURNS	900 TO 1900 METERS
250 TURNS	1100 TO 2400 METERS
300 TURNS	1400 TO 2900 METERS
400 TURNS	1800 TO 3850 METERS
500 TURNS	2300 TO 4900 METERS
600 TURNS	2800 TO 5700 METERS
750 TURNS	3500 TO 7200 METERS
1000 TURNS	4700 TO 9600 METERS
1250 TURNS	6000 TO 12500 METERS
1500 TURNS	7500 TO 15500 METERS

This chart shows the sizes of honeycomb coils which are to be used for the long-wave bands designated parts before they are assembled into a complete receiver, since such a procedure saves such time and temper as are lost when a loose contact is discovered after the set is fully assembled and wired.

When all the parts have been inspected properly, study the base layout of the receiver, as shown in Fig. 2. Note here that the tuning and other controls, instead of being mounted on a large piece of panel material, are supported from the base by short strips of bakelite or even wood. Thus you can keep down the expense of the rceiver by using such material as might be found in your junk-box. Although not shown in Fig. 2, the filament or "on-off" switch is located on the same strip of panel as the rheostat R2. The exact location can be seen in Fig. 3.

In mounting the National condenser with its vernier dial, proceed as follows: First, remove the knob and bakelite disk from the dial mechanism by loosening the setscrew in the knob, and then removing the three small screws which hold the disk to the dial works. Then drill the center hole for the condenser shaft. Next, hold the mechanism against the front of the panel on which the condenser is to be when completely assembled. To do this it may be found worth while actually to hold the condenser behind the panel, and then judge as accurately as possible the location of the dial mechanism. Once you have done this, hold the mechanism in place, with the four screw holes near its edge running parallel with the top and bottom of the panel. With a pencil or nail mark the location of the holes, and then drill. Next, mount the condenser and dial mechanism to the panel by means of the four screws supplied.

Drill the other panel strip and mount the rheostat and filament switch. Next, mount the two panels on the front edge of the baseboard.

Now study the layout, Fig. 2, again, and temporarily put the other parts, such as sockets, transformer, coil, etc., in their proper places. When you are sure they conform with the arrangement as shown in the layout, then screw them in place permanently. The coil mount for the honeycomb coil should not be placed too near the condenser unit. About halfway between the back of the condenser and the rear edge of the baseboard is satisfactory. Furthermore, placing it in an open space helps when it is necessary to change from one wave-band to another by plugging in other sizes of honeycomb coil.

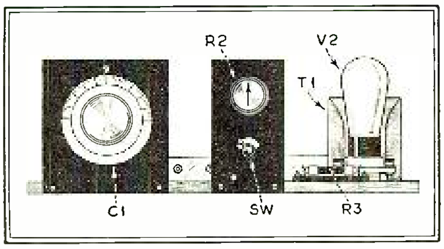
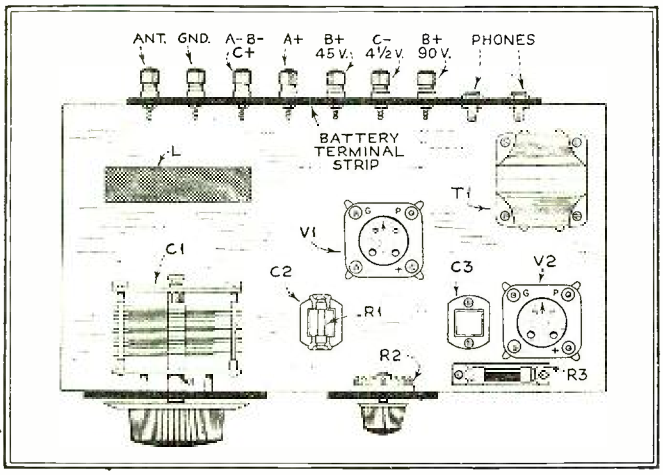


Fig. 3—Panel layout of the long-wave receiver, showing simplicity of design

Parts List

The following parts are employed in the construction of the receiver:

Fig. 2—The parts for the two-tube, long-wave receiver are mounted on the baseboard in accordance with the layout shown below



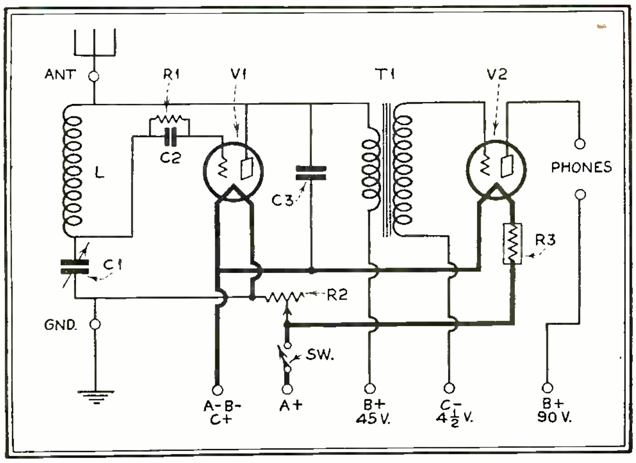


Fig. 4—The circuit diagram of the two-tube receiver for tuning in the long waves. The letters refer to instruments called for in the parts list

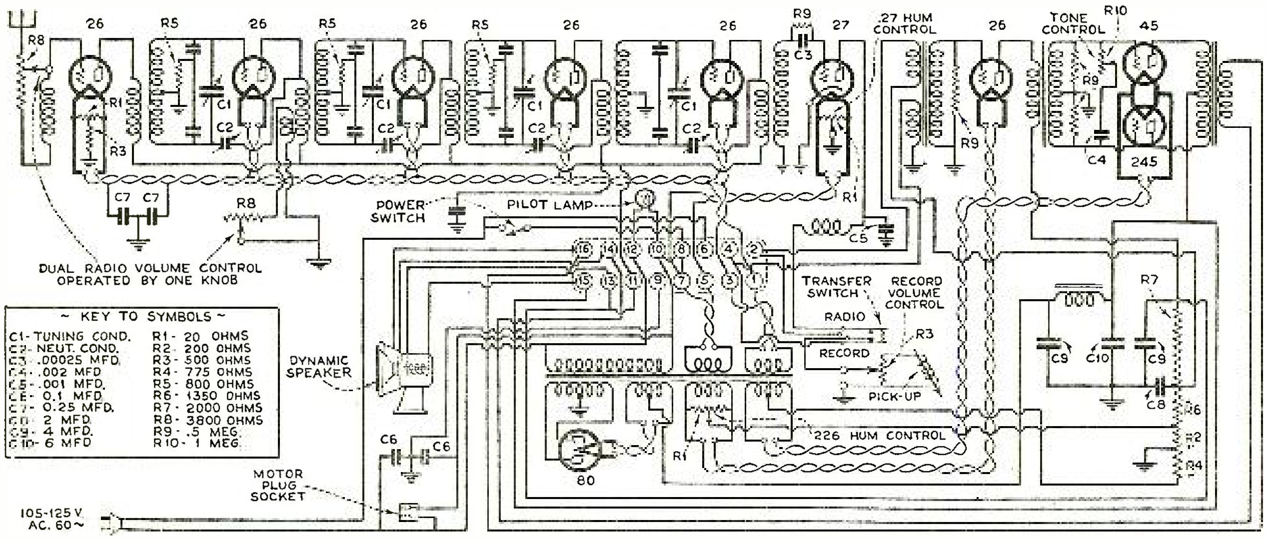
International Morse or Continental Code

Letter	*Signal*	*How It Sounds*
A	. -	dit dah
B	- . . .	dah dit dit dit
C	- . - .	dah dit dah dit
D	- . .	dah dit dit
E	.	dit
F	. . - .	dit dit dah dit
G	- - .	dah dah dit
H	. . . .	dit dit dit dit
I	. .	dit dit
J	. - - -	dit dah dah dah
K	- . -	dah dit dah
L	. - . .	dit dah dit dit
M	- -	dah dah
N	- .	dah dit
O	- - -	dah dah dah
P	. - - .	dit dah dah dit
Q	- - . -	dah dah dit dah
R	. - .	dit dah dit
S	. . .	dit dit dit
T	-	dah
U	. . -	dit dit dah
V	. . . -	dit dit dit dah
W	. - -	dit dah dah
X	- . . -	dah dit dit dah
Y	- . - -	dah dit dah dah
Z	- - . .	dah dah dit dit
Numerals		
1	. - - - -	dit dah dah dah dah
2	. . - - -	dit dit dah dah dah
3	. . . - -	dit dit dit dah dah
4	. . . . -	dit dit dit dit dah
5	. . . . .	dit dit dit dit dit
6	-	dah dit dit dit dit
7	- - . . .	dah dah dit dit dit
8	- - - . .	dah dah dah dit dit
9	- - - - .	dah dah dah dah dit
0	- - - - -	dah dah dah dah dah

L—Honeycomb coil, with mount (see table for sizes)
C1—One National tuning condenser, with dial, .0005 mfd.
C2—One Sangamo fixed condenser with grid leak clips, .0005 mfd.
C3—One Sangamo fixed condenser with grid leak clips, .001 mfd.
R1—One Durham grid leak, 2 megohms
R2—One Yaxley rheostat, 20 ohms.
R3—One amperite, type 1A
T1—One Sangamo audio transformer, 3 to 1 or 4 to 1 ratio
V1, V2—Two 01A tubes
Two sockets
Seven binding posts
Two Yaxley tip jacks
One Yaxley battery switch, No. 10
One baseboard, 9 by 7 inches
Two pieces bakelite panel One box Corwico stranded braidite

Radio News Manufactured Receiver Circuits

VICTOR RADIO MODELS R-32 AND RE-45



Victor

TEN tubes are required in the model R-32 and model RE-45 Victor radio receivers. Six of them are of the a.c. –26 type, one an a.c. –27 (detector), another a rectifier of the –80 (full-wave) type and two –45 power amplifier tubes.

The model R-32 is only a radio receiver, while the model RE-45 is a combination radio and electric phonograph.

By means of a variable resistance (R10) shunted across the secondary of the push-pull input transformer control of tone is obtained so that the high or low audio frequencies may be accentuated as desired.

The tuner, amplifier-power supply and loud speaker, are all wired separately and brought out to plug-in cables which connect to a terminal board, thus making installation a matter of simply plugging together the three units.

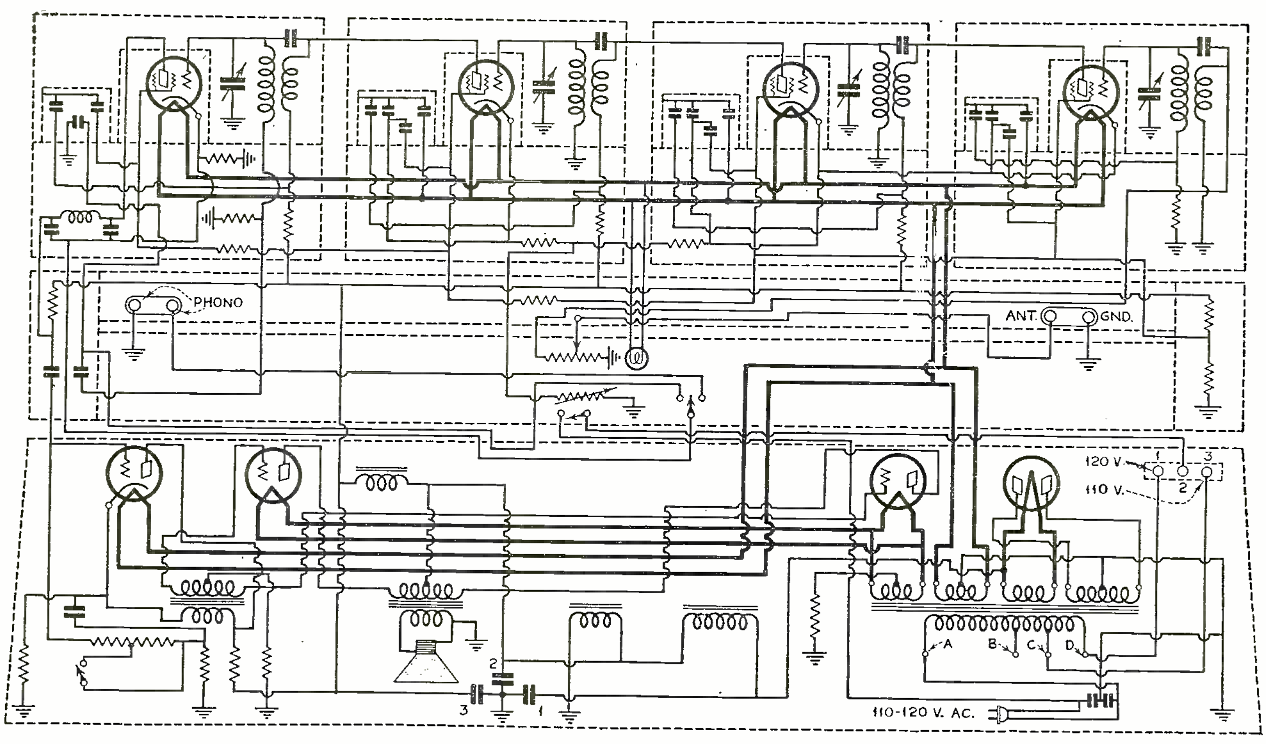
Colonial

IN the Colonial model SG-32 a.c. receiver four sharply tuned circuits which are totally shielded from each other are "staggered" to secure a flat-top resonance curve.

The tuner comprises four shielded and filtered stages of high gain radio-frequency amplification, employing four a.c. screen-grid tubes, one of which is used in the power-detector circuit. The detector outputs to a resistance-coupled first audio stage employing the –27 type tube. The final audio stage comprises a power-amplifier employing two –45 tubes arranged in push-pull.

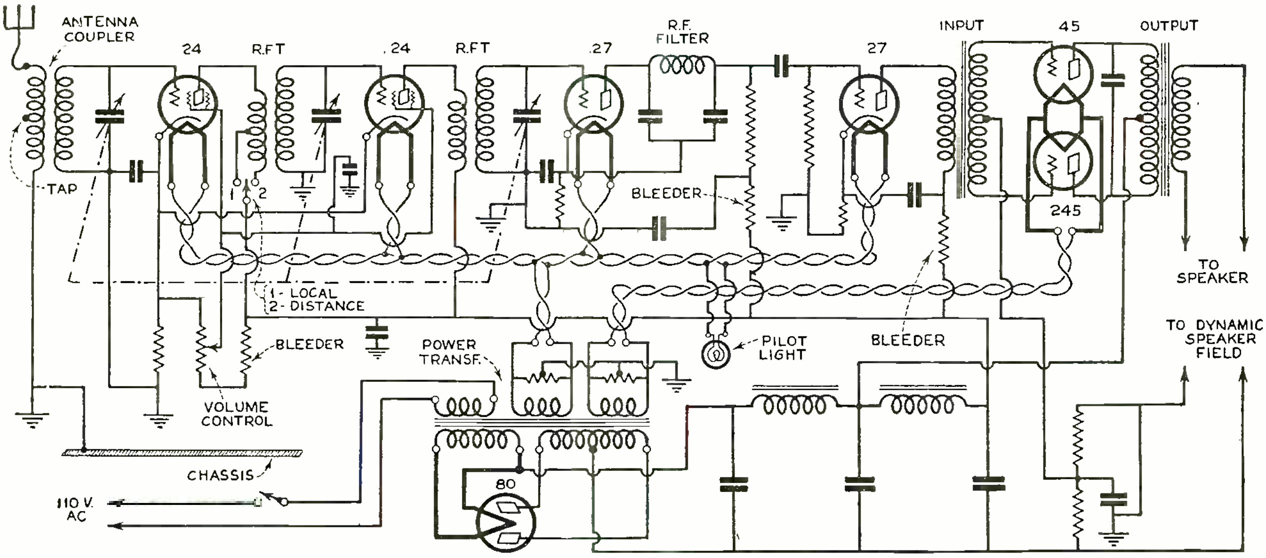
Automatic regulation of the audio channel allows equal quality of reproduction on both the low and high volume. A variable resistance, operated from the panel, controls the bias on the control grid and the voltage on the screen-grid for regulation of volume.

COLONIAL S-G NO. 32 A.C.



Radio News Manufactured Receiver Circuits

ATWATER KENT S-G NO. 55



Atwater Kent

IN this 7-tube Atwater Kent receiver two screen-grid tubes are used as high-gain amplifiers in the radio-frequency circuit. A –27 is used in the detector and first audio stages, while a pair of –45's complete the power amplifier channel. The –80 full-wave rectifier supplies plate potential to the tubes in the receiver and also energizes the field winding of the dynamic speaker. The first audio stage is coupled to the detector output through a resistance coupling unit.

Variable coupling for greater selectivity is obtained by means of a tap arrangement in the antenna primary circuit and also in the plate circuit of the first screen-grid tube. Volume control of the receiver is obtained by connection of the screen-grid element of the first radio-frequency tube to the center-arm of a variable resistance which is connected across the plate supply to the first stage radio amplifier.

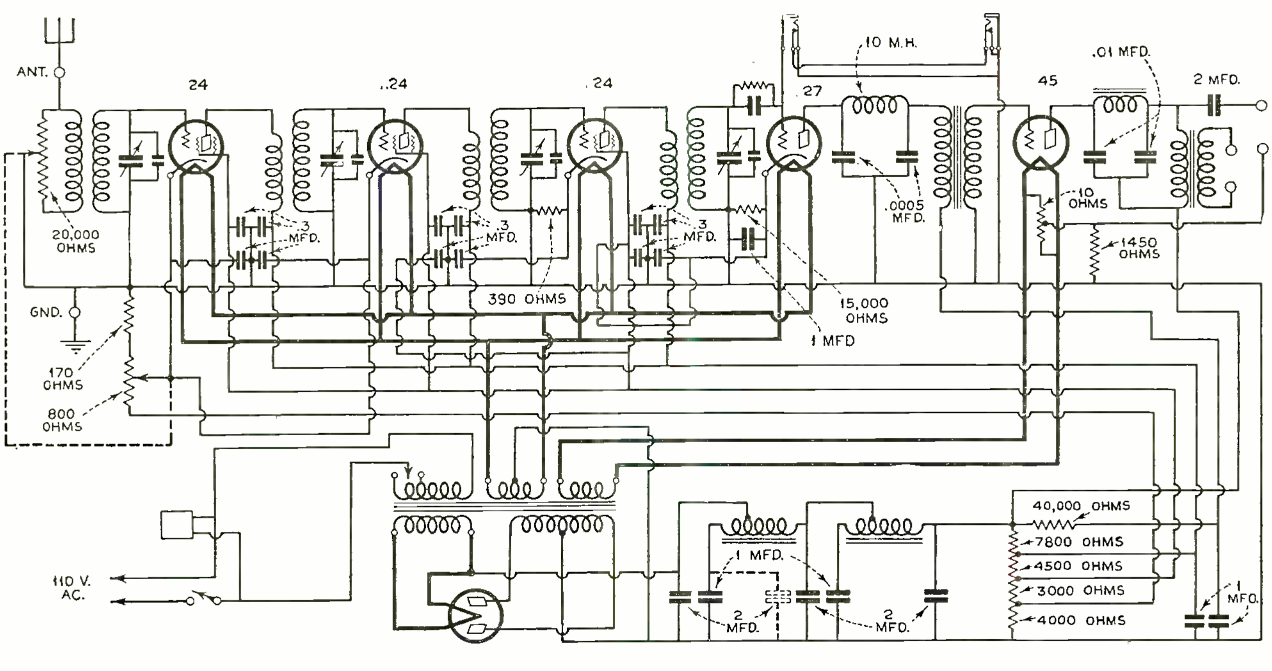
Stromberg-Carlson

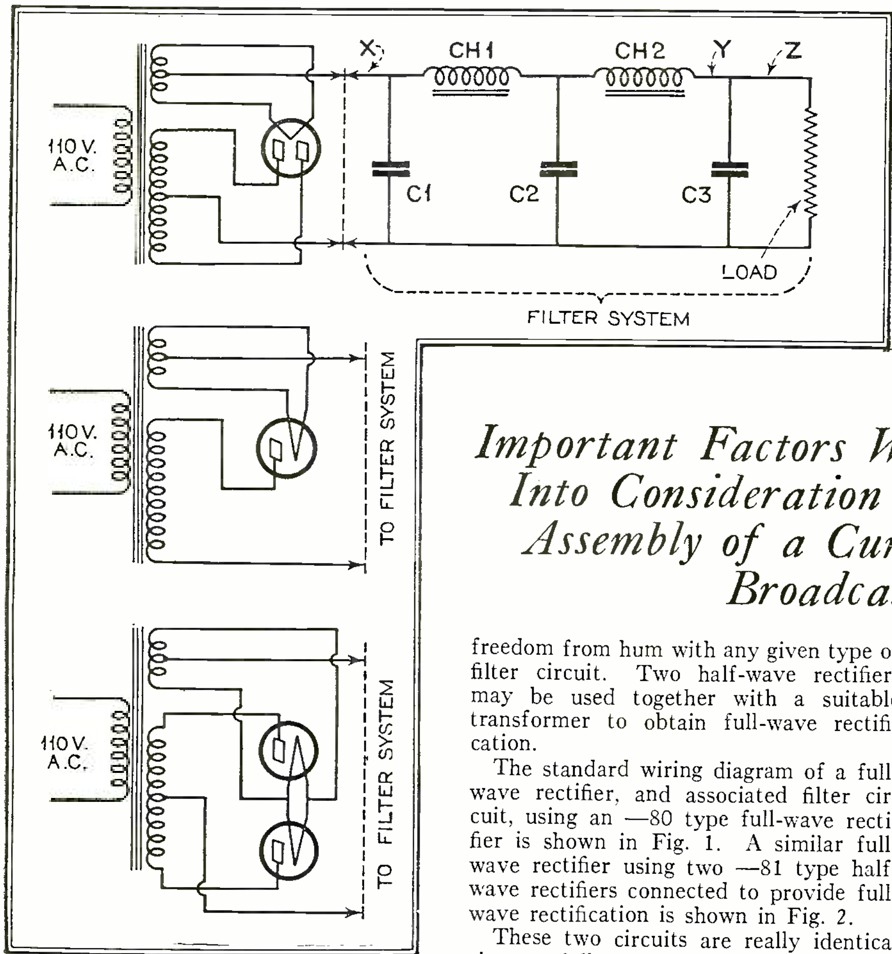
THE Stromberg-Carlson screen-grid receiver, No. 641, employs complete shielding. As a means of stabilizing the radio-frequency circuits, four filter condensers, in groups of two, arranged in series-parallel, are included in each of the radio-frequency amplifier circuits, to provide a by-path for the screen-grid and plate circuits of each of these amplifiers.

The three –24 a.c. screen-grid tubes used in the radio-frequency amplifier produce a high order of signal amplification which is inputted to the heater type or –27 a.c. detector tube. Only one stage of audio amplification is required, this being a single –45 power amplifier tube. Note in the diagram the filters which are placed in the plate circuits of both the detector and the –45 power amplifier tubes.

Provision is made for the plugging-in of a phonograph magnetic pick-up so that the audio channel may be employed for the reproduction of phonograph records.

STROMBERG-CARLSON S-G NO. 641





Note that for the three types of rectifiers (from top to bottom, Figs. 1, 2 and 3) which may be employed in a power supply the filter section remains the same, differing only in the electrical size or capacity of the separate parts, such as the chokes CH1 and CH2 and the filler condensers C1, C2 and C3

"Build

On

By

Important Factors Which Should Be Taken Into Consideration Before Beginning the Assembly of a Current Supply for Any Broadcast Receiver

IN THE preceding article of this series on power pack design, which appeared in past issues of this magazine, we stressed the importance of beginning the design of a power unit by considering the requirements of the receiver and amplifier with which it is to be used.

We also took up the actual design of the voltage divider necessary to provide the proper voltages at the current drain imposed by the receiver circuits.

It is easy to see that that procedure is the only logical one to follow in designing a power unit, for to wire up a power unit and voltage divider without due consideration to the load which is to be imposed is just as illogical as building a bridge without due consideration to the speed, the weight and the number of vehicles which it must carry.

Power supply units may be divided into two general classes, full-wave and half-wave, depending upon whether a full-wave rectifier for full-wave rectification or a half-wave rectifier for half-wave rectification is employed.

In general, the full-wave rectifier will give a smoother output and requires less filtering than a half-wave rectifier. To put it in another way, a full-wave rectifier will give a smoother output and greater freedom from hum with any given type of filter circuit. Two half-wave rectifiers may be used together with a suitable transformer to obtain full-wave rectification.

The standard wiring diagram of a full-wave rectifier, and associated filter circuit, using an —80 type full-wave rectifier is shown in Fig. 1. A similar full-wave rectifier using two —81 type half-wave rectifiers connected to provide full-wave rectification is shown in Fig. 2.

These two circuits are really identical since a full-wave rectifier actually consists of two half-wave rectifier units mounted in a single tube with the two filaments connected together in parallel.

The standard wiring diagram of a half-wave rectifier using an —81 type tube is shown in Fig. 3.

As is readily observed, the filter circuits, consisting of the choke coils "CH1" and "CH2," and the filter condensers "C1," "C2" and "C3" are identical for both half- and full-wave rectifiers.

Once the characteristics of the output required from the power supply unit have been determined, it is an easy matter to calculate the values of the elements required in the power supply unit, such as condensers, chokes, rectifier and transformer.

For the sake of simplicity, the total external load imposed on the power unit by the receiver and amplifier circuits and by the voltage divider resistance may be treated as a single resistance connected across the output. Such a resistance marked "Load" is shown in Figs. 1, 2 and 3.

In the case considered in the previous article of this series, it was found that to fulfill the requirements of the receiver and amplifier in question, plus an allowance of 20 milliamperes for a bleeder current through the voltage divider, a total output of 97.5 milliamperes at a terminal voltage of 301.5 volts would be required at the output terminals of the filter circuit.

These two characteristics, the output voltage required, and the current drain imposed by the load must be known before the filter circuit can be designed or the proper type of rectifier selected.

The voltage drop through chokes "CH1" and "CH2" depends on the current flowing in the filter circuit and the resistance of the chokes. In the case we have been discussing the current flowing through the chokes will be 97.5 milliamperes.

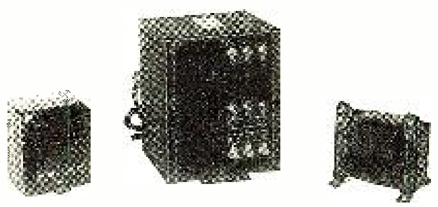
The resistance characteristics of the chokes available in the parts marked vary considerably, ranging from approximately 100 ohms to 400 ohms per choke.

Selecting the Choke Coils

In selecting the chokes for a power supply unit it is important to remember that the inductance rating alone is not a true indication of the efficiency of a choke. The resistance of the choke, the size and number of turns used, the material used in the core, the size of the air-gap are all important factors to be considered. A choke coil rated at 30 henries whose inductance measures 30 henries at low current flow may have an inductance of less than 10 henries under comparatively heavy current at which it may be used in an eliminator.

While it is difficult to determine the efficiency of a choke except by actual test, a safe rule to follow is to use healthy sized chokes, whose d.c. resistance is low. Such construction, while not an absolute test of efficiency, is usually a pretty good indication that there has been no skimping in the size of wire, number of turns and size of core.

The lower the resistance of the chokes in the filter circuit, the better will be the regulation of the filter unit, or in other words, the lower the resistance of the



Two types of filter chokes, the S-M at the left and the Amertran at the right. In the center is a Thordarson power compact containing chokes and line transformer

Your Power Unit "Paper First"

Joseph Calcaterra

¶ Too often the man who is about to build a B power unit for a particular receiver which he owns approaches the problem from the wrong angle. Usually he governs his choice largely by the type of power tube which is in the last audio stage of the receiver. Important as this consideration is, it is not by any means the whole story . . . it is not the sole deciding factor, as Mr. Calcaterra so very clearly brings out in this, the second of a series of articles on power supply devices.

Total current drain, voltage drop across the chokes, their impedance under operating conditions, condensers having the required capacity and voltage rating, a rectifier passing sufficient current, a transformer providing the correct a.c. secondary voltage, all these are items which enter into the systematic and satisfactory design of a socket power supply device. Read what Mr. Calcaterra has to say about them.

chokes, the less will be the difference in voltage drop across them under different conditions of load.

The reason for this is easily seen if we consider a representative case. If chokes "CH1" and "CH2" of Figs. 1, 2 or 3 have a resistance of 100 ohms each making a total resistance of 200 ohms, the voltage drop across both chokes will be 4 volts at 20 milliamperes (low load) and 19.5 volts at 97.5 milliamperes, a difference in voltage of 15.5 volts under the two load conditions.

If the chokes have a resistance of 400 ohms each, however. making a total of 800 ohms for the filter system, the voltage drop with a load of 20 milliamperes will be 16 volts while the voltage drop with a load of 97.5 milliamperes will be 78 volts, a difference in voltage of 62 volts.

In the case of the low resistance choke filter, the difference in voltage under the two load conditions is only 15.5 volts while in the case of the high resistance choke unit, the difference in voltage is 62 volts. The low resistance filter is easily seen to give much better regulation.

Good Regulation Essential

The better the regulation of a filter unit, the less noise and distortion will be introduced in the receiver and amplifier circuits due to changing voltage conditions caused by slight changes in load conditions.

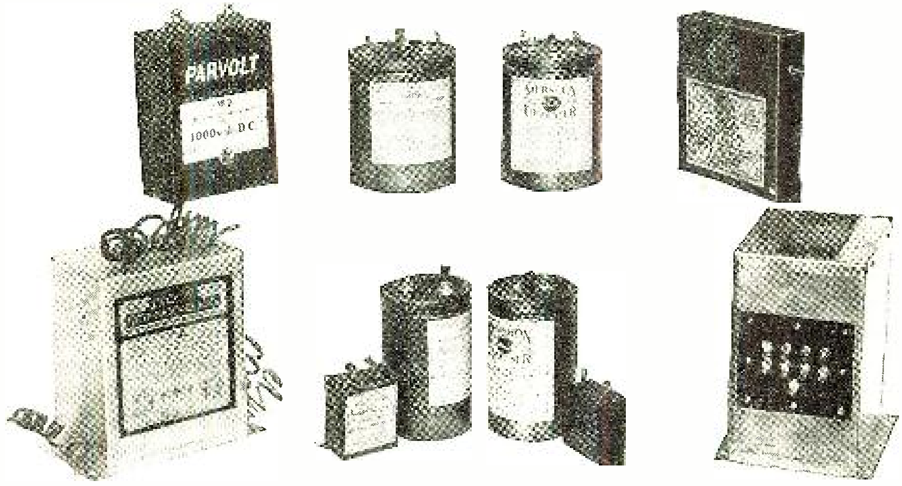
To produce a given voltage at the output terminals of the filter with a given load condition, the voltage input to the filter from the rectifier must be equal to the ouput voltage plus the voltage drop caused by the chokes at the current drain in question.

If we select filter chokes having a d.c. resistance of 100 ohms each, giving a total resistance of 200 ohms for the filter, and the current flow in the case we are considering is 97.5 milliamperes, the voltage drop through the chokes will be 19.5 volts. Since the output voltage desired is 301.5 volts, it will be necessary to apply a voltage of 301.5 + 19.5 or 321 volts to the input of the filter. In other words, a rectifier capable of supplying an output of 321 volts at 97.5 mils must be provided.

If 400 ohm filter chokes were used, giving a total resistance of 800 ohms for the filter, the voltage drop through the chokes at 97.5 milliamperes would be 78 volts, and the input to the filter from the rectifier would have to be 379.5 volts instead of the 321 volts required for the low resistance filter.

The necessity for using a higher input voltage to the filter would constitute a heavier strain on condensers "C1" and "C2" of the filter and in many cases it would increase the cost of the filter unit by necessitating the use of higher voltage condensers.

Once the input characteristics to the filter have been determined (321 volts d.c. at a current drain of 97.5 milliamperes for the low resistance filter), it is a simple matter to find the rectifier which will give the required output, and the type of transformer which it is necessary to use with the rectifier.

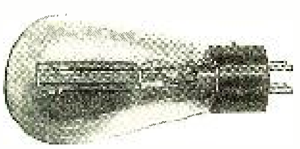
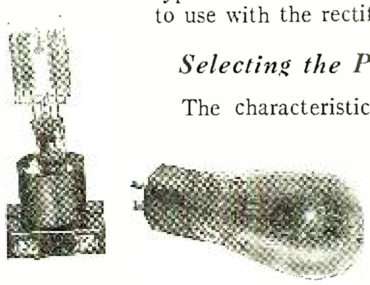


Some of the types of good condensers which may be used in the filter circuit of a power unit. Parvolt, Mershon, Aerovox, and Dubilier are represented

Selecting the Proper Rectifier

The characteristics of —81 and —80 type rectifier tubes when connected in eliminator circuits of the types shown in Figs. 1, 2 and 3 are shown in Figs. 4, 5 and 6. Fig. 4 shows the d.c. output characteristics of an —81 type tube in a half-wave rectifier. The two curves represent the output conditions which obtain with voltages of 600 volts a.c. and 700 volts a.c. applied to the plate of the tube.

As is readily seen, the maximum current output obtainable is 85 milliamperes and

Two types of rectifier commonly employed. The full-wave at the left, a stripped full-wave showing the dual elements in the center, and a half-wave rectifier at the right since the receiver we have been considering requires 97.5 milliamperes, a half-wave rectifier using an —81 rectifier would be unsuitable.

The direct current and voltage characteristics of an —80 type full-wave rectifier tube under different conditions of a.c. voltage applied per plate of the recti-

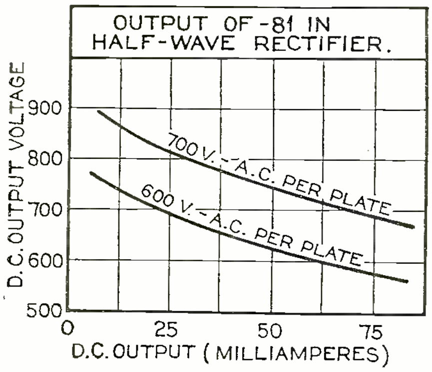


Fig. 4—Two curves which indicate the various current and voltage outputs obtainable from a half-wave rectifier

fier are shown in Fig. 5. These curves show that it is possible to obtain an output of 321 volts at 97.5 milliamperes, by applying an a.c. voltage of approximately 325 volts a.c. per plate of the rectifier.

If the high resistance filter were used, requiring a d.c. output of 379.5 volts at 97.5 milliamperes, it would be necessary to apply an a.c. voltage of approximately 375 volts per plate.

The curves of Fig. 5 show that the —80 type rectifier can be used wherever the output characteristics do not require a current of more than 125 milliamperes at approximately 325 volts d.c., obtained by applying an a.c. voltage of 350 volts to each plate of the rectifier, or where a maximum of 110 milliamperes at a d.c. voltage of 390, obtained by applying 400 volts a.c. per plate, are required.

Where higher current drains are to be imposed or higher voltages are required, two —81 type tubes connected for full-wave rectification can be used. The output characteristics of a rectifier consisting of two —81 type rectifier tubes connected for full-wave rectification are shown in Fig. 6.

Designing the Power Transformer

The transformer required for the receiver and power pack we have been considering would be one designed for operation on the type of current available at the house lighting outlet and provided with a high voltage secondary winding designed to give 325 volts a.c. each side of centertap, a 5-volt winding designed to carry 2 amperes for the filament of the rectifier, a 2.5-volt winding designed to carry 5.25 amperes for the two —24 and one —27 tubes, a 1.5-volt winding designed to carry 1.05 amperes for the —26 tube and a 2.5-volt winding designed to carry 1.5 amperes for the two —45 tubes.

To obtain the proper output voltage at the required current drain, it is important that the proper voltage be applied to the plates of the rectifier tubes. If the voltage is too low or too high proper operation and the correct voltages at the various taps cannot be obtained.

A transformer with a low voltage secondary is ruled out immediately. A transformer, however, which has a higher voltage however can be used and the voltage reduced at the input to the filter.

In the case we have been considering, the proper transformer to use is one which will provide 325 volts a.c. each side of the centertap. If no such transformer is available but one which will sûpply a voltage of 350 volts a.c. each side of the centertap can be obtained, such a transformer can be pressed into service. The curves of Fig. 5 show that with 350 volts a.c. each side of the centertap, an —80 type full-wave rectifier will deliver approximately 342 volts d.c. to the filter. Since all that is required at the input of the filter is 321 volts d.c., the excess voltage, amounting to 21 volts, can be dissipated by using a resistance of 215 ohms. This resistance should be inserted between the first filter condenser connection and the lead from the centertap of the rectifier filament winding as indicated by

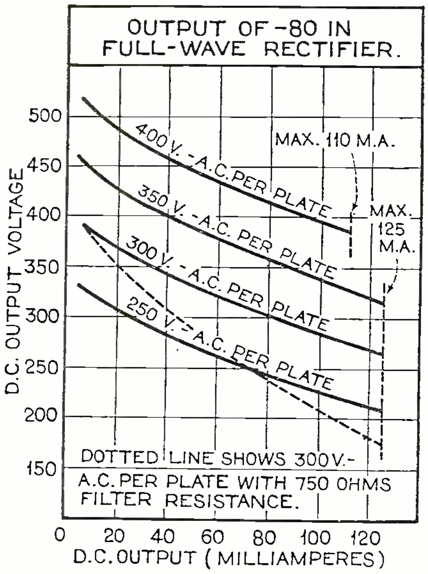


Fig. 5—Four curves of four applied plate voltages for full-wave rectifier

"X" in Fig. 1. The same object, as far as reducing the voltage across the load resistance is concerned, could be obtained by placing the resistance at points "Y" or "Z" but the resistance is most effective at point "X" for several reasons. At point "X," the resistance protects all the filter condensers from the extra voltage, limiting the voltages to the values which would obtain if the transformer secondary was properly designed to provide the required 325 volts a.c. instead of the 350 volts a.c., which it does provide.

When used at point "Y," the resistance protects only the last condenser "C3" against the extra voltage, but condensers "C1" and "C2" have to stand strain imposed by the extra voltage.

When the resistance is placed at "Z," all the condensers must stand the strain of the extra voltage, the only function performed by the resistance at that point being to reduce the voltage to the voltage divider. The use of the resistor at point "Z" would also make it necessary to use another condenser to bypass the high voltage tap of the voltage divider to the negative lead of the power unit.

"No-Load" Conditions

Under so-called "no-load" conditions, that is with all tubes out of the receiver and amplifier, or during the interval when the tube filaments are heating up so that little current is being drawn in the plate circuit of the tube, the condition which exists is really not a "no-load" condition because the resistance of the voltage divider, connected across the output of the filter, acts as a load.

The current drawn by the voltage divider, under such circumstances, is not the bleeder current which flows through when the tbues are all drawing current but the current drawn by a resistance of that value when connected across the terminal voltage.

Because of the poor regulation of power pack circuits, the terminal voltage across the output of the filter will be higher at the lower load drawn when the resistance of the voltage divider constitutes the only load.

The actual current flowing in the filter and voltage divider circuits under such conditions can be determined approximately by finding from the rectifier chart the current and voltage output characteristics of the rectifier with a load consisting of the voltage divider and choke resistance.

In this particular case, the resistance of the divider (11,753 ohms) plus the resistance of the low resistance chokes (200 ohms) would total up to 11,953 ohms.

With 325 volts a.c. per plate the d.c. voltage and current output characteristics of the —80 type tube, represented by a resistance load of 11,753 are 375 volts d.c. and 32 milliamperes. This 375 volts is applied across the first filter condencer "C1." If the voltage divider resistance is lower in value, the current drawn under so-called "no-load" conditions will be higher and the voltage across the condensers will be reduced correspond-

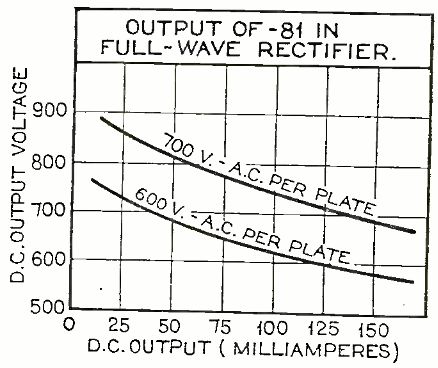


Fig. 6—When two —81 tubes are used in a full-wave rectifier, the curves below indicate the current and voltage operating characteristics

ingly. If the voltage divider has a very high resistance the current flow through the chokes and the voltage divider under the so-called "no-load" condition will be very small, the voltage drop across the chokes will be small, so that the voltage applied across condensers "C2" and "C3" will very closely approach the values of

(*Continued on page 774*)

The Junior Radio Guild

LESSON NUMBER SEVEN

Symbols and Circuits

Before the beginner in radio can become proficient in the building of receivers, and the absorbing of more or less technical descriptions of radio apparatus or their functions, it is first necessary that he familiarize himself with the tools with which he must work.

Just as the carpenter or cabinet maker must know the various special uses of the particular kind of tools with which he is expected to work, so too must the radio man, if he is to become successful, know how to master the use of the tools which are necessary in the art.

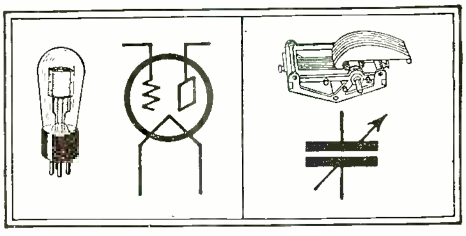


Fig. 1—Picture versus symbol. Here's how a tube and tuning condenser look when represented by symbols

One of the most important tools, if it may be called such, that the beginner in radio must learn how to use, is the symbol or graphical representation of a piece of radio equipment so that he may know how to read a radio circuit.

In radio a circuit diagram constitutes a short-cut "language," so to speak, which conveys an intelligent message from one individual to another.

Supposing one engineer wanted to describe a radio receiver to another engineer: that is, tell how many tubes were used, how they were connected one to the other, what battery connections were made, whether it used transformer or resistance coupling, whether the screen-grid tube or power tube were used, and so on. If he desired he could orally describe or perhaps write a lengthy description of the circuit employed, but the quicker way would be to graphically depict the various pieces of apparatus employed and show how they were connected to form a complete circuit. He might, in this graphical representation of the receiver, actually draw a picture of a tube, a coil, a resistor, a transformer and so on, but even that would be a long-drawn-out process. And so in radio, to make the job as simple as possible, we make use of symbols or characters to represent these radio parts.

For instance, in showing how a tube is connected in a radio circuit, instead of drawing the picture of a tube we use the symbol which has been adopted as standard by all the manufacturers, laboratories and the Institute of Radio Engineers. The picture and the symbol are shown in Fig. 1. Another important part which is commonly used is a tuning condenser, shown in the same figure.

And so we might go on indefinitely showing how each part used in radio looked in picture and in symbol. To expedite the assimilation of such knowledge, the Standard Radio Symbols Chart, showing practically all of the more common symbolic representations of parts used, is shown on page 734. This chart shows the several symbols for various kinds of radio tubes, different kinds of condensers, various kinds of meters and so on.

It is suggested that as an aid in learning how to draw these symbols you memorize a few at a time, then draw them from memory and compare your work with the symbol chart.

Fig. 2 shows the construction of a typical circuit, by connecting together in correct relation several symbols. The antenna or "aerial" is connected to the primary coil of the r.f. transformer, RFT. The secondary of this transformer has connected to its terminals a variable or tuning condenser, C1, and then connects to the grid and filament of the radio-frequency amplifier tube, V1. This tube has connected to its filament the "A" battery and to its plate the primary of the succeeding r.f. transformer. The circuit is completed by the connection of the lower terminal of the primary of the r.f. transformer to the "B" battery, which has its negative end connected with the negative end of the "A" battery. And so we have a complete radio-frequency amplifier circuit.

To make yourself proficient in the drawing of circuit diagrams, it is recommended that you attempt to read and redraw the circuits which appear on other pages of this magazine.

One of the best ways in which to familiarize yourself with radio parts and radio diagrams is actually to build a receiver, part by part, until one is finished which will tune in a great number of stations and which will produce loud speaker results. This lesson and the ones to follow will show how to do just that. The construction will be by easy stages so that you may completely master all of the various problems with which you will be confronted.

A five-tube receiver will be described and will consist of one stage of shield-grid radio-frequency amplification, a regenerative detector and three stages of resistance-coupled audio-frequency amplification. At the start the receiver may be used with batteries, but a later lesson will tell how to build an eliminator or power supply unit which can take the place of the batteries.

In last month's Junior Radio Guild lesson it was announced that the construction of the first unit would be described here, but it was decided to postpone the actual construction lesson until next month, so that Junior Guilders could have ample time to study symbols and the drawing and reading of circuit diagrams. However, the circuit of the first or detector unit of the five-tube receiver is shown in Fig. 3. Study it carefully and be prepared for the constructional information next month.

Fig. 2—A typical circuit arrangement represented by connecting several accepted symbols

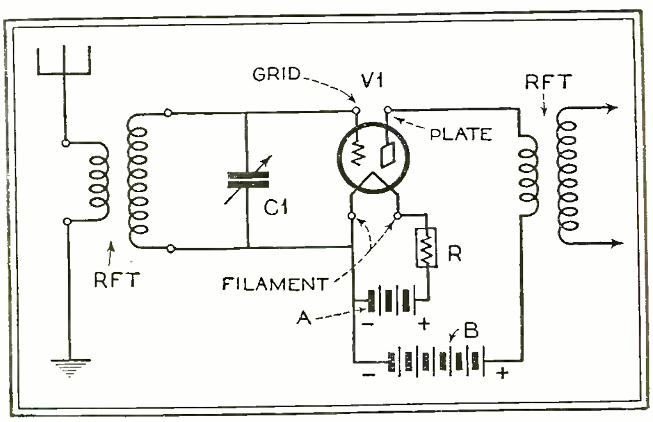
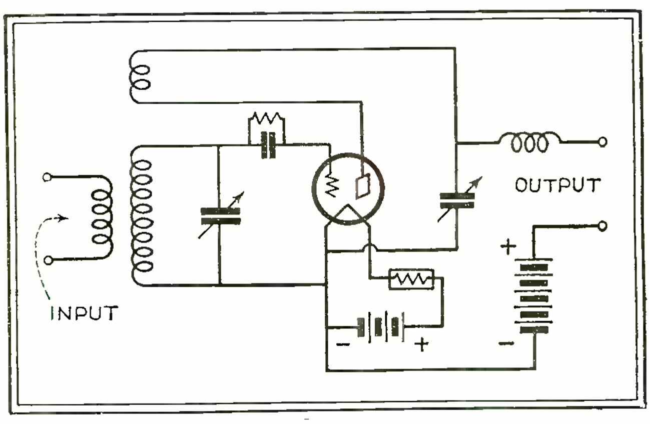
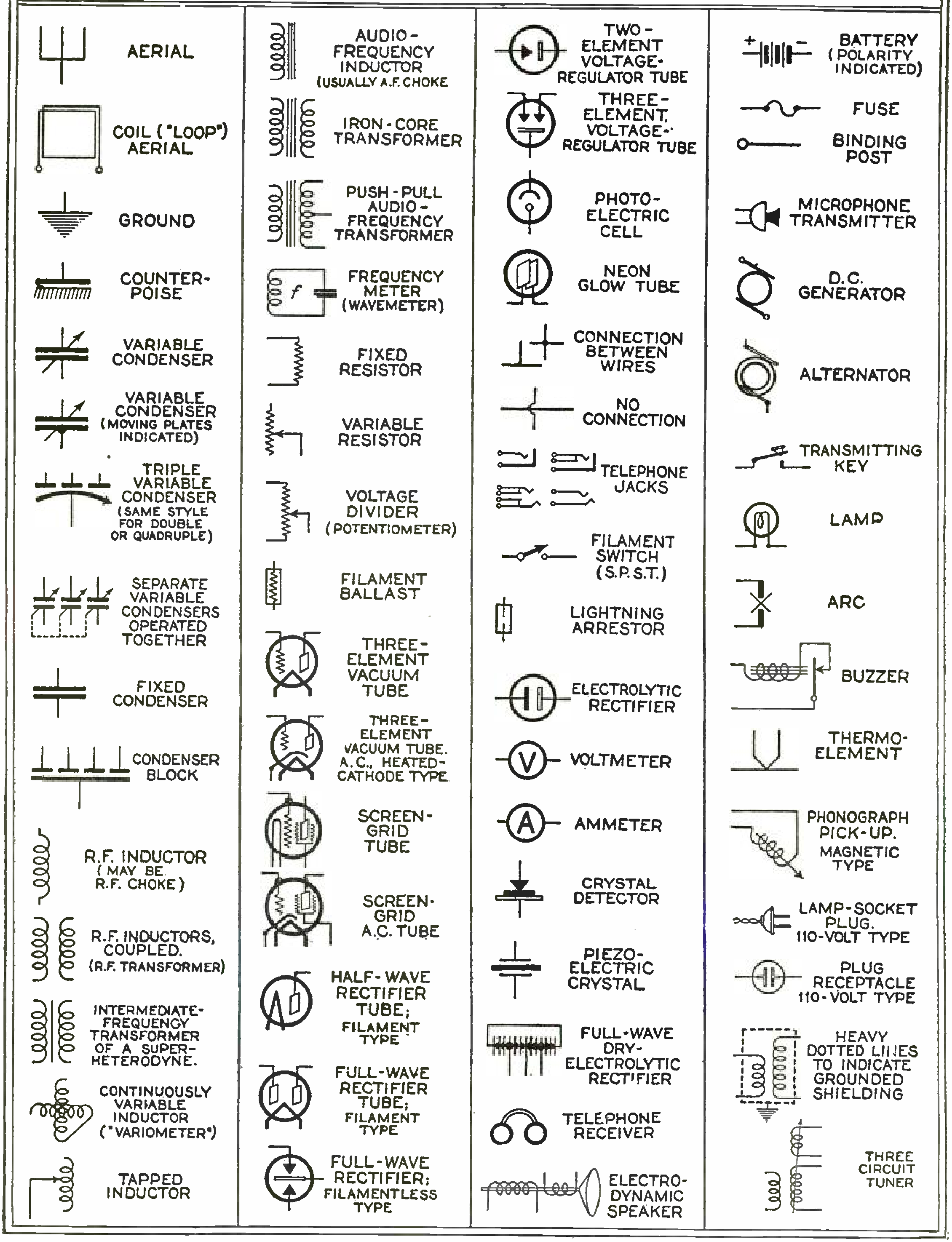


Fig. 3—The detector circuit of the five-tube receiver to be described in forthcoming lessons



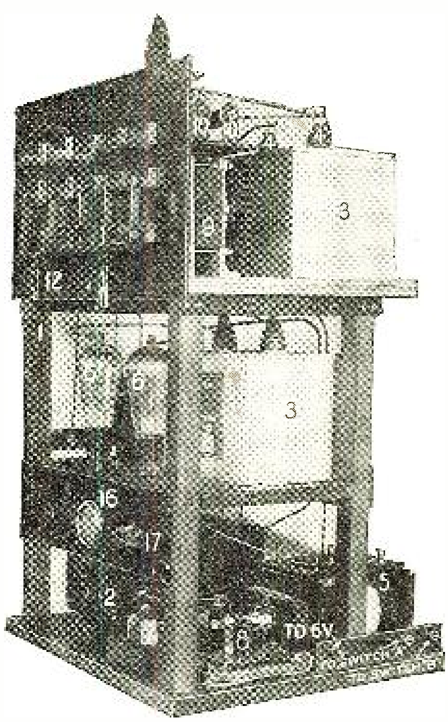
STANDARD RADIO SYMBOLS



Final Details for Completing

SPANGENBERG'S S-W TRANSMITTER

How to Build the Amplifier and Power Supply Unit for a 200-Watt "Ham" Transmitter



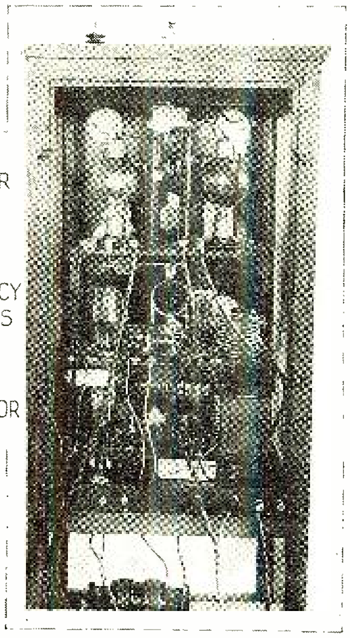
Above: The power supply unit, like the others of this transmitter, is built on the "deck" principle. Left: Here are the three units of the transmitter proper, in place in the supporting frame

THIS is the third and last installment of the story describing pictorially Lester Spangenberg's (W2MB) 200-watt short-wave crystal controlled "ham" transmitter.

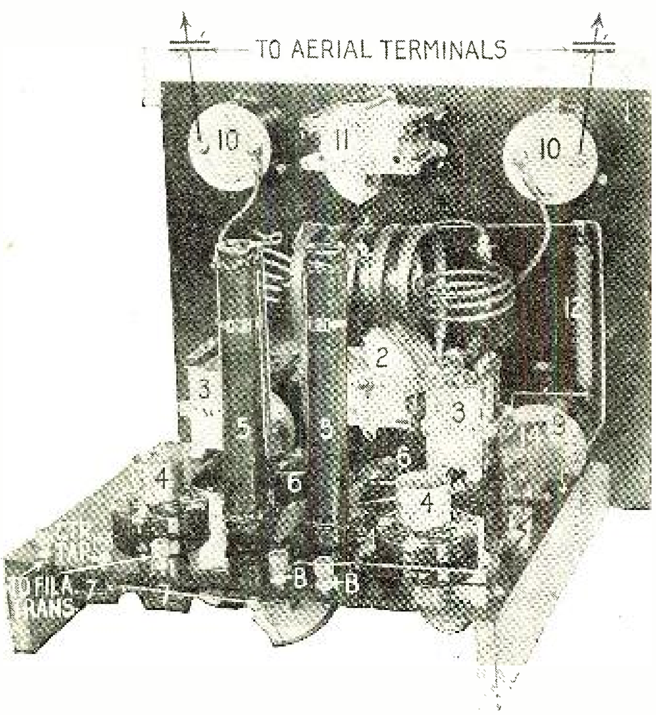
In the first part of the story, published in the November, 1929, issue of RADIO NEWS, the general layout or mode of assembly was described and illustrated. The second installment, published last month, described in detail the crystal oscillator and frequency-doublers and showed the circuit.

This month we deal with the power amplifier unit and the power supply device, thus completing the picture. It will be found helpful, in duplicating the construction of Mr. Spangenberg's transmitter, to refer frequently to the circuit diagram of the complete outfit, printed on page 643 of the January, 1930, issue of RADIO NEWS.

Mr. Spangenberg has housed the three units—namely, the crystal oscillator, frequency doublers and power amplifier—in a special frame glassed in on three sides, the fourth being provided by the front panel. The power unit was built as an independent unit on its own supporting stand. This unit, unlike the transmitter proper, is not enclosed, but is rather open in construction to allow rapid dissipation of the heat generated by the rectifier tubes.



The power amplifier assembly details may be clearly observed from this illustration. The parts are numbered to jibe with the parts list and the circuit diagram appearing on page 643 of the January issue of RADIO NEWS



LIST OF PARTS—POWER UNIT

1 frame (1)
1 R. C. A. power transformer, 750 watts (2)
2 4 mfd. Flechtheim condensers, type TH400 (3)
6 Faradon 1 mfd condensers (4)
1 5-volt transformer for filaments of UX866 tubes (5)
2 UX866 tubes and UX sockets (6)
1 power relay (7)
1 relay for filaments of UX866 tubes (8)
1 Acme radio-frequency choke, 30 henries, 150 mils. (9)
2 50,000-ohm resistance (to carry 30 mils) (10)
1 stand (11)
1 double-pole single-throw knife switch, for power leads (12)
1 Todd filament transformer, 10 volts (for UX203A) (13) (on bottom shelf of transmitter)
1 Acme filament transformer, 10 volts (for two UV852) (on bottom shelf of transmitter)
1 Allen Bradley primary resistance (radiostat) (15)
1 0-10 a.c. voltmeter for filament of UX866 tubes (16)
1 10-ohm rheostat for primary of UX866 filament transformer (17)
5 "C" batteries (45-volt size) (18)

PARTS LIST—POWER AMPLIFIER PANEL

1 frame complete (1)
1 Cardwell double-spaced .00025 mfd. condenser and dial with coil attached and two antenna coils at ends (2)
2 Cardwell two-plate condensers with knobs, as neutralizing capacity (3)
2 UX tube sockets (4)
2 Ward Leonard grid leaks (type 507-77), 20,000 ohms (5)
2 Sangamo .002 mfd. condensers (5,000-volt test) (6)
2 Sangamo .002 mfd. condenser (standard) (7)
1 Jewell a.c. voltmeter, 0-15 volts (8)
2 Jewell milliammeters, 0-500 mils. (9)
2 Jewell radio-frequency thermo-couple meters, 0-2 amps. (10)
1 Cardwell double-spaced .00025 mfd. condenser and dial (11)
1 radio-frequency choke, ½" diameter, 400 turns No. 28 d.c.c. wire (12)
2 UX852 tubes (13)
1 .002 mfd. high-voltage condenser (Faradon 5,000-volt test) (14)
2 .00035 mfd. variable condensers (used in series feed Zep. antenna) (15)
2 UX852 tubes (16)

More Light on Short-Wave Transmission

By Lieut. William H. Wenstrom

(*Continued from page 700*)

around 214 meters, but negligible for waves under 100 meters.

Critical Angles and Limiting Angles

Let us suppose that the luminous fish of Fig. 5 wishes to signal to a companion fish over at the other side of the creek, and that some obstruction such as eel-grass prevents vision along a straight line between the two. By using reflection from the water-air surface, this particularly resourceful animal can still maintain communication. At rather large angles from the perpendicular this reflection will be possible, but as the ray increases in elevation there will come a time when it is not reflected downward at all, but passes up out of the water entirely, though somewhat refracted. There is one particular ray which follows a middle course and skims the water surface; this, or the one just below it which is the highest useful for fish communication, we might call the limiting ray. The angle which this ray makes with the vertical is the critical angle, 48.5° in the case of water and air; and the angle which it makes with the horizontal we may call the limiting angle. By the laws of reflection, the limiting ray descends at the same slope as it ascends, though the ray just above it would not descend at all.

An exactly similar effect takes place in the downward-bending of radio rays from the refracting (or equivalent reflecting) layer. As in our fish illustration where the angles are complementary, or add up to 90° the limiting ray returns to earth at its ascending inclination; the next higher ray does not bend downward at all but skims the layer; any rays still higher go off into space, useless for any communication upon the earth. The inclination of the limiting ray varies with wavelength and layer height; in general, limiting angles are lower for the shorter waves, and correspondingly lower for any wave as the layer rises. The following values of limiting angle, copied from Taylor, serve as examples; at an (equivalent reflecting) layer height of 100 miles, corresponding to a spring day, 54° for 40 meters and 18° for 20 meters; at 225 miles (summer night) 53° for 40 meters and 14° for 20 meters; at 500 miles (winter night) 52° for 40 meters and 0° for 20 meters. The limiting angle of 0° means, of course, that even the tangent or horizontal ray is above the limiting angle, and long distance communication is impossible. The shortest wavelength which can be used with a given layer height is often called the critical wavelength. This is around 25 meters for a 500 miles layer, 11 meters for a 100 mile layer, and for long distance 5 meter work the layer must be as low as 40 miles, a very rare summer day occurence.

Skip Distance

Having now attained a clear understanding of the limiting angle and the limiting ray, we can define skip distance very simply by saying that it is the distance to where the limiting ray first returns to earth, measured sometimes from the transmitter and sometimes from the limit of the ground wave, which at high frequencies only extends out 30 to 50 miles. At the same layer height skip distance increases as the wavelength decreases. This means that at certain times of day we can work a station on 42 meters, but not on 38 meters. For any given wavelength the skip distance increases as the layer rises; the limiting angle is lower, and a given ray can rise farther before bending downward. These relations are diagrammed in Fig. 5a and 5b. Some quantitative idea of actual skip distances is given by the following figures: Height of equivalent reflector 100 miles—no skip on 80 meters, 100 miles on 40 meters, 500 miles on 20 meters, and 1,000-2,000 miles on 10 meters. Layer height 225 miles—barely noticeable skip on 80 meters, 200 miles on 40 meters, 1,000 miles on 20 meters, 10-meter wave never returns. Layer height 500 miles—very short skip on 80 meters, 400 miles on 40 meters, 20 and 10 meter waves never return. An airplane short wave transmitter may not show any skip distance at all if rays below the horizontal cover all the ground which would normally be skipped. In general, for any middle-range as day brightens we can use shorter waves, as night approaches we must use longer waves.

Signals are often heard inside the skip distance, but this does not disprove the general law. They can be accounted for by the ground wave, or by the "throw-back" theory advanced by Taylor and Young. They noticed echoes at a Washington transmitter which seemed to come from the broken country in Labrador and the southwest, and some later throw-backs on 15 meters which came from the ocean. In both cases the size of ground and rough water slopes in relation to wavelength makes the theory plausible. We have been speaking so far of only one skip distance. As we shall see later, on very short waves there may be several skips outside the first.

Useful Rays

From our earlier consideration of ground absorption near the transmitter and the foregoing discussion of limiting rays, we can see that the rays useful for communication will be included between the limiting ray and the lowest ray not absorbed by the ground, as shown in Fig. 6, for all these rays return to earth. Higher rays will not return to earth, and lower rays will be absorbed. The height of the transmitter, the kind of ground and nearby hills all have their effect on the lowest useful ray. This ray is much lower for short waves than for long, but the limiting ray is also lower. In general, therefore, low angle radiation is most useful on short waves, high angle radiation on long ones.

Extreme Range on One Refraction

We have said that the lowest useful ray is lower for short waves than for long ones. This means that with one layer refraction it will travel farther along the earth's surface. It may be reflected up again and refracted down again several times, but each earth reflection certainly takes away energy, and *we may now state the great advantage of short waves: that by permitting the use of lower useful rays they get farther along the earth's surface on one refraction, or on few refractions and reflections, with less consequent loss of energy.* We therefore use for long range communication the shortest wave possible, and find in practice that the strongest signals are always just beyond the first skip distance.

A particular example of this principle is shown in Fig. 7, and indicates how the extreme range on one refraction is governed by the layer height. A station in New York wishes to work San Francisco on a winter day, but at a layer height of 150 miles the lowest useful ray will return to earth far short of California. We find, in fact, that around 800 miles is the limit for daytime low power work on 40 meters. But at night, the same ray can rise to a 500-mile layer, and on its first return to earth will be well out in California. And we find, in fact, that low power work with California on a winter night is easy. For simplicity some considerations have been left out of this example, but it correctly illustrates the principles.

There is one other possible effect which may greatly increase the range on one sky refraction. It is conceivable that the limiting ray, or the one just above it, does skim along the layer for a great distance, perhaps half way around the earth; and then, encountering somewhat different refracting conditions, bend down again towards the earth. While this effect may occur quite often in practice, the weight of scientific opinion and the accumulation of experimental evidence seem to indicate that it is the exception rather than the rule, and that most extreme long distance transmission depends on earth or water reflection.

Earth Absorption and Reflection

If we direct a brilliant and concentrated beam of light obliquely downward on a mirror, we can see in dusty or smoky air that the beam is reflected upward in practically unchanged form. If we substitute for the mirror a piece of white paper as shown in the photograph, the reflected beam is much less intense, and is spread out in all directions. With gray paper or a rougher surface both the diffusion and the absorption increase, and with black felt the absorption is practically complete. The same general effects are possible when a downward sloping radio ray strikes the earth's surface. Sea water is a fair conductor and, if not excessively roughened by storm, a good reflector of short-wave rays, corresponding perhaps to the mirror of our light example. Damp ground, fairly level or smoothly rolling, is probably a fair reflector corresponding to rough white paper. Ground that is very dry or very rough must be a poor reflector, absorbing nearly all the energy. Incidentally, the "roughness" of either water or ground depends on the wavelength, just as a metal light mirror is only a surface which has been polished to the point where the scratches are small in relation to the wavelength of the light. The effectiveness of ground reflection is more or less in debate, and some scientists maintain that most of the energy is absorbed or scattered. In thinking of long distance communication, however, it must be remembered that three-quarters of the earth's surface is covered by sea water. Some energy is undoubtedly lost, and short wave efficiency proves that few reflections are desirable, but a good deal of energy is probably reflected mirror-fashion under average conditions. When the ground reflects a downward sloping ray skyward, it is usually brought down again by ionized layer refraction at twice the distance of the first ground-strike from the transmitter, and may conceivably continue these ups and downs all the way around the world. In high power transmission "echoes" which have completed the 25,000-mile circuit sometimes appear at the receiver and spoil the signals.

Patterns of Recurring Signal Zones

We have said that there may be at certain times and on certain wavelengths skip distances beyond the first; let us follow out in a few examples the full pattern of transmission. Taylor has reduced the matter to a very complete series of graphs, and it is from these that most of our information comes. On 40 meters, for instance, with a layer height of 225 miles (summer night) the first skip extends out 200 miles from the transmitter. At this range the signal comes in strongly, and from here on it is continuous with no further skips, for the first re-refracted ground reflection comes down again before the single refractions have extended out to the lowest useful ray. With the layer at 500 miles (winter night), the first 40-meter skip extends out to 400 miles, and there are no further skips. But on 20 meters the story is somewhat different. With the 100-mile layer of a summer day the first skip extends out to 500 miles, with no skips thereafter. On a spring night, however, with the layer at 300 miles, we notice the typical ultra-short-wave pattern. The first skip extends out to 2,000 miles, where the signal comes in strongly and holds out to 3,000 miles. Between 3,000 miles and 4,250 miles is the second skip, after which the signal appears again to hold until 6,000 miles. A third skip comes between 6,000 miles and 6,400 miles, and beyond 6,400 miles the signal is continuous. Again, a 10-meter wave would have an infinite first skip unless the layers were at 60 miles or lower. With this rather unusual layer the 10-meter pattern would be marked by wide skips and narrow signal bands as far as the antipodes at least. On longer waves any station in the signal zones is reached by several rays traversing widely different paths, and this is true of short waves also beyond the first or second skip. The result is that patterns are less definite in fact than they are in theory.

Fading

Knowing the extremely tenuous nature of the ionized region and the complicated nature of ray refraction, we can readily understand the causes of fading, always more violent on the shorter waves. The primary cause is probably variation in the height of the refracting layer. Heising has found, by measuring the effective layer height continuously for fairly long periods during the night, that it rises and falls in cycles, each of which lasts around a quarter of an hour. The rising rate is something like six miles per minute—the speed of the very fastest racing airplane. The falling speed is much greater, probably around twenty miles per minute. In general, the layer height swings up and down in slow cadence, rising gradually and falling rapidly. In the daytime under the sun's ultra-violet radiation the layer is much steadier; and in the daytime also fading is far less pronounced. The most violent short-wave fading of all occurs at the outer edge of the skip distance. Here the ground-strike of the limiting ray may flutter back and forth, with the signal jumping between maximum and zero. There are other matters to be considered besides layer height. Relative numbers of electrons and ions, upper air absorption, height to which ionization extends—all may count, and of course play some part in determining the effective layer height. Phase difference between rays arriving by different paths is important—it causes much of the 50-100 mile fading in the broadcast band. Considering the medium and the conditions, we are lucky to find short wave transmission as steady as it is.

Slopes in Layer

So far we have been considering a layer of uniform height; in very long distance work such an ideal condition rarely exists. If the night layer is much higher than the day layer, and we know that it is, there must be well defined slopes at the sunset and sunrise lines. In order to visualize these slopes as they probably exist on the earth, it is only necessary to shine a spot light on a small globe. To show conditions at any particular date, we can look up the sun's declination in the Nautical Almanac, and tilt the globe so that the shadow line is the given number of degrees beyond (for + declination) or short of (for — declination) the North Pole. Two photographs accompanying show sunset and sunrise in the eastern United States for November or February. Taking into account the percentage of path in darkness, and the consequent high layer suited to few re-reflections, sunrise is probably the best time for amateur work on the 40-meter band with Australia and New Zealand. This is paraticularly so in the Western United States, for in addition to giving a favorable slope the sunlight in the east silences interfering signals from most of the American continent. We have in fact worked Australia from El Paso, Texas, with the sun an hour up in the sky.

For work with Europe and Africa, on the other hand, sunset is preferable. We have worked Belgium from West Point, New York, as much as an hour before sunset, taking advantage of the darkness over most of the path, minimum interference from the west, and the layer slope. It seems quite possible that the layer slope may focus several incoming rays, most of which would normally go to other regions, on a single receiver with considerable increase in signal strength. This theory has, so far as we know, been developed by no other writer, but it seems quite plausible on the basis of very meager data. Fig. 8 shows the effect on an equivalent reflection basis. We have noticed at West Point that the 25 meter phone signal of 5SW at Chemsford, England, increases noticeably about an hour before sunset, continues strong through sunset, and drops off rapidly with approaching darkness. It would be interesting to see if any other observations bear out this hypothesis.

As Taylor has pointed out, the daylight—darkness layer slope may have a considerable effect on the patterns of ultra-short waves. There exists what might be called a non-reciprocity of east and west transmission across the sunset line. Toward darkness all skips after the first tend to close up, making the signal zone practically continuous. Toward day light the second skip and possibly outer ones, tend to open out, making narrow signal zones separated by wide skips. With a given wave such as 20 meters, therefore, it may be possible to transmit from a western station to an eastern station, but not from the eastern station to the western station. Or to put it another way we can use a shorter wave for west-east work than for east-west work.

Conclusion

Radio is usually considered a narrow and highly specialized science—even a narrowing one—but it does not need to be. Its practical applications are as wide and varied as life itself. The ships on their lonely ocean wanderings talk unceasingly, sometimes of excitement and danger. And the lonelier airplanes are beginning to talk, too, while snug stations on ground and shore scatter weather warnings that all of sea and air must know—a hurricane in the Caribbean, or a blizzard in Greenland. Thus the thread runs, through shipping, aviation, meteorology—even geography becomes interesting when electric voices illumine the map.

In more tenuous but equally fascinating theory, ratio is also broad enough for a da Vinci. It is a form of electric activity, and though the larger principles may wear engaging disguises, they do not change. Tuning theory is the same for a broadcast receiver or a high-power transmission line that lights Boston from a Georgia waterfall. Electricity itself is but a part of physics. As we have seen, radio waves and light waves differ only in length; they both speed alike with incredible velocity, are reflected and refracted by suitable mediums, and show in some degree the same shadows and interference. And today we are interested

(*Continued on page 765*)

Lieut. Col. Joseph I. McMullen

Uncle Sam's Views on Patents

How Our Government Acquires Rights to Inventions and Excercises Control Over Them and How the Inventor Is Treated

By Lieut. Col. Joseph I. McMullen*

GOVERNMENT departments, particularly those of the War and Navy, acquire the ownership of patents through various sources, either by purchase, donation, or direct operation of law. In addition, patent interests are also acquired in the shape of licenses. It is probably correct to say that the War and Navy departments together control ninety per cent. of the Government's patent interests. Approximately one thousand are owned outright by the Government and licenses on perhaps thirty thousand other patents have been acquired. The Government, not being in business for profit and not desiring to compete in business with private industry, acquires in the way of patent interests many times more licenses under patents than actual ownership rights.

¶When the Government acquires the ownership of a patent, the monopoly continues just as in the case of private ownership and the patent does not become public property.

¶The fact that the Government issues a patent does not affect its right to exercise all of the privileges that go with patent ownership.

¶The Government acquires the rights to patents by purchase, by donation from public-spirited citizens and, in some cases, from its own employees by operation of law.

Since a patent is really nothing more than the granting by the Government the legal right to control the use, manufacture and sale of an invention by excluding unauthorized parties therefrom, it is obvious that the principal purpose that may exist for the ownership of a patent is the exercising of the right of monopoly which the patent carries with it, particularly against competitors in business. Thus the interests of the Government are sufficiently taken care of by the acquisition of a license under a patent, since the main purpose of the Government is merely to avoid the payment of royalties and expensive litigations in court. It is really a question of economy with the Government.

From time to time within the last ten years proposed legislation has been submitted to Congress designed to inaugurate not only a uniform policy in regard to the handling of the Government's patent interests, but the setting up of a Government agency for the administration of these interests to the end that the needs of the Government, the rights of private inventors, particularly those in the Government service, and also the interest of the general public, shall be adequately taken care of. However, up to the present time all such proposed legislation has failed of enactment.

Since many of the patents granted are upon inventions made by people in its own service, the attitude of the Government is interesting. The War Department is deeply concerned with this question, and believes that great liberality should be shown to inventors in the Government service, so that the exercise of inventive genius may be encouraged. The Supreme Court, in a long line of decisions, has definitely settled the question that a patent is a property right just as susceptible of ownership and enjoyment as is any other property, either real or personal. The Supreme Court has also held in the famous Solomons case, that the United States Government is in the same position as any private employer in dealing with the patent rights of its employees. If, therefore, a person in the employment of the Government obtains a patent on an invention, the Government, if it desires to acquire it, must deal with the inventor in the same manner as a private employer and the same laws are applicable in each case. While, therefore, the Government does in some cases acquire the ownership of patents taken out by its employees by operation of law, as do other employers, and also acquires many patents by donation from public-spirited citizens, there are many other cases where the acquirement of patents is by purchase. The question then arises as to what the policy of the Government should be in regard to enforcing its right as owner of a patent monopoly.

The different departments of the Government, including the Department of Justice, agree that the right to exercise the monopoly of a patent is as pertinent in the case of the Government as it is in that of any private owner of a patent. The fact that the Government issues the patent does not affect the right of the Government to exercise all of the privileges that go with the ownership of a patent. In other words, when the Government acquires the ownership of a patent, the monopoly continues just as in the case of private ownership and the patent does not become public property. However, although the Government acquires the ownership of patents and, without question, has the right to protect its interests therein by court proceedings against infringers or any other unauthorized trespassers, a policy of so doing has never been put into effect. The various departments of the Government have not heretofore been in agreement concerning the enforcement of patent rights owned by the Government. Apparently, it has not been considered entirely proper for the Government to bring suits against private parties for damages for infringement, or bills in equity asking for injunctions. As far as can be known the Department of Justice has not entered this field of litigation.

In 1923, in an opinion directed to the Secretary of the Navy, the Attorney General held that the Government may not dispose of its patent interests except (*Continued on page* 751)

**Judge Advocate, War Dept.*

News FROM THE Manufacturers

Weston Resistance Meter

Adding to their long line of quality instruments, the Weston Electrical Instrument Corporation has produced a new meter which will be received with open arms by manufacturers, laboratories and servicemen. It is a direct reading resistance meter (Fig. 1).

This Resistance Meter, known as Model 506, solves resistance measurement problems in radio servicing by directly indicating resistance values from 10 to 10,000

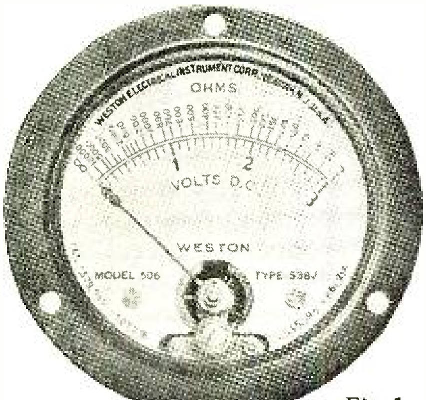


Fig. 1

ohms. It can also be used for making continuity tests.

It operates on two flashlight cells or any other 3-volt d.c. supply. To use, it is only necessary to make a series circuit of the instrument, the 3-volt battery and the resistance to be measured.

The instrument has an etched "volt-ohm" scale and is enclosed in a 2-inch flush style case. It can be mounted on a panel or used as a portable unit by placing it in a small box together with the two flash-light cells.

Pierce Airo Chassis

In the 1930 Pierce Airo (Fig. 2), employing a screen-grid tube in the r.f. end and a pair of 245 tubes in push-pull in

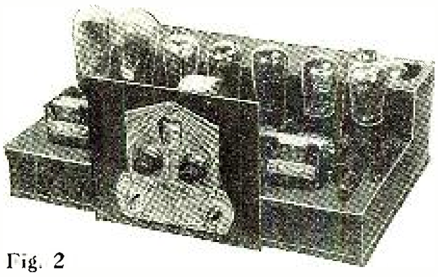


Fig. 2

the audio channel, Pierce Airo, Inc., of New York City, announce a significant step forward in the design of radio receivers. The company's engineers claim that a.c. hum has been entirely eliminated by the use of a high quality filter system. A phonograph jack is included in the circuit, for music lovers who wish to play phonograph records. The receiver is available in metal cabinets, as well as in chassis form for placing in art consoles, and may be obtained for either a.c. or d.c. line supply.

Electrad Super-Tonatrol

A new volume control, the Super-Tonatrol, obtainable in seven types, has been announced by Electrad, Inc., of New York City (Fig. 3).

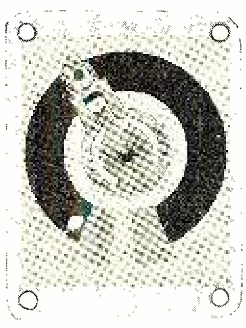


Fig. 3

Due to special manufacturing processes, resistance values remain constant and uniform indefinitely, it is claimed. The resistance element comprises a metallic deposit fused on a metal plate at a high temperature, and contact with it is made by a floating silver brush.

New Acme Screen-Grid Set

The Acme chassis No. 88 SG is the offering of the Acme Electric and Manufacturing Co. of Cleveland, Ohio, to the

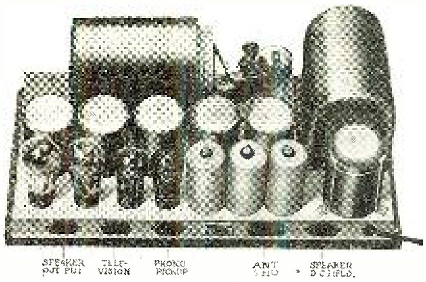


Fig. 4

dealer and home constructor who desire to choose their own console and speaker equipment. The salient features of this chassis include a four-gang condenser mounted on a heavy steel chassis; eight tubes, as follows: three –24's in the r.f. stages, two –27's for the detector and first audio, two –45's for the push-pull output stage and one –80 as a rectifier. Others are complete shielding, including the r.f. inductances, condensers, transformers, and power unit; built-in antenna; Mershon condenser having a capacity of 24 mfds.; current supply for the dynamic speaker, and attachment terminals for the phonograph pick-up and television. See Fig. 4.

Steinite Console Receiver

The latest offering of the Steinite Radio Company is the Super Steinite Screen-Grid Receiver, employing a total of seven tubes. Three of them are the type –24 screen grid, and two are –45's in the push-pull audio stage. Four variable condensers are used for tuning, providing extreme selectivity. According to the Steinite laboratory engineers, circuit perfection in the detector stage has been included in this receiver by the use of linear power detection with automatic grid bias. Real humless reception, plus a high order of tone quality, is obtained from the set by the use of an electro-dynamic speaker. See Fig. 5.

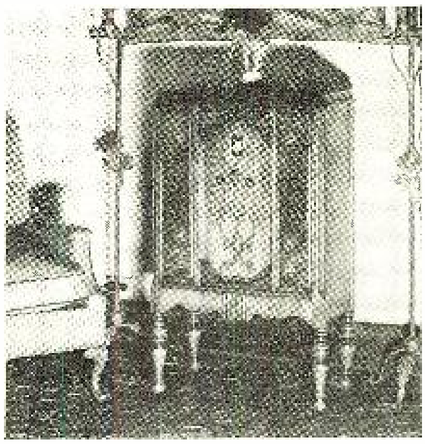


Fig. 5

Rola Auditorium Dynamic

From the Rola Company of Cleveland, Ohio, and Oakland, California, comes the announcement of the new Rola Electrodynamic Auditorium Speaker, type "R." This speaker, for use (2 models) on 110 volts a.c. and 225 volts d.c., functions effectively and without blasting or rattling at the full output of four 250 tubes in push-pull arrangement, and is particularly suited for use with speech amplifiers and public address systems at public gatherings, for talking pictures, in auditoriums, schools and outdoor work. Extraordinary magnetic field density is obtained by a field winding of 3,000 ampere-turns energized by a built-in rectifier using the 280-full-wave rectifier tube. See Fig. 6.

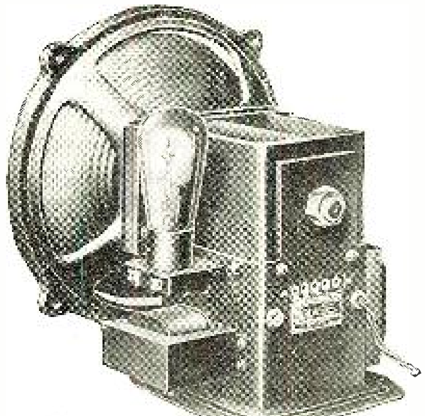


Fig. 6

Current Comment

(*Continued from page 693*)

Commission it was found that loudly operated radio speakers are leading the cause for noise complaints. What the ordinance will do if passed by the Board is to eliminate loud-playing speakers in public places and require listeners to lower the level of their machines to the approximate volume of the human voice.

The lack of discretion with which some radio receivers are employed is likely to drive a great many of us to pursue drastic measures which may not be as effective as they are impetuous. For instance, there is a very rapidly growing field for equipment, which for want of a better name is called a "public address system." Public address equipment finds its greatest utility in enabling a speaker, by the aid of amplifiers and loud speakers, to address with comfort a very much larger audience than he possibly could if he had to depend entirely upon the force of his voice. We can see where legislation or ordinances of this nature can be used to extremely good advantage by the legal fraternity. If the loud speakers are to be held within the approximate volume of the human voice, there is plenty of room for argument over the definition of "approximate."

At a recent convention, held in Washington, D. C., an interesting suggestion bearing on the subject of loud speakers was brought about by Major General George O. Squire, retired Chief of the U. S. Signal Corps, and U. S. Air Service. General Squire, who is well known in radio circles for his work in connection with wired radio, painted a verbal picture of a new day for the home listener-in.

His suggestion was that several programs would be introduced over the ordinary telephone line through the medium of some new equipment which would require no changes in the present telephone system and would enable the subscriber to have a whole group of what the General characterized as "soft-speakers" operating in various parts of the house. He suggested that the volume level of any one of these speakers could be held down so that pleasing results could be obtained in any part of the house without it being necessary to raise the volume on a single speaker to fill the house. This is an extremely interesting development which should appeal very strongly to students of acoustics. It should also appeal to the present manufacturers of loud speakers who would, we feel sure, find very little engineering difficulty in rearranging their production schedules so that they might manufacture "soft" instead of loud speakers. Furthermore, this, like almost every other step taken in the radio business, seems to provide more virgin territory for the lawyers.

The Two-Radio Family

In a recent issue of *Printer's Ink*, we saw a most interesting full page ad over the name of Paul Block, Inc. It had to do with "selling" the idea of two-radio receivers for each family. That is a notion which we have harbored for some time but have not had the temerity to suggest. Since Paul Block has taken the initiative we can but second his motion. Of course a careful statistician or some legal-minded individual might pass a wise-crack or two about our automobile radio receiver being up the same street and we would simply have to crawl right back into our barrel and blush for shame.

Further perusal of the ad indicates that it is based upon one of Arthur Brisbane's editorials from the New York *American*, which we quote, "To have only one radio in your house is like having only one book in your library," and the date on which that statement first saw the light of day was October 27th, 1929.

Seriously, however, there is a lot of real logic in the two-radio family idea. We can think of a number of good reasons for more than one receiver being in use, in the same household.

How often has it happened when we most wanted to hear some specially interesting program that we have been deprived of the pleasure because the family radio was serving as a peace-offering by entertaining the cook or the butler. Many a young man, we have been told, would give almost anything for a good loud radio in order to keep the family under the impression that he was a musical or lecture enthusiast when calling upon one of the family's eligible females. We have heard a number of serious complaints about the unhandiness of having to get up so frequently to change phonograph records.

We Laugh at Atwater Kent

A few years ago the American Society of Authors, Composers and Publishers decided that they should collect a royalty on all of the copyrighted work owned by their members. The National Association of Broadcasters believed that this royalty would place a very severe hardship on broadcasters and would have a very bad effect upon the radio business in general. Bill Brady, the showman and self-confessed "gambler" and friend of Arnold Rothstein, presented himself in Washington, where a hearing had been called so that the entire matter could be properly thrashed out, and addressed the assembled delegates with his customary cigar in his mouth and without removing his hat. The session was a very stormy one, and immediately following it a number of us adjourned to Powel Crosley's room for lunch.

Among those present were Paul B. Klugh, now guiding the destinies of the Zenith Company; George Lewis, who is now vice-president of the Arcturus Tube Company; one insignificant scribe and A. Atwater Kent.

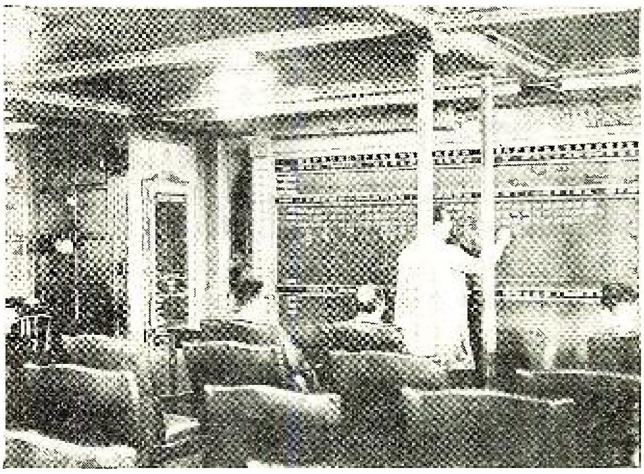
After lunch everybody's business was dragged out into the open and discussed. Certain among us who had a very fair idea of how everything in the radio business should be conducted nodded dubiously over the possibility of the continued progress being made by the Atwater Kent Company. Since that time the quality of Atwater Kent receivers, the foolishness of the Atwater Kent broadcasting and the extravagance of the Atwater Kent advertising campaign, both magazine and billboard, have provided humor for a great many of us.

Most recently the subject came up with a prominent sales engineer over a bottle of Chianti in a New York restaurant, but this time there was a complete reversal of the former attitude. Our host voiced his reaction in the following fashion:

"Isn't it funny how much amusement Atwater Kent has furnished the entire radio industry? Almost every step he has taken has been looked upon with scorn by all of the wiseacres of this, that and the other manufacturing company. But isn't it funny also, that there are very few radio receivers that have anything like the same public acceptance as Atwater Kent's and also there are very few presidents of radio manufacturing companies who can afford to provide themselves with two-and-one-half-million-dollar homes without feeling the pinch pretty badly."

To which we rejoined:

"And you have said nothing of the largest radio factory in the world. Regardless of anything else which Mr. Kent may have done, he has certainly provided the remainder of the industry enough laughs to keep them in good humor during what might otherwise be rather trying times. We understand that he has recently taken on several thousand employees and that his dealers are now complaining of the shortage of Atwater Kent's receivers. It is to laugh!"



Short-wave radio links the Leviathan's brokerage office, shown above, with the New York Stock Exchange ticker service

The Radio Forum

A Meeting-Place for Experimenter, Serviceman and Short-Wave Enthusiast

The Experimenter

Improving Tone Quality

Mr. L. A. Didsbury, of Bridgeport, Conn., has in his work as a serviceman built up quite a clientele by improving the tone quality of a number of the older type of radio receivers. The revamping of the audio circuit as shown in Fig. 1 is especially applicable to the ordinarily

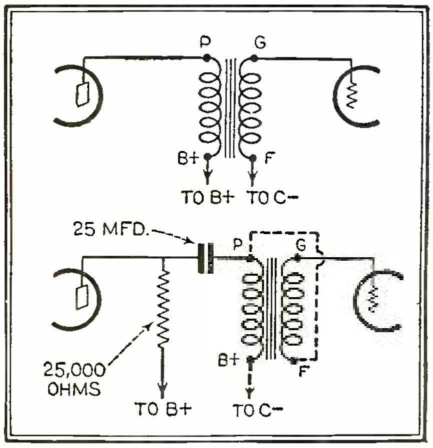


Fig. 1

poor or slightly inferior audio transformer. It is, of course, a well-known fact that the inductance of the transformer primary is decreased as the current passing through it is increased or vice versa. It follows, therefore, that by forcing the current through the resistor, we have removed from the primary coil of the transformer all the d.c. components. The effect of this operation is an increase in the effective inductance of the primary, correspondingly greater efficiency, especially as regards the lower portion of the musical scale. Incidentally, after the above changes have been made, the serviceman will have converted the audio channel to that of an amplifier, practically identical to that of a system which is claimed to be more than ordinarily efficient.

Improving Freed-Eisemann NR45

"Having made a few changes," says Mr. C. L. Brown, of Hallsville, Texas, "on a Model N-R 45 Freed-Eisemann, I thought other servicemen might benefit if I passed this information along. The changes improve the selectivity, r.f. gain and ease of tuning on this Freed-Eiseman receiver, which is of the neutrodyne type, with aperiodic antenna primary, two stages of r.f. amplication, detector, and two audio stages, the last being parallel tubes. The improvements are as follows:

"I removed the filament connections from one of the parallel audio tubes, placing it on the radio-frequency rheostat, which is also the volume control of the receiver. Next, remove the primary leads from the antenna coil and also from the aerial and ground, discarding the antenna series condenser, .00025 mf. The ground side of the antenna coil should now be connected to B plus r.f. and the antenna side to the new r.f. tube plate. Between the antenna and ground-binding posts is placed a small radio frequency choke coil, the ground side also being connected to the A minus terminal on the new radio frequency tube socket, the antenna side of the choke coil to the grid of the new radio frequency tube. This adds an untuned radio-frequency stage which results in the three dials stepping in line over the complete tuning band, better control of volume makes the first dial sharper in tuning, and also adds some to the r.f. gain (Fig. 2). The only extra part needed is the r.f. choke coil. On my own receiver, these changes have made a marked improvement."

THE Radio Forum is a department conducted solely for the benefit of the Experimenter, Serviceman and Short-Wave Fan.

The Editor invites contributions to the department of short articles, one or two hundred words in length and will pay regular space rates for all accepted and published manuscripts dealing with novel wrinkles, kinks or experiments which have been found to produce results of a practical nature.

All manuscripts submitted should be typewritten, if possible, and on one side of the paper. They should be accompanied by sketches, drawings or diagrams illustrating the experiment on separate sheets. Photographs are particularly desirable.

Address all contributions to The Editor, Radio Forum, Radio News Magazine, 381 Fourth Avenue, New York City.

Space-Charge Detection

For the benefit of those who are interested in experimenting with the screen-grid tube (–22) as a space-charge detector (our mail indicates that there are a large number interested), the following circuit is suggested. Before going too far it may be well to glance at the circuit diagram Fig. 3. Here it will be found that the connections for the space charge detector differ from both the usual –01A detector and the screen-grid tube when used as a r.f. amplifier. The grid connections constitute the change and are the reverse of the usual accepted screen-grid connections. The grid which terminates at the top of the tube in a metal cap is connected to a positive potential of 22½ volts and the screen-grid leading to a prong in the tube base is wired directly to the grid-leak and condenser. In other words, the connections at the socket terminals are the same as those of the usual detector with the addition of the application of a 22½-volt potential to the metal cap (grid). In a majority of detector circuits the grid leak is connected directly across the grid condenser.

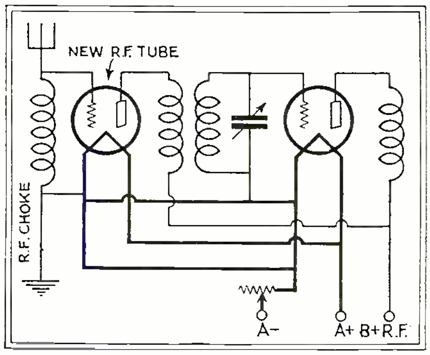


Fig. 2

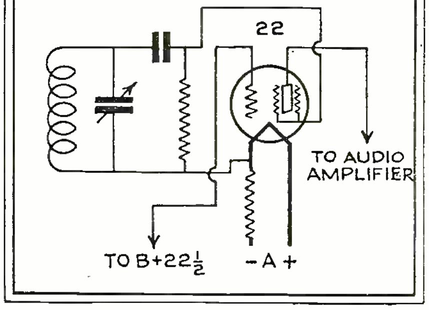


Fig. 3

The Serviceman

A Tube and Set Tester

In his service work, Mr. Everett James, Hazelton, Indiana, found the need of an efficient and reasonably priced tube and set tester. The tester devised by Mr. James will locate all troubles of a battery-operated set except those caused by the "unbalancing" of condensers. Its name, of course, comes from the source of many of its parts. The mounting of the meters does not interfere with their use for other outside measurements.

The necessary parts are as follows:

1 voltmeter, 1 to 10 volts; 1 milliammeter, 1 to 25 milliamperes, or even higher; 1 universal socket; 1 30-ohm rheostat; 1 discarded transformer with a good secondary winding; 11 binding posts, battery posts and spring brass which were salvaged from discarded B batteries to make the push-button switches; 1 panel, 5 x 9; 1 discarded UX 201 tube and some flexible insulated wire.

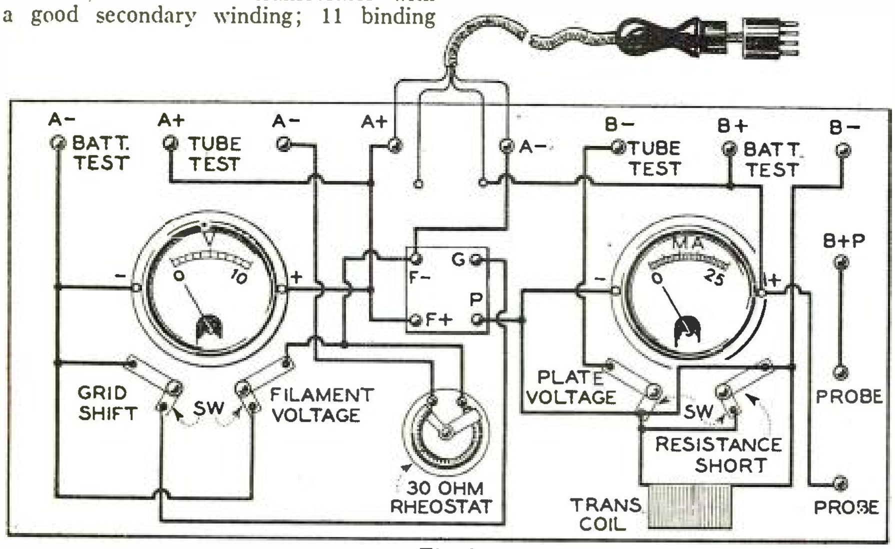


Fig. 1

Many substitutions may be made for these parts (all of which were obtained from the junk box, with the exception of the meters). However, if new parts are obtained for the tester it would still be well worth the money invested.

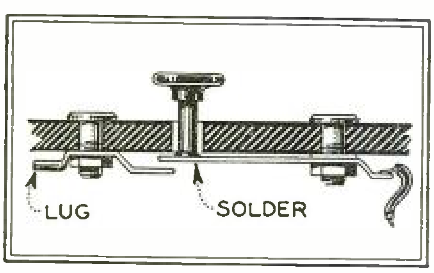


Fig. 2

In building, first drill and cut the panel to mount the parts in the positions shown in Fig. 1. Next mount the binding posts using soldering lugs under the nuts behind the panel. The binding posts if desired may be replaced by clips from the tops of B batteries and fastened by machine screws through the panel. Here also use soldering lugs or some convenient substitute. For the push button switches use binding post tops and machine screws of suitable length and size Fig. 2. The brass is cut into suitable widths (about 3/8") and lengths and fashioned as shown. The circuit is to be open except when the button is pushed. Push buttons for electric bells might be so used.

The secondary coil is then taken from the transformer, care being taken not to injure it in removing the primary coil. The secondary coil is then mounted by the aid of a spool and a brass angle bracket to the under side of the panel. (Fig. 3.)

The old tube is next broken from its base and the base cleaned. A suitable handle is whittled from some soft wood to fit into the tube base and a hole for the wires is bored through the handle. Next wires 3 or 4 feet long are soldered inside the tube prongs passed through the hole in the handle and cabled together. (Fig. 4). Here a short piece of four or five wire cable could be used to an advantage. Be careful in getting these wires connected correctly. The wire from the grid prongs goes directly to the grid socket post on the set. The filament leads connect to the A plus and A minus binding posts at the center top of the panel. These wires have "spade" connectors so that they may be easily changed in order to make the voltmeter show a positive reading. The posts are connected in turn to the F plus and F minus connections on the socket. The plate lead goes to the plus on the milliammeter. Run a lead from the minus on the milliammeter to the plate connection on the socket. This puts the meter in series and thus any plate current is registered. (Under-panel connections are nearer.)

The voltmeter is then wired across the filament circuit, with the switch marked "filament voltage" in series with voltmeter. A lead is run from the grid of the socket to one side of the switch marked "grid shift" and from the other side of the switch to the filament minus. This permits a change of grid voltage for tube testing by pressing the switch button.

The voltmeter is wired across the A

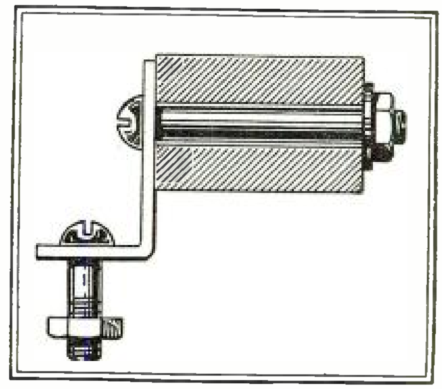


Fig. 3

minus and A plus binding posts to the left to permit a direct test of dry cells. The next A minus post (third from the left) is wired through the rheostat to F minus. The voltmeter is also wired across this circuit using the switch marked "filament voltage." The B minus post to the right of the cable filament posts is wired to A plus and to the plate voltage switch. The next post to the right, B plus, goes to MA plus. The B plus post in the upper right corner is wired through the resistance coil (transformer secondary) to the minus post of the milliammeter. The resistance short switch is arranged to "short" this coil. Another wire goes from this B minus post to the other side of the plate voltage switch. When the tester is plugged into a set and a high resistance voltmeter placed across the B battery test post, a plate voltage is obtained by pressing this button. The B plus P post is connected to one "probe" post and the other "probe" post to the plus of the milliammeter. This completes the wiring. The mounting is arranged to suit the builder's

(*Continued on page 775*)

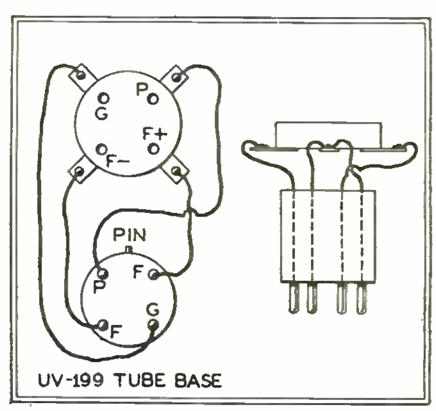


Fig. 4

On Short Waves

A Completely Shielded S.W. Receiver Fan

Editor Short Wave:

May I congratulate you for the excellent articles and circuits published in the best radio magazine I have ever read—RADIO NEWS.

It will interest you to know that I am getting successful results with "The Completely Shielded Short-Wave Receiver" described in the October, 1928, issue. The day I built it W2XAF was received with fairly good volume on the phones. Two days later this little set provided the most thrilling moment I have ever felt. When I was searching for W2XAF, I got a carrier wave supposed to be theirs at 10 P. M. G.M.T. sharp. I heard, for the first time in my life, the Portuguese hymn through the ether. After this the announcer identified the station as PCJ, with a special program addressed to Madeira, consisting entirely of Portuguese songs and musical numbers.

Later on the announcer called the Canary Islands and another special program to the Canary Islands was given. W2XAF was by that time jamming me on PCJ's, thus further reception from either was impossible.

Last night, June 3rd, I enjoyed the whole program from G5SW. At 12 P. M. E.S.T. the twelve strokes of Big Ben came through, after which the announcer said London was closing down, but that the program was being continued with phonograph records. W2XAF was too faint to be of any interest and I therefore gave up. A few other broadcasting stations have been heard, one on 40.5, another on 31.5 and the rest around 33 m.

I have tried the screen-grid valve as detector and l.f. amplifier with fine results.

Wishing the new editors of RADIO NEWS every success and hoping that the S.-W. section will be enlarged, I am,

Yours truly,
TELESFORO JOSE GORDINHO,
Radio Polana,
Lourenco Marques,
Portuguese East Africa.

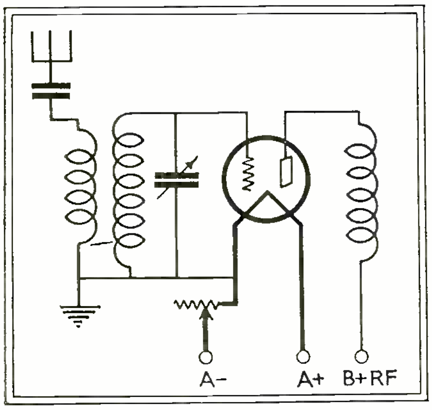


Fig. 1

S. G. Amplifier

Mr. Leo E. Sands, of Everett, Washington, has completed considerable experimental work with the screen-grid tube as an r.f. amplifier in connection with the Grebe CR18 receiver, first using the screen-grid tube as an untuned r.f. amplifier but not much amplification was obtained with this method. A marked improvement was obtained in the amplification when the screen-grid tube was employed as a tuned radio-frequency amplifier. This tuned r.f. stage was not shielded, shielding was tried but was not much improvement, the arrangement as shown in the circuit diagram Fig. 1 certainly pepped up the set a great deal. Many signals that could not be heard before are now heard with lots of kick. All the signals are louder than before and I certainly recommend tuned screen-grid r.f. for the short wave receiver.

An Emergency Key

A serviceable key may be easily made from a single-pole, single-throw knife switch. Using the porcelain base of the switch as the base for the key, we first take the switch from its copper mounting bracket, straightening out the bracket so that it takes the form of a letter U, as in Fig. 2. Fasten the U bracket on one end of the porcelain base, tightening the switch blade to the top of it. The contact fastened the other end of the porcelain switch base is made up from a metal binding post. Binding posts or Fahnestock clips may be fastened in the extra holes in the porcelain base. The wooden handle of the switch is filed flat, forming a convenient gripping surface. Mr. J. L. Davis of Albany, Ga., has used a key of this type for some time on his amateur transmitter with very satisfactory performance.

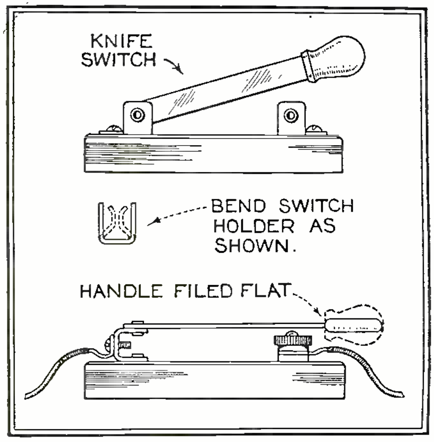


Fig. 2

Copper-Clad Special Results

Editor Short Waves:

In the constructional article describing the Copper-Clad Special short-wave receiver one important item was omitted relative to the coils. Not a handicap to the experienced builder, it might prove a stumbling-block to the fan building his first receiver. With the Aero coil kit, LWT-11 and 12, the later comes from the dealer with a rather large primary, and should be torn down, rewinding with 6 turns of No. 16 enameled wire. The small coil originally had 3 turns; I added a turn, making 4, with marked improvement in operation.

My receiver was to be used with a loud speaker, so it was necessary to add a second stage of audio. Knowing of some of the evils that sometimes occur with the addition of a second stage of audio, I tried by-passing the batteries, buit with little effective results against common coupling. Fixed and variable resistances across the secondary of the audio transformer afforded some remedy, but in some cases this affects the peaking of a good audio transformer. As good transformers were included in my set, I did not wish to change their operating curve, so the method as shown in Fig. 3 was employed, which eliminated all trouble at not too great an output voltage loss.

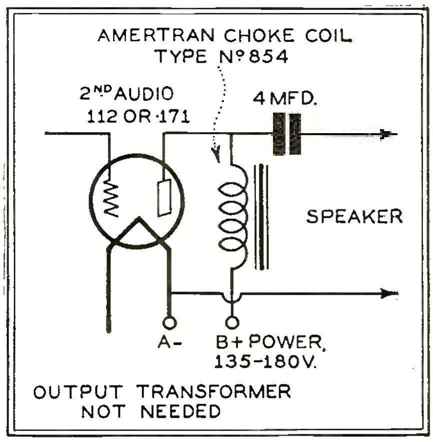


Fig. 3

As to the tubes, I have experimented with a number in the detector socket, (–01A, –00A and –12A). The –12A, an exceptionally sturdy tube ,affords smooth regeneration control; the –01A is sensitive and quiet, but the –00A has a keen edge on them even if somewhat noisy. The best tube I have found for my set is the Zetka 200. It operates without the noise usually found in a number of super-sensitive detector tubes. Two antennae were built specially for short waves, the first a flat-top 40 feet long and 25 feet high, the other a 20-foot vertical type. The 40-foot antenna has worked perfectly at all times, while on good nights the vertical will duplicate tre results obtained on the flat-top.

I have operated the Copper-Clad Special in a section that has been pronounced "dead" as far as short waves are concerned, and have been able to receive programs from W8XK, W2XAF, W2XAD, W2XAL, W8XAL, W8XAJ, W9XU, G5SW, CJRX, PCJ and as a crowning achievement 2ME of Sydney, Australia. This last station was with one stage of audio on earphones.

I feel greatly indebted to RADIO NEWS for sponsoring the Copper-Clad Special Short-Wave Receiver. It is a real he-man's job and produces the results.

Very truly,
A. F. HUNTER,
Durham, N. C.

Ask the service man, he knows

"The De Forest radio tube surpasses every known make,"
—says Joel J. Michaels,
Executive Chairman, Citizens' Radio Committee.

This is one of many unsolicited letters we have received from service men the country over.

New York City
Oct. 1, 1929

De Forest Radio Co.
Jersey City, N. J.

Gentlemen:

I have kept a record of service calls during the past four years, and almost every conceivable type of radio set has come under my observation.

Sixty-five per cent of the entire troubles lay entirely to faulty tubes.

Of the entire quantity of tubes found defective, less than five per cent were De Forest Audions, and I have certainly found in my travels around the New York section, carloads of De Forest tubes giving splendid service and many of them bearing the earmarks of long service.

I prefer to recommend to my clients your vacuum tubes, because they are designed and constructed by scientists who know their business, whose background and experience antidates every existing vacuum tube manufacturer, and whose researches and improvements are widely copied and considered standard. The De Forest tube, in my judgement surpasses every known make, for performance, efficiency, mechanical construction and general all-around service.

I can testify to the fact that some of the World's D.X. records were obtained after De Forest tubes were substituted for others whose manufacturers claimed unbelievable performance.

When better vacuum tubes are made, De Forest will make them.

Respectfully,
Joel J. Michaels
Radio Service Engineer, Executive Chairman, Citizens Radio Commit

de Forest AUDIONS

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PASSAIC, NEW JERSEY

Branch Offices Located in
Boston, New York, Philadelphia, Atlanta, Pittsburgh, Chicago, Minneapolis, St. Louis, Kansas City, Denver, Los Angeles, Seattle, Detroit, Dallas, Cleveland

And Now— RADIO *Guides* AIRPLANES

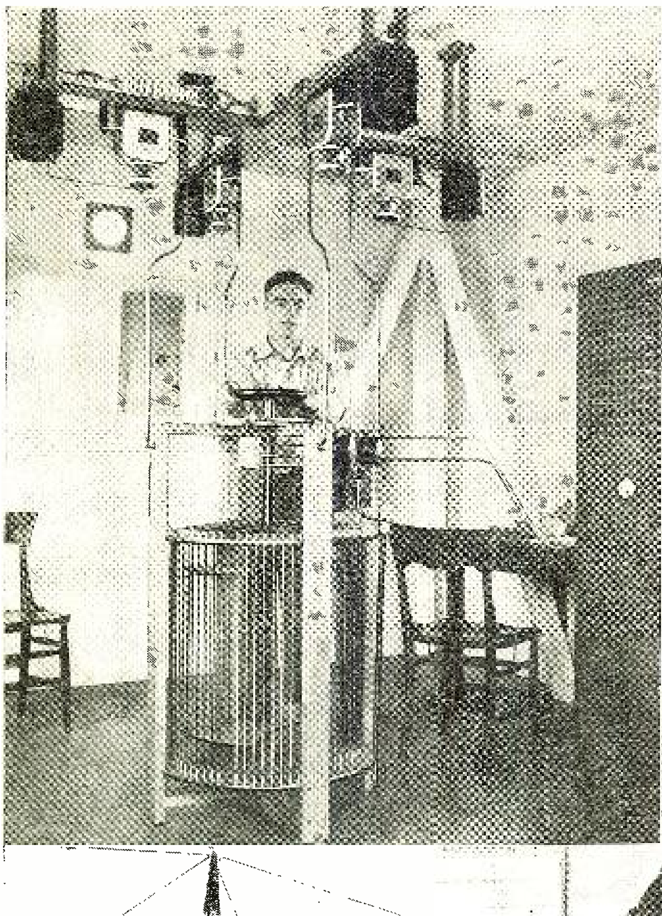
Radio Beacon Beam Great Aid to Air Navigator

RADIO as an aid to air navigation has come out of the experimental stage and is fast becoming an accepted item in the equipment of a well-appointed plane, whether it be for air transport, mail service or for pleasure hops.

Perhaps the most outstanding development in the radio-aviation field during the past year has been the perfection of the visual and audible radio beacons whose transmitters are rapidly being installed at important airports both by the Department of Commerce and the Signal Corps of the U. S. Army.

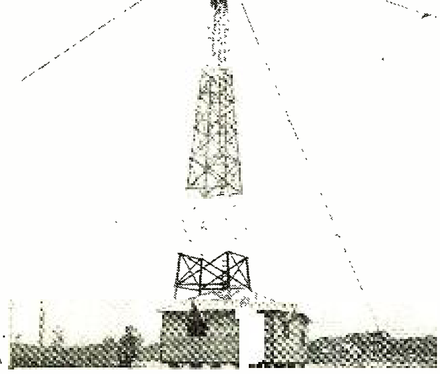
The illustrations accompanying show the peculiarly striped radio beacon mast, goniometer and signal field radiation adjustment of a modern up-to-the-minute radio beacon station. The one illustrated is that located at the Army Airport at Mitchel Field, Mineola, N. Y.

By means of the goniometer (overgrown variometer) and the four-sided umbrella antenna, the field of the transmitted signal can be so adjusted as to radiate to any four equidistant points of the compass.



To the left, the operating room of the radio beacon station. In the foreground is shown the huge goniometer with which the path of the signal is regulated

Masts and other tall objects offer hazards to flying. Below, left, is shown the radio beacon mast, striped so as to make it visible to aviators. Directly below is shown Lieut. Walter B. Hough, Radio Officer at Mitchel Field, adjusting the control wheel of the goniometer



Path of Four Beams Set by Goniometer

The transmitted signal is radiated in the directions to which the goniometer is adjusted, at a frequency within the tuning range of the receivers with which the planes are equipped.

This signal is composed of audio tones of an extremely low frequency, something like 65 cycles.

In the aeroplane is located an ordinary receiving set to which is attached a reed unit which will respond visually to signals of the frequency to which it is adjusted.

Messrs. Dellinger and Pratt of the Bureau of Standards, in a paper delivered before the Institute of Radio Engineers (Proc. Inst. Radio Engineers, Vol. 16, No. 7, p. 902) said, in explaining the functions of the beacon: "On the aeroplane, the receiving set output is fed to the indicator, consisting of small electromagnets between which two vibrating polarized steel reeds are mounted. The reeds are tuned mechanically to the frequencies of the beacon modulation voltages. . . . The reeds vibrate with equal amplitude when on the course. When off the course, the observer can estimate the distance he is off by noting the relative reed amplitudes. An advantage of the system is that if the beacon ceases to function the observer is aware of it, whether he is on or off the course."

For day flying the beacon is effective within a radius of 400 miles, while at night its range is increased to 1,400 miles.

Visual Beacon Decided Improvement Over Audible System

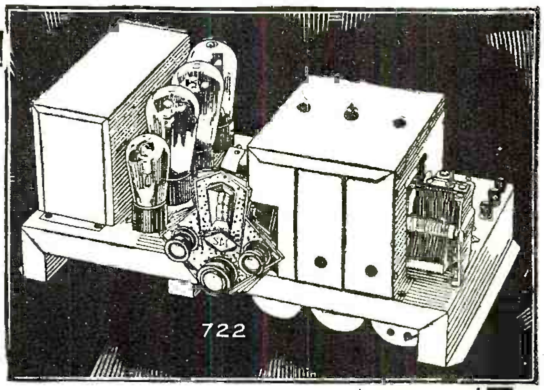
The use of the visual or reed type of indicator to show when a pilot has his plan on or off the beacon's course provides a distinct advantage over the audible system, in that the former will respond only to the transmitted signals, while with the audible system there is mixed in with the received signal a great deal of interference set up by the sparking of the many spark plugs with which the engine is equipped. Of course, if the ignition system is completely shielded, this criticism does not hold true.

The application of the Diesel engine to airplane use will naturally eliminate at one stroke this entire source of interference. since these motors do not require the high tension ignition system for exploding the compressed gasses within the gas engine cylinder.

Thus, we may look for better aerial navigation in the future because of the advances, both radio and mechanical, which are being made.

SM

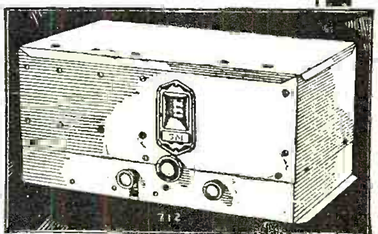
"S-M 722 a Knockout" —Setbuilders Demand D.C. Design—It's Here!



The Record-Breaking S-M 722

Experienced setbuilders have learned to expect big results from any screen-grid custom design that S-M offers—but the 722 Band-Selector Seven has broken all records. And no wonder—a custom receiver that is sold, completely wired, at $74.75 net, topping the performance of widely advertised factory sets selling at twice the price. Yet there is nothing mysterious about it—just the long experience of S-M engineers applied to the job of producing those essential receiver parts whose quality spells the difference between the performance that "gets by" and the performance that an S-M fan demands. Everything that is the "last word" is in the S-M 722—the '24 power detector, the band filter—the uniform gain all over the dial—single dial tuning—all-electric with built-in power supply. Tubes required: 3—'24, 1—'27, 2—'45, 1—'80. Wired, less tubes, $74.75 net; parts total $52.90.

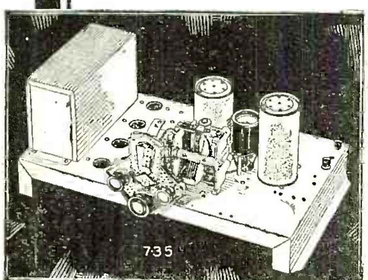
The new 722DC for battery use gives every advantage of the a. c. design—big volume, DX ability, and uniform amplification at all frequencies, just like the a. c. set—truly the ideal battery receiver. Tubes required: 3—'22, 3—'12A. Similar in appearance to 722 illustrated. Wired, less tubes, $57.50. Parts total $38.50.



Do You Want Absolutely the Best There Is?

It doesn't cost an awful lot more than the 722, but this S-M 712 tuner, in its neat innocent-looking all-metal shielding cabinet, is absolutely guaranteed to out-distance and out-perform all competition regardless of circuit or price—just as its famous predecessor, the Sargent-Rayment 710, did last year. Read, in last month's issue of this magazine, how one listener living only a mile from the powerful WSM tunes in regularly a station 400 miles away with only 20 kc. separation! That's performance—and with one-dial tuning—*no verniers*. Tubes required: 3—'24, 1—'27. Wired as shown, less tubes, $64.90 net. Parts total $40.90.

Any good audio amplifier can be used with the 712; ideal tone quality and perfect convenience are secured by using the S-M 677. Uses 1—'27, 2—'45, 1—'80 tubes. Wired complete, less tubes, $58.50. Parts total $43.40. For 25-40-cycle current, $72.50 wired.



And a "Bearcat" for the Short Waves

"The little 735 is a "bearcat". The way it will pick up stations is nobody's business. You want to see the hams come in and play with it. First one I wired I got 5SW Chelmsford, England, also a Dutch station and a lot of others . . . this was around 2 P. M."

That's the verdict of R. G. Sceli of Hartford, Conn.—one of the most expert setbuilders in New England, and remember he is speaking of the first completely-a.c.-operated short-wave sets ever brought out! The new S-M 735 Round-the-world seven is carrying all before it this year. On same chassis as the 722; tubes required: 1—'24, 2—'27, 2—'45, 1—'80; wired $64.90, parts total $44.90. 735DC for battery use, using 1—'22, 4—'12A, wired $44.80. Parts total $26.80.

A full line of cabinets is available for all these S-M receivers—the beautiful 707 table cabinet, in rich crystalline brown and gold, is only $7.75 net. The cabinets of remarkable charm are listed in the S-M catalog—see coupon.

"THE RADIOBUILDER" for December contained details of the 722DC; every issue gives advance technical information of great interest and profit to setbuilders. Use the coupon!

Over 3000 Authorized S-M Service Stations cover the United States and Canada. Many are profiting handsomely! Write us for the address of the nearest one if you wish a custom-built set. Setbuilders write us regarding a franchise in your territory.

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Chicago, U. S. A.

Silver-Marshall, Inc.
6405 West 65th Street, Chicago, U. S. A.

........Please send me, free, the new fall S-M Catalog; also sample copy of the Radiobuilder.

For enclosed..............in stamps, send me the following:

......50c Next 12 issues of The Radiobuilder
......$1.00 Next 25 issues of The Radiobuilder

S-M DATA SHEETS as follows, at 2c each:

......No. 3. 730, 731, 732 Short-Wave Sets
......No. 4. 255, 256, etc., Audio Transformers
......No. 5. 720 Screen Grid Six Receiver
......No. 6. 740 "Coast-to-Coast" Screen Grid Four
......No. 7. 675ABC High-Voltage Power Supply
......No. 8. 710 Sargent-Rayment Seven
......No. 9. 678PD Phonograph-Radio Amplifier
......No. 12. 669 Power Unit
......No. 14. 722 Band-Selector Seven
......No. 15. 735 Round-the-World Six
......No. 16. 712 Tuner (Development from the Sargent-Rayment)
......No. 17. 677 Power Amplifier for use with 712
......No. 18. 722 DC Band-Selector

Name..

Address..

Light-Sensitive Cells Make Talking Pictures Possible

(*Continued from page 723*)

described as a piece of apparatus which, when subjected to a light source, will undergo a change, either electrical, chemical or thermal, producing as the result of this exposure to light an electrical potential across its terminals. To date there are four different types of cells which for a lack of terminology are arbitrarily termed and defined as follows:

1—*Actino-electric or Photo-conduction Effect.* Here a cell composed of either selenium, molybdenite, argentite, stibnite and of metallic oxide and sulphides of these metals when subject to light exposure will change in its resistance or ohmic value and thus cause to be generated a potential across its terminals. In other words, a current will be caused to flow from one terminal to the other, and if a suitable meter be inserted in the circuit, the amount of current generated can be read. Cells of this type are not in great commercial use because of their inherent lag or inertia, a measurable quantity, and thus do not apply themselves readily to application in circuits where the frequency of change in the light source is quite rapid.

2—*Photo-electric Effect.* In a three-element vacuum tube the electrons emitted from the filament when it is lighted to incandescence, are attracted towards the plate and are controllable by the grid, which acts as a shutter, thus giving rise to the flow of current between the filament and plate. Here we obtain the electronic emission by means of a local battery which heats the filament to incandescence. The same flow of current can be observed in a photo-electric cell consisting of two elements: one, an alkali metal deposited in the form of a film on the inner wall of an evacuated glass bulb, and the other a collector ring placed in the center of the bulb so that it faces this coating or film. In such a cell when it is exposed to a source of light, there is a splitting or tearing off of the electrons from the alkali metal surface. This electronic emission produces an electrical current flowing from the coating to the collector ring, thus giving rise to the generation of a potential across its terminals.

3—*Photo-voltaic or Photo-chemical Cell.* If two metal elements be placed in an electrolyte contained in a glass jar or cell, either one or the other of the metals being exposed to light, there will be a chemical change giving rise to the "battery action." Here we have a light-sensitive battery where the effect of light on the compounds (organic as well as inorganic) increases the rate of chemical reaction which forms the potential. In simple terms, what we have is a light-sensitive Leclanche cell.

4—*Thermo-electric Cell.* If two dissimilar metals (fine wires) are welded together and the point of junction subjected to a source of light, a potential will be generated resulting from the action of the heat of the light source itself. This we call the Thermo-electric Effect.

These four types of cells, all commercially available, have been put to many modern uses. Perhaps the outstanding present-day use to which the light-sensitive cell has been put is in connection with the talking movies, and in future issues of RADIO NEWS magazine experiments conducted in Radio News Laboratory will be described, tending to show how the home experimenter may build units which he may attach to his radio receiver and home movie machine, so as to record sound on film.

In an attempt to explain the simplicity of the principles underlying the function of light-sensitive cells, Mr. Wein cites a very simple analogy. He says, "It is my belief, based on experiments, that, for instance, a photographic plate or paper with terminals applied to opposite ends of the plate or paper and connected to a sensitive meter will give a meter deflection showing the generation of an electric current when the photographic plate or paper is exposed to light. Once exposed, however, the plate or paper will not revert back to its original unexposed condition. Take as a further example the following:

"A nail struck long enough on the head with a hammer will become heated, the change in temperature giving rise to the generation of an electrical potential which is measurable. Note that in one instance subjection to a light source gave rise to the generation of the electrical current while in the other the heat source did the work.

"In the photo-voltaic cell, with whose development I have been identified, if we take two particular kinds of metal and immerse them in an electrolyte, exposure to light will give rise to a chemical change and thus create an electrical potential, the only difference between it and the other examples stated above being that once the work has been performed no further change can be noted, while with the photo-voltaic cell the removal of the light source restores the metals to their original state ready for the generation of another potential when light is once more applied."

In the photo-voltaic cell two metals, one of which is a film of cuprous oxide (Cu_2O) on a copper plate, the other another metal, are inserted in the electrolyte. The cuprous oxide is the light-sensitive medium. When subjected to light, the cuprous oxide undergoes a chemical change and becomes cupric oxide. When the light source is removed then the cupric oxide undergoes a chemical change and returns to cuprous oxide. Briefly, this explains the action of the photo-voltaic cell.

SERVICEMEN!!

SERVICEMEN interested in placing their names with manufacturers who need men for installation and service work are referred to the *Radio News* Serviceman's Questionnaire on page 770 of this issue.

Uncle Sam's Views on Patents

(*Continued from page 738*)

upon the specific sanction of Congress. This opinion, of course, follows the general laws governing the disposition of all Government-owned property. The Attorney General held, however. that the granting of a non-exclusive revocable license was not a disposition of property within the meaning of the laws controlling all Government-owned property. and therefore any department of the Government might grant such a license without the special sanction of Congress. This opinion, of course, was rendered upon the facts of a specific case and leaves in doubt the question as to whether or not a Government department may grant a non-exclusive license irrevocable in its terms, under a patent. This is still undecided.

Since this question was first raised. the Goernment has from time to time issued non-exclusive revocable licenses under Government-owned patents. but no further steps have been taken. The Government's attitude toward patent monopolies owned by itself is. then. that patents should only be acquired by the Government when necessary to its own interests or in cases where the public welfare is better safeguarded by Government control of patent monopoly. That in the acquisition of patents by the Government, the rights of the inventors. particularly including those in the Government service. should be scrupulously safeguarded and suitable prices paid for patents so acquired. That Government-owned patents should not be allowed to remain dormant or unused, but should be widely administered for the public welfare. particularly through the granting of licenses to industries. and that the rights of licensees under Government-owned patents should be protected through court action against infringers.

Appropriate legislation is necessary to put such a policy into practical effect. particularly since non-exclusive revocable licenses, such as the Government Departments are limited to grant. are inadequate. It is obvious that no prudent business man would stake an investment of any substantial amount upon such a license.

In order to encourage the private use of Government-owned patented inventions. the Government should. without question, be able to issue irrevocable licenses either exclusive or non-exclusive, or in some cases a complete assignment of the patent concerned. Such authority can only come from Congressional action.

Flying Hams

(*Continued from page 719*)

of 1,000 volts. and .4 amperes. takes its power from a 12-volt battery. However. a double-voltage, engine-driven generator will soon be installed to furnish 1,000-volts direct to the transmitter.

A trailing-wire antenna of the type which can be let down or taken up on a reel operated from the pilot's cockpit is used. When lowered for use it is weighted with a 2¼-pound attachment streamlined to reduce wind resistance.

Control over the installation is effected by a single switch which throws the circuits from receiving to transmitting.

Tips on R.F. Transformer Design

(*Continued from page 709*)

larger the primary winding the greater the amplification of the transformer. Consequently the primary is made as large as possible consistent with keeping it tuned below 200 meters. The coefficient of coupling between the primary and secondary should also be made as large as possible. This means that the separation between two windings is small, but here again trouble is encountered if the surface of the primary presented to the secondary is large, for then capacity coupling is introduced so that the amplification of the transformer is reduced. To reduce this effect a bunched or slot-wound primary is used, consisting of several layers of very small wire.

Now that the points in the design of the radio-frequency transformer have briefly been considered, the problem of isolating each tuned circuit so that the feedback in the complete multiple stage amplifier will be small, is confronted. Of course, the coils must be shielded, for otherwise the coupling due to the interlocking of their fields would be sufficient to cause oscillation before a great deal of gain was obtained. By the use of shielding the amplification of each stage is somewhat reduced, the amount depending upon the distance of the shield from the coil and the kind of metal used for the shield.

To determine the size of the shield a number of copper cans were made, varying in diameter from two and one-half inches to four and one-half inches, and the amplification of a single stage using the screen-grid tube was determined. The 2½″ shield gave about 92% of the amplification obtained with the unshielded coil. The three-inch shield, somewhat superior, was selected as the best size to use for commercial purposes.

It was also necessary to determine whether copper or aluminum shielding was superior to all other materials or whether brass and even iron could be equally well utilized. The results of the experimental work on this subject are interesting inasmuch as shielding with iron shows a peculiar trend. Fig. 3 gives the curves of the amplification of the transformer under the various conditions. Curve 1 shows the gain obtained with the radio-frequency transformer without shielding. Curve 2 represents the amplification of the r.f. transformer in a three-inch shield of either copper, aluminum or brass. (The values for these three metals were so close that one curve is given for the three.) Curve 3 shows the amplification obtained when an iron shield the same size was employed. It is interesting to note that the iron shield is not as bad as one would expect at the low wavelengths, for at 220 meters 86% of the total gain is obtained. However, at 550 meters (lower frequency) the relative gain drops to 57%. Thus it would seem that iron might be used for shielding at very high frequencies without too great a loss. The explanation of this action lies in the fact that the higher the frequency the less the magnetic field set up by the coil penetrates the interior of the iron shield and consequently the less loss introduced.

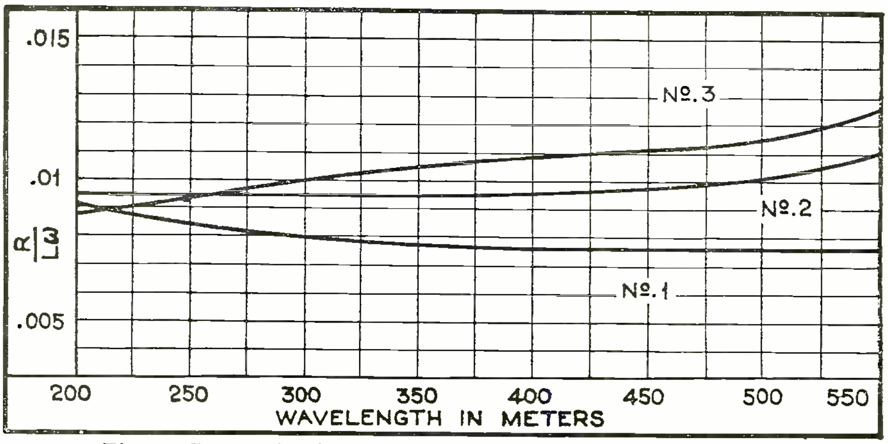

Fig. 2—Curves showing the r.f. resistance of three types of coils

Were it not necessary to bring leads into the shielded transformer there would be very little coupling between any number of stages of r.f. amplification. However, the leads in a properly laid-out set may be made very short and all the radio-frequency current may be kept out of the "B" supply. This is accomplished in the MB-29 by using a by-pass condenser and a radio-frequency choke in each shield-can. This type of construction is essential if maximum gain is to be obtained in the complete amplifier. The high-frequency current would have a much longer path to travel and as a consequence inter-stage coupling would occur if the by-pass condenser and radio-frequency choke were located outside the can. This arrangement is shown in Fig. 4. The path for r.f. current is then from the plate of the amplifier tube through a very short lead into the primary of the transformer. From the primary the current flows through the by-pass condenser directly to the cathode of the tube. From the secondary the radio-frequency current goes to the stator plate of the tuning condenser through a lead about one-half inch long.

As a whole, the question of radio-frequency amplification with the screen-grid tube resolves itself into obtaining a large amount of gain per stage and isolating the stages with the least possible loss. All the questions confronting the design engineer have not been answered, but at least some of the outstanding facts have been discussed and a small amount of working data has been given.

The Movies Come to Life

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the most reliable means of securing this result accurately.

Duping and Dubbing

Where this has not been accomplished in the original recording, re-recording may be resorted to. However, re-recording is not confined to this function; its potentialities are much wider. The development of equipment and technique for re-recording is perhaps the most important technical problem of the sound motion picture industry today. The process consists of taking a record, placing it in a reproducing machine, but, instead of reproducing in the form of sound, using the output energy to make a second record. Other names for this procedure are "duping" (film origin, from "duplicate") and "dubbing" (phonograph recording origin, from "doubling"). The term "duping" used in this connection is a misnomer. During the re-recording, levels and frequency characteristics may be changed and, subject to physical limitations of the original record or the equipment, improved. Various tracks may be mixed, sound effects or music added, etc. In film recording, where the various sound "takes" may be spliced together in the proper sequence, dubbing is largely a medium of improvement; in disc recording it is a basic procedure, since the different scenes, taken at different times and in different lengths on individual waxes, must be assembled on standard release discs. In either case, the control of noise, design of networks for improvement of quality, and the adjustment of levels are paramount factors.

The great economic advantage of re-recording is that changes may be made at moderate cost and under relatively leisurely conditions. Exact adjustment of levels on the stage, with a cast and crew of hundreds of people standing by and the overhead piling up at the rate of thousands of dollars an hour, is one thing; and a consultation between the director and two sound men in a re-recording room, with opportunity to review the film as often as desired, and only at the cost of raw stock, processing, and the time of a few men, are vastly different things. Sometimes a poor record may be made into a fair one, obviating a re-take, and much oftener a fair record may be converted into a good one. Improvements in this field are being effected rapidly, and alert sound movie technicians will do well to keep in close touch with what is being done.

If space permitted, many additional developments, such as progress in acoustic design of stages and sets, could be discussed to advantage, but the above outline describes the main trends. To realize how rapidly the field is improving one has only to listen to a sound picture six or eight months old and compare it with a current production of one of the large studios. Even when there is little difference in basic qualities, such as clarity of dialogue and freedom from gross acoustic defects, the contrast is startling and gratifying. I heard a production recently which, while well recorded by early 1928 standards, was so far inferior to the best or even average 1929-1930 output that one could hardly take it seriously from a dramatic standpoint. The dialogue was crisp and intelligible—often too good, in fact; it ran along on a steady level of high modulation and clarity, like a schoolboy reciting poetry. Music heard in a room and then through a closed door showed no change in characteristics; speech along corridors, from a distance, through partitions, and in different sorts of rooms sounded exactly the same. It was all excellent and totally ineffective recording, and one was always conscious of the microphone above the people's heads. The use of sound perspective, the utilization of natural distortion while retaining intelligibility, the appropriate setting of volume levels, were all absent. In no other way than by listening to a number of such productions can one realize that the movie industry, true to its traditions, is "on the go" in sound as much as it ever was in the silent era of the past.

More Men for Radio

(*Continued from page* 707)

orders, as well as a large proportion of their original sales, depend upon the serviceman.

In the stress of competition manufacturers have claimed all sorts of things for their receivers. Having sold the set on the basis of these claims, the manufacturer must see to it that it delivers the goods, that it lives up to its claims, not only for the first month, but for as long as the owner desires to keep his receiver. Only in this way can the manufacturer assure himself of repeat sales in addition to growing good will that may be built up, and the possibility of additional sales by friends of the set owner.

And so the manufacturer is frantically seeking trained radio men—men who will be able to keep his sets working in the field. Of course, it is his own fault that he has to look so frantically. He neglected the servicemen when he thought that he could do without them. Now that the manufacturer sees that he is dependent upon his men in the field, he wants them, and wants them badly.

The manufacturer has built up a huge plant on the basis of his past prosperity. Now he must keep that plant going even though most of the potential purchasers have been sold, developments have slowed, and sales must be more of the repeat variety. As the populace gets to know more about radio, it demands more. No longer can the manicured salesman do the whole trick himself. The serviceman and the salesman, well versed in radio, must help.

All this and more the manufacturer is learning. For which reasons he is looking so frantically for trained radio men. And all the time complaining that they do not exist.

Those foreseeing men who train themselves will reap a rich harvest, for on their shoulders will rest, to a large extent, the prosperity of this great industry. The manufacturers know it. The trained radio man, therefore, can demand high prices for his services.

To be more specific, Mr. F. J. Kahn, chief field engineer of the Kolster Radio Corporation, in a statement on the subject, says: "We, like every other radio manufacturer, are constantly in need of trained radio men, particularly in our field organization. . . . We place them at various centers throughout the country, and it is their responsibility to keep their territories as free from trouble as possible." Speaking of the difficulty of finding trained men, Mr. Kahn says: "It took us nearly three weeks to obtain a man whom we wanted, most sources of supply netting us only truck drivers, would-be radio experts, or what have you, all claiming to be trained radio servicemen. During the radio shows recently held at New York and Chicago, several meetings of the Service Section of the Radio Manufacturers' Association were held, at each of which the problems of trained personnel were presented. Fortunately, the level of the men in the service work has been raised in that the responsibility of efficient service is now being recognized by the radio industry in general."

Kolster pays $175 a month plus living expenses. Surely this is an inducement for good men. And salaries are readily increased in accordance with the efficiency of the men. Kolster is constantly cooperating with the various trade schools and service organizations, realizing that dealers throughout the country are fast recognizing the need for competent servicemen, proper installations, and demonstrations provocative of sales.

Williams Ostrove of the Radio Receptor Company, writing on the subject of servicemen, says, in part: "I believe that a man who has a good knowledge of radio sets, especially servicing, will prove a valuable aid in all sorts of test work. It is my opinion that radio set servicing tends to develop a man in thinking clearly and logically, and gives him an excellent conception of the theory and mechanics of radio."

And there are many other concerns that hold similar views. Mr. Deeley of the Buckingham Radio Corporation thinks that a serious need exists for efficiently trained laboratory men, inspectors, testers, service and repair men. This company employs from sixty to a hundred such men, being paid between $40 and $100 per week. The claims of the radio schools, institutes and correspondence courses as to the need for such men and the high salaries they command are not in the least exaggerated. They are more than substantiated by the experience and statements of the leading radio concerns.

As to the supply from which to meet this demand, the president of a large middle-western instrument company says that not over 25 per cent. of the men engaged in radio servicing are competent, and the average qualification of this 25 per cent. is low. Of the remaining 75 per cent., many, in his opinion, lack the natural intelligence and common education necessary to master the technical problems of the work. Some of this 75 per cent. could, with better education and training, be developed into really compe-

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On With the Dance

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the output stage employs two 350 tubes in push-pull. The power supply for plate and filament is built into the amplifier. It employs two 381 tubes and operates off the 110-volt a.c. line. The amplifier is rated at 15 watts undistorted output, and a gain of 85 TU.

The power amplifier output is fed to the loud speakers through the switch panel indicated as F in Figs. 3, 5 and 6. This switch panel permits any or all of the speakers to be turned on or off from the amplifier, and also carries the main power supply switch, controlling the 110-volt supply, to the two amplifiers. A pilot light is mounted with this switch to provide visual indication when the power switch is "on."

Several Types of Speaker Used

The speaker equipment is quite varied, to meet the varying requirements of the different rooms. A single Amplion exponential horn, with 108-inch air column, and equipped with a dynamic unit, is employed in the main ballroom to provide reproduction at the end not satisfactorily reached by the unaided orchestra. This type is advantageously used in this location because it directs the sound toward the "dead" area, and also away from the microphone, preventing microphonic trouble. This speaker is shown at G in Fig. 1.

A portion of the fourth floor hall is shown in Fig. 2, with the two speakers, I and J. These speakers are Amplion dynamics, each equipped with a horn-type baffle, which serves both as baffle and as a projector of sound. The speakers are so mounted that each covers approximately one-half of the floor area, but without conflict or trouble with phase relations.

The second floor is small and, being used for instruction, it is neither crowded nor noisy. The low noise level and small area permit the use of an Amplion magnetic speaker, with which ample coverage is obtained.

To take further advantage of the amplifier system the management has had another Amplion dynamic speaker installed in the vestibule of the building, for publicity purposes, on the theory that passers-by will be kept "dance conscious." The public will often overlook signs, even of the illuminated variety, but is always conscious of audible advertising. When the music is of the type that starts feet a-tingling, it is a logical assumption that it will attract the public to the dance floors.

It was stated above that the voice energy to the speakers was controlled from the switch panel, F, in the amplifier rack. But the dynamic speakers presented a problem because of the necessity of turning the field supply off and on for the individual speakers. It hardly seemed worth while to wire the four dynamic fields from a central switch bank located at the amplifier, because of the extent of such a wiring system. But investigation disclosed that the lighting system for the fourth floor was controlled from a wall type switch panel on the main, or third floor. Furthermore, one of the switches in this panel controlled outlets on the

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A High Quality Audio Channel

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one and one-half to one and the push-pull input has a ratio of two to one. To obviate any possible distortion in the first stage a.f. amplifier tube, it is operated at the maximum plate voltage of 180, with a suitable grid bias maintained by the voltage drop caused by the flow of its plate current through a 2,000-ohm biasing resistor.

The two 245 type power tubes used in the output stage are connected in push-pull. This last or output stage provides a reserve of power sufficient to supply almost any degree of volume desired, and in addition insures full, rounded tone even at low volume levels. Two different output transformers are available, depending on the operating conditions to be met. One of these transformers, AF-M, is designed to match the output impedance of the 245 tubes to the ordinary magnetic type loud speaker, also to dynamic speakers with built-in input transformers. The other, AF-D, is designed to match the tube impedance directly to the moving coil of a dynamic speaker having an input impedance of the order of ten ohms.

Special Features Identified with Power Unit

The power supply apparatus, consisting of the power transformer, filter chokes, filter condenser and voltage divider were designed especially for the Hi-Q 30. The power transformer and two filter chokes are housed in a steel compound-filled case. The power transformer has a 110-volt primary tapped at 80 volts. This tap permits the use of a regulator tube to control the line voltage fluctuations met with in most localities. The several secondaries are designed to furnish the exact voltages required for this particular receiver. While the 245 filaments are rated at 2½ volts, the same as the 224 and 227 tubes, a separate 2½-volt secondary is provided for them in order to obviate any possibility of coupling between the output and input circuits of the receiver. The first filter choke is a heavy duty affair designed to pass the entire output of the rectifier tube, which is of the full-wave (280) type. Under operating conditions the current through this choke is 100 milliamperes. At the output end of this choke the current divides; 60 mils going directly to the plate of the 245 power tubes and 40 mils flowing through the second filter choke to the voltage divider. This second filter choke has a higher inductance than the first and consequently greater filtering efficiency. Taking off the plate supply for the power tubes at the end of the first choke results in a further isolation of the output circuit from the remainder of the receiver. The current through the voltage divider has been made high to secure better regulation on the lower plate voltages under operating conditions, since a variation in the setting of the volume control causes a variation in the plate current drawn by the screen-grid amplifier tubes. The lower section of the voltage divider (850 ohms) carries the plate current of the two power tubes back to the negative of the "B" supply; thus automatically furnishing the grid bias for those tubes.

The filter condensers and voltage tap by-pass condensers, 12 microfarads in all, are housed in a single case for convenience in mounting and wiring. A large safety factor has been allowed in the specifications of these condensers to insure against breakdown. The three main filter sections, 2, 4 and 2 mfds. are conservatively rated for continuous operation at d.c. voltages of 600, 500, and 400, respectively. The 1 mfd. section across the 180-volt tap is rated at 400 volts and the 90-volt by-pass section at 300 volts. The two remaining 1 mfd. sections are connected as by-passes across the 50-volt detector tap and the power tube grid biasing resistor which are both rated at 200 volts.

Although the foregoing description covers the completely a.c. operated model including the audio amplifying system, the receiver can be used as a tuner only in conjunction with any high grade power amplifier which may be available. A battery-operated model has also been designed, the characteristics of which do not differ greatly from those of the a.c. model.

Assembly Details

In assembling and wiring together the various units of the Hi-Q it is well to adopt a definite procedure—one that will aid in the systematic building up of the receiver into a complete whole without the necessity for backtracking on one's work to correct an error which may have been made. This is amply covered in the instructions which accompany each kit.

Unlike other kit jobs, this receiver is mainly composed of several units rather than a collection of separate parts. The units, comprising a three-circuit preselector, a three-stage r.f. amplifier and a power supply unit, are internally wired at the factory and need only to be set in place on the chassis, their leads protruding through to the under side of the metal base.

Sockets, audio transformers, line receptacles and the like are separately mounted and fastened on the base in accordance with the very complete instructions contained with each kit.

Wiring is merely a matter of connecting the terminals of one unit to another, *underneath the chassis*. Only a few wires are actually visible from the top of the set. These are the several leads which come up through the base and attach to the terminals of the voltage divider resistor and the three shielded leads which attach to the caps of the screen-grid tubes. A majority of the wires underneath the chassis, especially those which start at or connect with the power supply unit are twisted so as to minimize the possibility of the production of hum.

Every connection is soldered and in this respect it is well to make sure that the soldering iron is kept clean and free from the dirt deposit which so rapidly forms on the iron's tip after it is in use for a while. The soldered joint should be clean and firm.

On With the Dance

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fourth floor which were wired but not in use. It was therefore necessary only to plug the dynamic field supply cords into these wall outlets, to control them from this main lighting panel. This panel, shown at H, Fig. 1, was almost directly under the exponential speaker on the main floor, so control of the field supply in this case offered no problem.

The magnetic speaker on the second floor, of course, required no field supply and the dynamic speaker in the vestibule was provided with a local switch. Inasmuch as this speaker is kept in operation constantly while the hall is open for business, it is necessary only to turn its field supply off when closing for the night. To make sure that it is not overlooked, however, it is equipped with a pilot light. The two dynamic speakers on the fourth floor are also equipped with pilot lights and with pendant switches to control the field supply current. Thus they can be individually controlled from the fourth floor when desirable, as when this space is being used for private parties.

Speakers Individually Equipped with Volume Controls

The amplifiers employed in this installation include volume controls, by means of which the general output level can be regulated as desired. But obviously this general control alone would not provide the flexibility required in adapting the volume to the varying conditions in the different rooms. For instance, the speaker in the vestibule could use maximum volume at all times, and decreased volume would reduce its effectiveness as a publicity medium. But on the other hand, if the speakers on the dance floors were operated at full volume at all times, the volume of sound with only a few dancers in the rooms would be uncomfortable.

For these reasons the speakers are equipped with individual volume controls, except the two on the fourth floor, which are jointly regulated through a single control unit. This arrangement is admirably suited to conditions at the school, because the person in charge of each hall can regulate the intensity of reproduction to fit the conditions. As the number of dancers increases throughout the evening, the volume control can be turned up accordingly—or during announcement of exhibition dances the volume can be turned down.

The volume controls employed consist simply of 50,-000-ohm potentiometers connected across the line with one side of the speaker connected to one side of the line and the other side of the speaker to the center arm. In some installations this type of volume control would not be suitable, since extensive variation of the volume at one speaker would affect the others. But in this instance, with plenty of power available, and the need for relatively small adjustments of volume, this trouble has not been encountered.

It so happens that this building is equipped with both a.c. and d.c. supply. The d.c. supply is, therefore, used for

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A Compact Five-Tube Auto-Radio Receiver

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embodied in a receiver of this type, in order to insure satisfactory reception under such adverse conditions.

It was found, during the course of our experimental work, that a receiver employing two stages of screen-grid r.f. amplification producing from 50 to 60 per stage together with a screen-grid detector and two stages of resistance-coupled audio-frequency amplification would produce the requisite sensitivity for satisfactory reception in practically all urban localities, using an antenna as prescribed above.

Novel Primary Winding in R.F. Coils Provides High Sensitivity

High sensitivity in a radio-frequency amplifier was attained by a method of primary winding which, while not believed to be new, has apparently never found extensive employment in broadcast receivers. This method of winding consists in serving over a standard secondary winding of the S-M 122 type primary turns, equal in number to the secondary, of No. 38 double cotton-covered wire, each turn being laid in the valley formed by the two underlying secondary turns. Considerable criticism has been made of radio-frequency transformers having high primary-to-secondary capacity, but from all our tests we may conclude that with a winding of this type, this capacity is of no great moment. This is due to the fact that while this capacity exists there also exists unity coupling between the primary and secondary coils; also due to the fact that any turn of the primary winding has substantially the same potential as the adjacent secondary turn. Hence, while the capacity exists, there being no voltage across it, no current flows through the capacity and, hence, there are no deleterious effects due to its existence. These coils make possible the high gain per stage produced by the S-M auto receiver in the broadcast band and coils of similar design for other frequencies also make possible substantial gains at frequencies higher than the broadcast band, so that special order receivers may be produced for police car and similar uses.

The gain produced by three coils of this type are shown in Fig. 1. It is not to be implied from the above that this receiver design utilizes plug-in coils, but these curves are merely presented to show what can be done in the design of a receiver of the same mechanical type in other frequency ranges than the broadcast band. The real advantage of these coils is that by their use amplifications may be obtained as great as can be with the tuned plate choke system, without the attendant mechanical and electrical difficulties of a condenser and leak in each stage.

A.C. Tubes in a D.C. Circuit

Considerable thought has been given to the power supply for the auto receiver. The use of the 222 tube under circumstances where the vibration and jolting are as great as in an auto receiver has brought such adverse comment that it seemed out of the question to utilize this type. On the other hand, the 224 type is of much more rugged construction and is much less microphonic as a detector, and to be preferred. It is very desirable that an auto receiver should operate from the 6-volt battery already installed in the car to save additional expense and the trouble of charging an extra storage battery. Providing the drain can be kept sufficiently low, the charging rate of the generator can then be set up slightly to compensate for the additional drain of the radio receiver. Measurements on the potential of the auto battery made on several cars indicated that the voltage between the ammeter terminal and the chassis had a minimum of 6 to 6.2 volts, rising to 7.5 volts when charging at the maximum rate. These figures indicated the feasibility of operating the heaters of three 224 type tubes in series, under which conditions they would have slightly over 2 volts across the heater terminals at the lowerest voltage in the driving range and 2.5 volts (normal rating) at the highest charging rate. The effect of the lowered heater voltage was carefully studied in the laboratory and it was found that with 2 volts heater potential, the mutual conductance was not seriously altered and the heating time extended from thirty seconds to one minute. This would not appear to be a serious disadvantage; hence, the series connection of the three tubes was adopted, as will be seen in the circuit diagram of Fig. 2.

It will be seen, also, in the circuit diagram that the grid bias for the r.f. stages is taken as the drop across one of the heaters. This connection provides a very nice compensation for changes in the voltage for, inasmuch as when the heater voltage increases, thereby tending to increase the mutual conductance of the tubes, the grid bias is also increased, tending to reduce the mutual conductance.

In spite of the thermal inertia of the heaters in responding to these voltage changes, there seems to be a sufficient compensation in this way so that no change in the volume appreciable to the ear occurs at any driving or charging rate from the generator.

It will also be noted in Fig. 2 that fuses have been provided in the battery circuits to protect the battery and charging equipment in the event of a short-circuit developing in the radio receiver. These fuses are conveniently accessible under the small fuse cap on the front panel of the receiver, as seen in Fig. 3.

Grounding Precautions Necessary

It was necessary to make some deviation from the customary practice of grounding various parts of the circuit to the metal chassis of the receiver, for the reason that in some cars the positive side of the battery connects to the chassis while in other cars the negative terminal does. In view of this, no choice may be made as to which side of the auto receiver supply circuit should be connected to the chassis, in view of the fact that the receiver proper will usually be mounted where it will be in contact or in

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danger of contact with some of the metal parts of the car. For this reason, a separate circuit ground is used internally to the receiver and the complete electrical equipment grounded to the receiver chassis through a fixed condenser. In this way the receiver may be installed on the metal dash plate or any other likely part of the car, thus providing ground connection for the receiver without damage to the electrical equipment, irrespective of which terminal of the starting battery may be grounded already.

For similar reasons it is necessary to insulate the speaker completely from the "B" battery supply. This precludes the possibility of operating the speaker directly in the plate circuit of the power output tube, or of using a condenser and choke. Hence, a 1:1 ratio output transformer is provided for operation into a magnetic speaker which reduces the problem of insulation of the speaker leads to a negligible one.

Weight Not a Serious Consideration

No special consideration has been given to the weight of the model shown, which is made of pressed steel parts throughout. Anticipating, however, that special use may arise for such a receiver where weight would be of paramount importance, the parts have been so designed that sufficient rigidity and mechanical strength would result if they were duplicated in aluminum. Also, in order to facilitate such a change, resistance coupling has been used in the audio end rather than transformer coupling which would add considerably to the bulk as well as the mass of the receiver. It is contemplated that receivers of this type will be operated almost entirely by the remote control system with flexible shaft and for that reason may be substantially mounted on some rigid portion of the car so that the weight of the receiver in itself is no great consideration so long as it is kept within reason.

In order that servicing costs shall be kept at the utmost minimum, it is highly important that the receiver be as dust-proof as it is possible to make it. This is particularly true when using it while summer driving, with windows open and the entire interior of the car open to road dust and the like. In order to carry out this idea, the mechanical assembly is made of two shallow steel pans, one of which is the front and one the back. Along the corners of each of these pans is placed a quarter-inch strip of waterproofed felt. When the receiver is assembled, the walls of the cabinet (made in one piece) engage against this felt and are drawn tightly by four tie-bolts which go entirely through the receiver. A similar felt washer is placed around the shaft of the variable condenser to prevent entrance of foreign particles at this point.

The rear view, Fig. 4, shows the manner in which the cushion sockets are mounted on a rigid sub-panel to which all other light parts such as radio-frequency

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More Men for Radio

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tent men, but are unwilling to apply themselves as closely as the acquirement of such education demands. A small proportion are striving earnestly to improve themselves, have the intelligence, and are making excellent progress. It is the opinion of the same person that even if all the men engaged in radio servicing were competent, the supply would still be inadequate. He says, "The future sales of radio depend on the degree of pleasure derived by present owners from their sets. Sets kept in continuous efficient operation means 100 per cent. enthusiastic satisfaction. Such sets develop new business, while the set that is not so maintained is an obstacle in the path of new sales. If the radio industry is to make the most of its opportunities, more and higher types of servicemen must be available."

In case the reader is still in doubt as to the real and urgent need for trained radio men, there follows the opinion of one of the highest authorities in the radio world, David Sarnoff, executive vice-president and general manager of the Radio Corporation of America:

"The problem of providing the necessary trained personnel is an outstanding one in radio today. The future is dependent upon trained radio men who will be capable of carrying on the great work of the radio art and industry.

"The personnel problem has been more emphasized because the technique of radio has overflowed the confines of communication. The revived phonograph industry, sound reproducing installations, sound motion pictures, and photo-electric cell applications in industrial processes, are but a few instances of the use of radio technique outside its original boundaries. Never before has there been such a demand for men versed in the principles and practices of the radio technique.

"Through the R. C. A. Institutes, Inc., the Radio Corporation of America is endeavoring to contribute its share towards the training of the necessary personnel for present and future needs."

Mr. Sarnoff mentions the communication activities and also the phonograph industry and other associated fields. Earlier in this article, we pointed out that radio has branched out into other fields. This is what we meant: The talkies depend on radio-trained men to install, operate, and service both the theatre installations and the studio recording equipment. Halls and auditoriums throughout the country are being equipped with sound amplifiers, all based on radio technique. Television may soon be in our midst as an infant industry. The use of photoradiograms is spreading, with newspapers, business houses, governments and banks using this fast and fool-proof method of transferring signatures, photographs and type matter. Surely, the field is wide.

And still we have not touched upon the need for trained men at the broadcasting and radio communication ends. Mr. J. E. Smith, president of the National Radio Institute, says, in a statement on the subject: "I cannot recall a time when the shortage of trained men for the operation and maintenance of transmitters has been so grave. I believe that before long the radio industry will support twice the number of operators now in existence.

"At present there are no more than 7,000 licensed commercial radio operators in the country. There are over 600 broadcasting stations, each required by law to have at least one commercial operator. The majority use several operators, and the larger stations dozens.

"The Universal Wireless Communication Company is carrying out a program involving the building and operation of more than 200 commercial land stations, each requiring many operators. Aviation is also imposing its demand upon the ranks of licensed commercial operators.

"And finally, the Safety at Sea League, at its recent convention, ruled to double the number of operators required at sea. With all these fields bidding for the services of the trained radio man, the 7,000 present licensed operators will fall far short of being able to handle the situation."

Our attention is called to the growing demands of world-wide radio service by Mr. W. A. Winterbottom of R. C. A. Communications. What with radio circuits spreading out to all parts of the world, together with the need for extensive inter-city short-wave circuits in our country to serve as feeders for our world-wide radio circuits, there is certain to be a shortage of skilled radio operators and technicians unless every possible training facility is employed from now on.

The man, standing in the hall of life wondering which door to open, will do well to turn to that marked "radio," for it leads to many rooms, containing the most fascinating display of knowledge, experience, wealth and opportunity, and is inhabited by the most interesting personalities, scientists, business men and artists. The rooms are not crowded, the air is fine, and there is plenty of room to move about. But the door will not open by itself. Nor would the young man or anyone desiring to enter the room marked "Radio" be pleased were the door so easily opened. He must first fetch the keys—education, experience, radio training, natural inclination, intelligence. With these he may open the multiple locks of the door and be welcomed with open arms by those already within.

THE attention of servicemen is directed to the application blank appearing on page 770 of this issue. When filled out and sent to the Serviceman's Department of RADIO NEWS, it will be filed for the information of manufacturers who call upon us for additional man-power in the service field.

THE EDITORS.

Radio Links the Americas

(*Continued from page 713*)

Byrd, with Balchen, June and McKinley, was on his way over an undiscovered country above which no airplane had ever flown. The night sped by and it was not long before the fading signals testified that dawn was at hand with the rising sun to sap the strength from the Hertzian waves. The signals waxed and waned, finally disappearing. And so a mysterious curtain was drawn on the drama being enacted on the Antarctic stage, with Nature dropping the curtain in true theatrical fashion just at the dramatic moment.

Afternoon papers carried big black headlines that no word had been heard from the plane for ten hours. The radio men were aware that sunlight and not disaster was responsible for the silence. They stood by until about 4 P. M., when their fingers again slowly turned the dials. It would soon be dark and the signals ought to come back. Slowly the great curtain in space began to rise. Faint were the dots and dashes from Little America, but they were gaining in strength every minute as twilight in New York blended into the night. At 5 o'clock it was dark, and the operators wearing the headphones were busy deciphering the code. Byrd and his men successfully had encircled the Pole and were safely on their way back to camp.

Concerts in Japan Prisons

Prisons in Japan are to be equipped with radio. Concerts will be tuned in occasionally, but the convicts will be especially directed to listen to educational programs.

A Compact Five-Tube Auto-Radio Receiver

(*Continued from page 759*)

chokes and coupling resistors are mounted. In our earlier models we employed solid sockets mounted on a cushioned sub-panel, but with this arrangement it was found that after all the necessary leads had been attached and the sub-panel properly anchored against creepage in the sponge rubber mounting blocks, that the tubes were actually not afforded as adequate protection as resulted with the separate cushion sockets in a solid assembly. It is also felt that the use of the latter is much more adaptable to assembly by the novice.

Other features of auto receiver operation, such as those resulting from ignition noises, etc., have been so well treated in the present and previous issues of RADIO NEWS that it seems unnecessary to repeat them here. It was found with the above receiver operating in a Chrysler car that neither ignition noises nor generator noises were particularly objectionable, except when operating at extremely high speeds. Under these circumstances, resistance suppressors in the spark-plug leads do away with ignition noises to a point where perfectly satisfactory reception from stations as far as Milwaukee could be had when operating on downtown areas of Chicago streets.

The Amplifier Steps Out

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about 1 microfarad, a low-voltage condenser being altogether satisfactory.

For hum elimination by bucking, the potentiometer P of about 400 ohms is inserted in arm R1 far enough from the negative leg of the filter to leave a full 45 volts for the screen-grid connection as shown. The potentiometer contact arm is connected to the cathode of Tube VT1 through a condenser Chb of some value below 1/10 microfarad, selection of the value of this condenser being such that the hum minimum is had with an approximate mid-point setting of potentiometer P.

We have planned Fig. 1 to operate with 180 volts on the plate of VT1 and a like difference of potential across Rc to have what we term "symmetrical operation," which is nothing more or less than matching internal and external output impedances. Operation with much smaller potential will be pointed out in later articles. Since we have provided for only 250 volts total in arm R1, 110 volts more is needed to come up to the required double of 180 volts, or 360 volts. combined plate potential for VT1 and drop in Rc. This we acquire by inserting high resistances R5 and R6 (100,000 and 300,000 ohms respectively, for example, the matter not being a critical one) and connecting Rc to the junction point between them as indicated, thus adding the 100 or more volts of R5 to the 250 volts of R1.

Since the 250 tube VT2 does not need as an operating grid bias the full 180 volts across Rc, the opposing 110 volts or more of R5 nicely cuts this potential down to a desirable 70 volts, thus meeting 250 tube operating requirements. It is to be noted that the total of 400,000 ohms of R5 + R6 prevents increase of current drain on the filter beyond 1 milliampere.

In the beginning of the present article we referred to an effect we term "drift" in cascaded direct-coupled systems, and pointed out many sources of the tendency. In our article in the March, 1928, Proceedings of the Institute of Radio Engineers, the effect was discussed in detail. While we have devised a number of arrangements effective for drift prevention, which will be described in future articles, the drift-preventer of Fig. 1 is decidedly effective and most interesting. It functions as follows:

Circuit Is Self-Regulating

The combined plate current and screen grid current flow from VT1 through R3 develops a negative potential available for the grid of VT1, and with R3 about 25,000 ohms as previously given this potential may be about 25 volts. This is too much initial bias, and is accordingly reduced to an initial approximate 2 volts by connecting the grid-return to a point about 23 volts positive on R1 as shown in Fig. 1. If all constants and potentials of the system have been carefully selected as previously set forth, this initial bias will now establish the plate current of VT2, and therefore the current through arm R1, at about the 50 milliamperes that indicates operation at the midpoint of VT2's output current curve.

Now considering, for example, the worst encounterable cause for tendency to drift, that is, the impressing of a strong carrier current on the input of VT1, the result is a rectifying action tending to increase the plate screen-grid current of VT1. This increase of current tends to increase the potential across Rc, and therefore the negative bias on VT2, resulting in a tendency to lower the output current of VT2 and consequently the current in arm R1, the tendency lasting so long as the carrier is impressed. For correction opposing this drift tendency, however, we have the increase of combined plate and screen-grid current through R3 tending to increase the negative potential developed in R3 and, at the same time, the tendency for lower current in R1 to lessen the positive potential of the point in R1 to which the grid of VT1 is connected. That is, the correcting change of grid bias on VT1 is developed differentially, and at a greater rate than the change of current through R3 alone, so that drift cannot proceed very far before being arrested with a round turn, so to speak.

Summarizing this effect, it is seen that the correction system provides for starting with an initial low bias most sensitive for weak signals and automatically converts itself into a varying degree power handler as called upon to do so through increase of strength of incoming carrier.

It is obvious that a drift corrector so effective for carrier current is more than adequate for correction of the milder drift tendencies arising from changes in line voltage and manufacturing tolerances in tubes and resistors, previously mentioned.

How to Use the Circuit

To use the system of Fig. 1 the indicated input IP may be either a tunable circuit coupled to an antenna or the output of a radio-frequency amplifier, or may be an audio-frequency device, such as a phonograph pick-up including a volume control. The phonograph pick-up should be insered directly in the input circuit, and not through a step-up transformer.

We lay particular stress upon the fact that the system imposes negligible load on a tunable input circuit, so that damping is extremely low compared to other detector systems, and selectivity high. For this reason we also caution that if a neutralized radio-frequency system is placed in advance of the system of Fig. 1 it may be found not adequately stable under the light load if originally stabilized for operation with a heavier loading detector system.

System's Effectiveness Graphically Shown

The two graphs of Fig. 2 give some idea of the effectiveness of a simple 2-tube system such as that detailed in connection with Fig. 1. The logarithmic abscissae and linea ordinates show the measured and plotted voltage gain throughout the entire audio range, the upper graph being for a ¼ megohm value of Rc as specified for Fig. 1, and the lower graph being for a reduction of Rc to 1/10 megohm along with other modifications which will not be taken up at the present time.

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The Amplifier Steps Out

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The skeleton diagram superimposed on Fig. 2 shows and states the details of the output system employed in measuring for these graphs.

The 1/10 megohm graph shows the substantial gain of 208 uniform from 140 cycles to 5 kilocycles with a loss of but 10% of the low point of 50 cycles and a loss of but 6% at the extreme range of 10 kilocycles. These end droops can in large part be accounted for in the frequency-reactance relations of the output circuit, substantiating the theoretical constancy of the direct-coupled amplifier *per se.*

The ¼ megohm graph shows the much greater gain of 360 (80% increase) substantially uniform from 140 cycles to 3 kilocycles, but an increase of loss to 16% at the 10-kilocycle point. This increase of loss is, in part, due to an increase of feed-back effect through the internal capacity of VT2 with increase of value of coupling resistance Rc. We cure this effect by simple feed-back neutralization as indicated by the dotted portion of the graph, so that the high gain continues much beyond the audio range, but this feature will be left for later treatment.

The desirable features of direct-coupled systems are also useful elsewhere. The drift-corrector and automatic bias arrangement of Fig. 1 has characteristics that fit nicely into the present practice of so-called power detection to aid in adapting the detector to sensitive handling of weak signals and powerfully handling strong signals. How this may be done is shown in Fig. 3, and the results may be quickly verified by anyone having the apparatus at hand.

Capable of Handling Weak or Strong Signals

In Fig. 3 D may be a detector tube of any type, a -27 for example, having a tunable input circuit and an output circuit coupled to a power amplifier VT2, a -50 for example, or any push-pull arrangement, through a transformer AT. R3 is a high resistance through which the plate current of detector D flows, thereby developing a potential which will materially change with rectification of impressed carrier currents. R1 is a resistance through which the plate current of the output tube VT2, or push-pull tubes, flows to develop the high bias potential required for the output tube, for example, 70 volts for a -50 tube.

Obviously, return of the grid circuit of D to a selected point in R1 provides a positive potential for opposing the negative potential developed in R3, and the difference gives any desired initial bias on the grid of D. The values involved in creating the difference are extremely large, so that special effects can be obtained.

To appreciate the effects that may be obtained, assume that the unaffected plate current of D and the resistance R3 are made such that the negative potential across R3 is initially 72 volts, and this is opposed by the full positive 70 volts derived from the grid bias of the output tube, there is had an initial 2 volts for

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The Amplifier Steps Out

(*Continued from page* 764)

sensitive detection of very weak signals. Now should a strong signal be impressed to change the plate current of detector D by 25%, for example, the 72 volts original increases by 18 volts to 90 volts, and being opposed by the same 70 volts as before, the bias now becomes 20 volts, plenty to handle powerfully, very strong signals encountered in practice. It is seen that should R3 be used alone, there is no way to make it cover any such range of change of grid bias potential. In usual practice the bias is made initially high to handle powerfully strong signals, so that weak signals suffer and accordingly fail to come through.

More Light on Short-Wave Transmission

(*Continued from page* 737)

less in the transmitters and receivers of which we know much, than in the actual transmission of which we know relatively little. The problem goes back to known physics, and forward to the unknown changes rung in the altitude of the northern lights by the distant yet all-powerful sun. Where will it end?

Partial Bibliography

The writer wishes to express his indebtedness for many ideas developed in this article to the following books and papers, and also to list them for the convenience of readers who may be interested:

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Circuit and Constructional Details on the Automatic Volume Control

(*Continued from page 725*)

gives the total value of resistance to be used, in thousands of ohms, and E′ min. shows the low value to which the r.f. plate voltage is reduced by the automatic control when the grid bias of the control tube goes to zero.

It will be seen that for good control I max. must be kept low. This can be done by using plenty of grid bias on the r.f. tube under control. Selectivity will thereby be increased, and any tendency toward oscillation will be taken care of by the automatic control itself when properly adjusted. If the potential to be controlled is that of a screen grid tube, the full advantages of a small current will be realized. In this case it should be the screen grid and not the plate which is controlled. Exactly the same procedure as that given above will suffice to provide the proper 45 volts for the tube or tubes under control. Two low-range milliammeters or possibly B-eliminator voltmeters used as ammeters may be required for these special conditions.

A trial will determine whether any given receiver will permit the use of a resistor at R2 instead of a choke. In any case, R1 should not be unduly reduced if good automatic control is desired.

The values of E′ min. were obtained by a potentiometer method, so as not to disturb circuit conditions by drawing current. Curves were plotted, but these were so nearly alike as not to be worth reproducing in full. Moreover, they give no clue to the behavior of the controlled r.f. stage, which is the point of chief interest. Accordingly, only one typical plot is given, in Fig. 4.

In the experimental work summarized in Table II, the grid bias on the control tube was of course varied in uniform steps. In actual use, however, it is the speaker voltages which change this bias. Hence the plate-to-filament d.c. resistance of the control tube changes or oscillates about some mean value at an audio frequency, and but for the use of filter circuits the plate supply to the r.f. tube under control would do the same. In practice it is found that the time-constant of R1C is amply long enough to protect the source of high potential from these audio variations. For a resistance of 50,000 ohms and a condenser of 4 mfd. the time-constant is 0.2 second. If a 30 henry choke is used in the place of R2, the resonant frequency of the combination with a 4 mfd. condenser is 14 cycles per second. This is low enough to give no trouble.

The writer has not experimented with various sizes of bypass condenser in the automatic control, though it seems likely that a smaller one than 4 mfd. might be used under favorable conditions. From the viewpoint of terminating impedances, though these are extremely variable, their average values are such that a high-inductance choke and a smaller condenser would seem appropriate. If a resistance is used in the place of the choke, it may permit audio feedback unless the r.f. stage under control is properly bypassed.

With the receiver in operation, the action of the automatic control can be understood from the deflections of the two meters. When a loud signal comes in, the first meter will kick up, and the second down. The device is properly adjusted when the deflection of the first meter is doubled or trebled by a loud signal, and that of the second is reduced to zero or thereabouts.

As to the precise effect on the amplification of the controlled r.f. or i.f. stages, whether using conventional tubes or the screen-grid variety, it is not easy to present any useful information. The measurements involved are of considerable difficulty, and the theoretical methods not fully applicable to the usual broadcast receiver, with its imperfect shielding. It is of course true that the amplification of the ordinary stage depends upon the mutual conductance and a.c. plate resistance of the tube, which in turn depend on the plate current.

TABLE II

Minimum R.F. Plate Voltages Obtained When Grid of 171-A Control Tube Has Zero Bias

(Maximum R.F. Plate Voltage = 90)

E max.	250	250	250	250	180	180	180	180	130	130	130	130
I max.	3	2	1	0.5	3	2	1	0.5	3	2	1	0.5
$R_1 + R_2$	53	80	160	320	30	45	90	180	*13	*20	40	80
E′ min.	26	21	15	9	29	24	17	11	36	29	22	12

*Choke recommended in place of R2.

A Correction

INADVERTENTLY, certain errors appeared in the article "What Do You Know About Audio-Frequency Amplifiers?" published in the January issue of RADIO NEWS.

The last formula in the second column on page 664 should read = *Total Gain (Gain per stage)*^{n} where n is the number of stages. This formula should be used to calculate the number of stages required in the example at the end of page 664 and the example at the top of page 665.

Thus calculated, the number of stages required to get a total gain of 280 with a stage gain of 7 is 2.5, and in practice three stages would be used. In the following example on page 665 the correct answer is 2.7, assuming a stage gain of 15.

On With the Dance

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the field coils, eliminating the rectifier and power transformer ordinarily required for a.c. operation.

The diagrams, Fig. 5 and 6, show the complete wiring and connection layout. All of the wiring from amplifier to speaker, and from microphone to amplifier, is in the form of twisted pairs. The microphone circuit is without shielding of any kind. This is rather unusual inasmuch as the leads are approximately thirty feet long. But in this particular case the usual shielding proved unnecessary. All of the wiring from amplifier to speakers employs No. 18 rubber-cov- pair is enclosed in a flexible metallic ered wires, twisted in pairs, and each conduit (BX). The conduit is grounded and thus shields each pair of wires.

Amplifier systems hold many advantages for dance halls. Many present-day halls present difficulties of one kind or another that can be corrected by such an installation as that adopted by Mr. Remey. In some cases existing halls could use more space to accommodate over-flow crowds, but have been hesitant about expanding because of the necessity for hiring an additional orchestra. In other cases, particularly in the small halls and dance schools, an amplifier used in conjunction with a phonograph can be substituted for small, and oftentimes inferior, orchestras.

Among dance-hall and dancing-school owners, therefore, are many ripe prospects for amplifier installations and sales.

Book Review

Radio Law. By W. Jefferson Davis. Parker, Stone & Baird Co., Los Angeles. 364 pages. $5.00.

With the growth of the radio industry, there have simultaneously sprung into being great numbers of radio laws. The average man interested in radio knows some of these laws as they are, several more imperfectly, and most of them not at all. It is for him, then, that Mr. Davis' book is written.

Mr. Davis maintains that since radio has become a public concern, and not a private enterprise, the passage of public laws regarding it was necessary, and that the knowledge of these laws by all those interested in radio is a good thing. Consequently he has presented in *Radio Law* a clear, concise and comprehensive analysis of those laws which directly control the great institution of radio.

He begins with a discussion of the trend of radio, and its rapid progress, maintaining that "a system of law should keep pace with the economic development of the country." He comments particularly upon the famous radio act of 1927, with its amendments of 1928 and 1929. This leads to a discussion of state and municipal regulation of radio, radio copyright and patents, and the more important radio conferences that have taken place. His chapter on European progress in radio control is especially interesting.

This is a book to be read for its soundness of treatment, interesting point of view, its clearness of presentation, and its analysis of a subject which heretofore has hardly been completely clarified.

Visual Music

BY means of a new device, the projection osiso, it is now possible for vocal and instrumental artists to see the sound waves they produce dance across a screen, just as they dance invisibly through the air to the ears of audiences.

This device was developed by C. Anderson, engineer of the Westinghouse Electric and Manufacturing Company, Newark, N. J., in collaboration with William Braid White, acoustic engineer of the American Steel and Wire Company. The sound waves are caught by a microphone, which can be placed in any convenient location, and are conveyed electrically to an osiso, which consists essentially of the delicately suspended mirror that is oscillated in unison with the received sound waves. A beam of light, directed on this mirror, is reflected by it to a system of revolving mirrors, which, in turn, project it upon a screen where it can be viewed by any number of people.

When all is quiet around the microphone, a long white line is seen on the screen, but as soon as any kind of a sound reaches the sensitive electrical ear, the white line on the screen is agitated into waves, much as a clothesline is thrown into waves when its end is shaken. The form of these waves varies with the sounds producing them, and they range from gentle ripples, produced by low, pure tones, to the most intricate of patterns produced by loud complex chords and noises.

"Two practical investigations are now being carried on with the aid of the projection osiso," stated Mr. White, "and its possibilities seem almost endless.

"In the first place, we are using it to study the construction of pianos and other musical instruments in order to improve them. You need only watch the waves formed on the screen to notice that when I strike successive keys on this piano, though I strike each with approximately the same force, some notes produce distinctly larger waves than others. This means that those particular notes produce louder sounds than the rest due to some peculiarity in the construction. Your eye can see it, although, if you are not a musician, your ear may not detect the difference. Secondly, when I strike various notes and then hold the loud pedal down after each, you can readily see that the vibrations last longer in some cases than they do in others, which shows that the sounding board reverberates better at some points in the scale than at others. Such characteristics, together with others which only an expert would notice, are being investigated.

"Another application of this instrument," continued Mr. White, "is that of helping the student to improve his technique. The sound waves produced by the touch of a master pianist differ from those produced when the same keys are struck by an unskilled hand. Permanent records of the wave patterns produced by distinguished musicians have been made by means of the older photographic type of osiso, and, with these before him, the student can endeavor to reproduce them on the screen of the projection osiso. It seems certain that improvement can be attained in this way. (*Cont'd on page 773*)

Trapping the Hum

(*Continued from page 703*)

plate current is caused by periodic additions to or subtraction from the plate or grid voltages supplied externally. The voltage hum is in phase with the filament voltage. Its frequency may be equal to that of the filament voltage frequency, double that frequency, or a combination of the two, depending on the connection of the grid and plate circuits to the filament circuit.

The temperature effect is caused by periodic variation in the temperature of the filament, caused in turn by the periodic heating power supplied to it. It produces an increase in plate current with each increase of temperature. The heating currents are applied in pulses having a frequency double the frequency in cycles of the filament current, so the temperature hum also has this doubled frequency. The hum current lags behind the filament current because of the thermal inertia of the filament, the phase lag usually being about 90 degrees. However, this will vary with the thermal inertia of the filament.

The magnetic effect is caused by the magnetic field of the filament current. We have long known that a current-carrying conductor in a magnetic field will wave if either the strength of the field or the strength of the current in the conductor be changed. This is the principle of most of our electric power motors and of those vibratory motors which we know so well as electrodynamic speakers.

In the vacuum tube the electron stream is the current carrying conductor. The fact that the electrons shoot through empty space instead of along a conductor-guided path does not matter. The magnetic field is the variable field of the filament current. The reaction between the variable field of the filament current and the otherwise steady field of the electron stream is to cause the electron stream to change its position or direction. Since any change of direction of the electron stream from the straight line it might execute in going from filament to plate, will cause an increase in the path length. this causes an increase in the impedance of the tube, and a decrease in the plate current through the tube. Each time then there is a pulse of filament current, there is a decrease in the plate current. Since the filament current has two pulses per cycle—one negative and one positive in direction—the magnetic effect hum also is of the bicyclic type, double the filament current frequency. This hum is in phase with the filament current. If the filament current is in phase with its voltage, then the magnetic effect hum is 180 degrees out of phase with the voltage effect. If these two hum effects are made equal in amplitude, by design of the tube and by the manner in which it is operated, these two effects may be made to neutralize, if not completely, at least to a large degree, leaving the temperature effect as a cause of residual hum.

From a collection of several hundred I have selected four oscillograms to illustrate the three different types of hum in a raw a.c. filament tube. These oscillograms were made with a cathode ray

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Trapping the Hum

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tube, using a d.c. amplifier to simplify both the hum and the filament voltages.

Fig. 1 shows the hum and filament voltages of a –26 tube under an operating condition where the voltage effect is the predominant cause of hum. Note that the hum wave Eh1 is double the frequency of the filament wave EF1, and that for each rise in filament voltage there is an increase in plate current of the tube. The polarity was such that the light spot of the oscillograph tube moved upward with an increase in plate current of the tube under test. Note further that the two waves are almost exactly in phase.

Fig. 2 was taken for the same tube under conditions of minimum hum. Here the temperature effect is the predominant cause of hum. Note that at the hum frequency there is about a 90 degree phase displacement of the hum peaks from the peaks of the filament voltage wave. This displacement is caused by the thermal lag of the filament, whose temperature cannot follow the pulsations of input best generated by the filament current.

In Fig. 3 I show a magnetic effect hum wave, again along with the filament voltage wave. Note that here the hum wave decreases where the filament voltage increases. This is the characteristic sign of the magnetic effect. Note further that there is no appreciable phase displacement.

Inasmuch as the temperature effect is always present, there will always be some of this type of hum along with the voltage and magnetic effects. Unless the latter are very much stronger than the temperature effect, it will cause some noticeable displacement of phase.

In Fig. 4, the temperature type hum is very strong, much stronger, in fact, than it appears because it was amplified about twenty-five times less than the others, which were produced by a modern a.c. tube. Fig. 4 was produced by a —99 tube, whose filament has very low thermal capacity, and whose filament temperature varies very much more than the filaments of the tube which produced the other graphs.

In February Science and Invention

- Why I Am Interested in Short-Wave Receivers (constructional), by George R. Brown.
- Remote Push Button Station Selector of Simplified Design (with construction details), by Joseph Attardo.
- Radio Oracle—Questions and Answers.
- Latest Radio Patents.
- Tips for the Young Machinist.
- Byrd's South Pole Flight and Radio.
- Light Beam Stops Train in Danger.
- New Telephone Magic.
- Hints for the Home Workshop.

Index to Advertisers

How to Install an Auto-Radio Receiver

(*Continued from page 722*)

upon the receiver chassis while the car is in motion, both to prevent breakage of the tubes and to minimize microphonic noises produced by vibration, several systems may be employed. One is to support the receiver chassis in a frame by suspending it at the four corners of each end by means of springs. This method is illustrated in Fig. 2. Another is to make a sling of several layers of rubber strips and support the receiver chassis from hangers as shown in Fig. 1. Discarded inner tubes are excellent for this purpose.

Use of Gears

Turning the condenser shaft by means of the flexible cable presents another problem, which cannot always be solved by directly connecting the end of the cable to the condenser shaft through a coupling medium such as a universal joint. Fine tuning, or in other words, the direct turning of the condenser shaft without "back-lash," which is just as necessary whether the set be in a car or in the home, is very difficult while the car is in motion. Some means of gearing down the revolution of the tuning control knob for vernier action must be utilized. Straight and worm gears have been found reliable and satisfactory for this job. Moreover, their use permits locating the set so that there are a minimum of twists and turns in the flexible cable itself. Details of the gear drive are shown in Fig. 9.

The Antenna Problem

To a certain degree the amount of signal coming from the loud speaker is dependent on and in proportion to the efficiency of the antenna. In automobiles, where size injects a limiting factor, the pick-up is boosted by the use of several stages of high-gain radio-frequency amplification, but of course there is a limit beyond which they cannot be used effectively. Several ways of providing an acceptable collector are possible. First, one may use a copper screen fastened to, but insulated from the roof, inside the car (Fig. 5). Second, five or ten turns of wire may be strung around the inside of the car at the top, where they will be out of the way. If this latter system (Fig. 6) is used the collector may be connected to the receiver as a straight antenna or as a tuned horizontal loop. When used as a loop some experimentation will be required to determine the correct number of turns to be employed so that the antenna stage tunes in step with the other radio-frequency stages.

Suppressing Interference Noises

The main source of noise in a receiver installed in a car is from the spark plugs, induction coil and associated ignition wiring. To prevent pick-up from the wiring it has been found necessary not only to shield the receiver itself, but also to run the receiver battery wires and all other leads connected to the set through flexible metallic braid, grounding the latter to the car's frame. (Fig. 3.)

Eliminating the noise caused by the discharge of the spark plugs presents a more complicated problem. Shielded spark plugs may be substituted for the usual ones, or choking resistors of about 50,000 ohms may be inserted in series with the spark-plug leads. (Fig. 7.)

Noises produced by the action of the brushes against the generator's commutator may be eliminated by shunting a .25 mfd. fixed condenser across the relay box to ground.

Suggestions Invited

Only the high spots in the installing of a radio receiver in a car have been touched upon here. There are many others, of course, which we have not had the opportunity to fully investigate ourselves or report on at this writing. Our readers are invited to write to us, recounting their experiences in this new field of radio endeavor, and include in their letters any new kinks which they have found helpful so that such suggestions may be incorporated in future articles which RADIO NEWS will publish.

Visual Music

(*Continued from page 768*)

"Obviously, the grosser errors in playing, singing, and speaking can be overcome with the aid of this instrument, since, with the eye to aid the ear, an error can be more readily appreciated and its correction effected.

"Master musicians are also interested in studying the details of their own technique. For example, one well-known pianist has learned by osiso sound-wave photographs that he can produce a single note with at least 18 different gradations, each individual in tone and color and loudness. He can thus determine the actual difference between his 'cantabile' and his accompanimental notes, between his 'forte' and his 'fortissimo.' and so on. Though great artists are in many ways beyond instruction, they nevertheless gain much from accurate information as to their own work, and the osiso is capable of showing them many things that have heretofore escaped direct observation."

The osiso in its older form, which is suitable for photographing waves and for carrying on scientific work, has been used extensively in a wide variety of electrical and acoustical investigations. It is, for example, the instrument used by Byrd's radio experts in the Antarctic in their study of the behavior of radio waves, and it is also being employed by Dr. Max Goldstein for instructing the totally deaf to speak correctly. The present development, by magnifying the wave forms to any desired extent, enlarges its range of usefulness, especially in the educational field.

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Inventions Commercialized. Patented or unpatented. Write, Adam Fisher Mfg. Co., 278 Enright, St. Louis, Mo.

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Build Your Power Unit on Paper First

(*Continued from page 732*)

voltage applied across "C1." The use of a fairly low voltage divider resistance, which results when a fairly high bleeder current is allowed for, acts to protect the filter condensers against excessive voltages under so-called "no-load" conditions.

The Filter Condensers

The only reliable plan to follow in selecting the voltage ratings of the condensers used at "C1," "C2" and "C3," is to use a peak voltmeter to measure the maximum voltage applied in those positions, at the conditions under which the power unit is to operate. During such tests, filter condensers of fairly high ratings should be used. If the power unit is to be operated under full load at all times, the voltage ratings of the condensers may be selected on the basis of the peak voltmeter readings under full load.

"No Load" Test

However, it is safer, in order to guard against possible breakdown of the condensers, due to operation of the power unit under "no-load" conditions such as will obtain if the tubes are removed from the receiver, or burn out while the power unit is tuned on, to measure the peak voltages under "no-load" conditions, that is with all the tubes out, and only the voltage divider and choke resistances connected across the output of the rectifier.

Where a peak voltmeter is not available, the approximate voltage ratings may be arrived at in the following manner: The d.c. working voltage rating of the first filter condenser, "C1" should be 1.4 times the a.c. voltage, each side of the centertap of the transformer secondary winding. In this particular case with a transformer designed to apply 325 volts a.c. to each plate of the rectifier, the first filter condenser should have a d.c. working voltage rating of at least 325 times 1.4 or 455 volts. The rating of the second filter condenser for protection under similar "no-load" conditions, that is with the voltage divider and choke resistance across the rectifier, should be equal to the d.c. voltage output of the rectifier under such conditions times 1.1. In the case under consideration, we found that using a transformer applying 325 volts a.c. per plate of the rectifier, the d.c. voltage output characteristic of the rectifier with a load consisting of 11,753 ohms would be 375 volts. The d.c. voltage rating of the second filter condenser, "C2," would therefore have to be 375 times 1.1 or 412.5 volts or higher.

The d.c. working voltage of the third filter condenser may be the value of the d.c. voltage output of the rectifier under the above-mentioned "no-load" conditions or 375 volts d.c.

The ratings of the filter condensers therefore depend not only on the a.c. voltage applied to the plates of the rectifier but also on the conditions under which the unit is operated.

The Radio Forum
"Serviceman"

(*Continued from page 744*)

own plans. The writer mounted the set in the top tray of a home-made tool box. Below this tray was one for tools and below that was a space for tubes. This made a box about 6 x 10 inches by 12 inches deep inside measure.

Now to use our tester. Following a brief examination to see that the set is connected up, that the tubes light and that there is some "set" noise if only a slight hiss: remove the first audio tube and plug the plug of the test set into the vacant socket. Then place the tube in the socket on the tester. Turn on the set and depress the "filament voltage" switch. If the reading on the voltmeter is not correct for the tube used, adjust the rheostat on the radio set. Take the reading on the milliammeter and press the "grid shift" switch, again taking the reading. The difference in reading is the value of the tube. It is best to take the reading on a tube known to be good and use it for comparison. Test all the tubes in the set in this way except the power tubes and special detector tubes which are tested by plugging in their special socket.

Now if tubes are O. K., go from socket to socket plugging in each one and taking readings as before. Failure to get a reading requires investigation. However, some radio sets are peculiar in giving no grid readings on some of the tubes. Which these are is determined by experience. Failure to get an MA reading shows an open plate circuit, due to a defective transformer, speaker or a loose or broken connection. Then the "probe" test may be used to locate the exact point.

To make a "probe" test, connect 45 volts to B plus P and B minus. Then connect the "probes," or flexible wires with stripped ends, to the "probe" posts and make a point to point test for open circuits. First however, remove the tubes and disconnect the batteries. It is also advisable to remove the chassis from the case. If condensers are tested, no MA reading should be obtained. Be sure, however, that there is no coil in shunt with the condenser.

The milliammeter may be used as a voltmeter to test B batteries by connecting the leads to the B battery test posts and then using a suitable multiplier which is obtained by testing some new batteries of known voltage.

To use as a tube tester without a radio set, connect suitable A battery to the posts marked A plus and A minus "Tube Test" and 45 to 90 volts B battery on the B minus and B plus "Tube Test." Place tube in the socket and adjust the voltage by means of the rheostat. Take the milliammeter reading and press the "grid shift" button, again taking the reading. Compare the reading with a tube known to be good. A slight difference in A or B voltage varies the reading so that the experimenter will have to figure that out for himself. Once accustomed to the use of the tester, one may find most radio troubles easily.

This has been given for 201A tubes or their equivalent. Adaptors for other tubes may be bought or made, however.