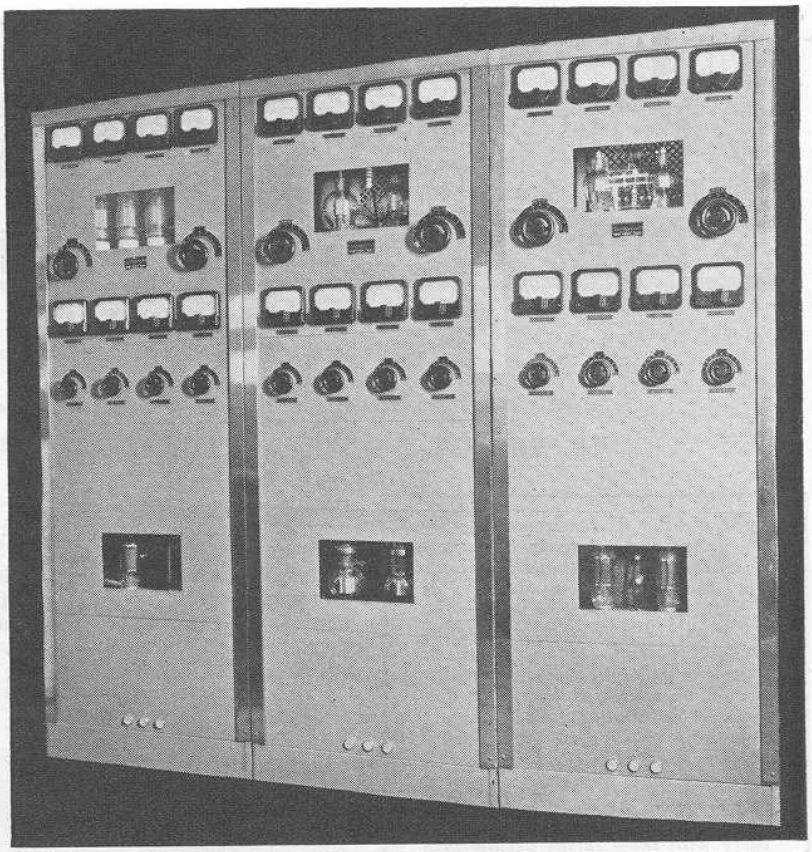
MODEL 1 KW RIG

by OLIVER READ, W9ETI
Technical Editor, RADIO NEWS

Presenting the most commercial-like in ham rigs, wholly home constructed.



AMATEUR radio operators can usually be divided into two classes; those who get the greatest amount of satisfaction out of building a neat rig by taking plenty of time in its construction and adjusting the various stages for high efficiency, and those who are content to throw their units together and begin operations as soon as r.f. reaches the antenna (or even before).

Many of them are not interested in how the rig looks to the eye as long as a signal is forthcoming, and the only pride that they may feel regarding their stations is this ability to catch an elusive dx station, particularly if a visitor is in the shack at the time.

Back in the early days of amateur radio, we were given the impression that metal cabinets or chassis were to be avoided in constructing our transmitters. We were led to believe that if we used this type of construction, that all of the soup from the rig would be soaked up by the metal and we would get nowhere by attempting to use it. Perhaps this was all very true when we consider that we were using high capacity tubes and circuits and multi-stage transmitters were yet to make their appearance and we did not know how to shield these stages properly.

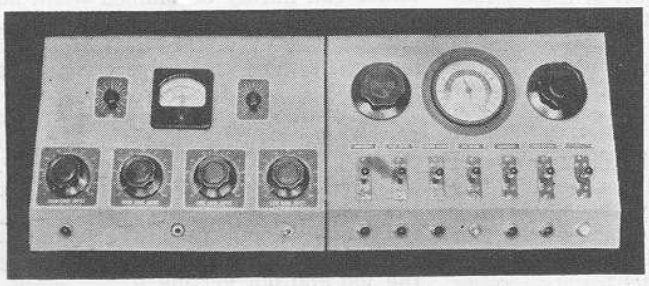
Coils are now used which are of much smaller size, condensers are more compact, insulation is very much improved, stand-off insulators and assemblies raise the r.f. units above the metal chassis, flexible condenser couplings are available and many more factors that permit us to use these metal cabinets and bases. More labor is involved in this type of construction, but this is offset many times by the satisfaction of a job well done and a rig that will perform without adding a maze of parasitic suppressors, extra chokes to keep the r.f. out of the microphone and other precautions that are required in phone operation by many rigs.

The past several years has seen a marked reduction in bulky equipment along with the common acceptance of the low C tubes in amateur rigs. It also proved the value of the higher frequencies for everyday use, rather than that of an experimental spectrum to play with. We soon discovered that by keeping the radio frequency power within the stages, and by using more efficient methods of coupling, we could obtain a much higher percentage of efficiency at the antenna and the energy we were trying to conserve would not be shooting around our shacks.

The manufacturers of broadcast and marine transmitting equipment have taught us how to construct units for fool-proof performance, but we have been slow in accepting their basic designs. After many visits to stations in various fields of service, I was definitely sold on their method of construction for my own rigs.

The following paragraphs and illustrations show what has been done to carry out the above theories in amateur transmitting equipment and results have indicated that these are well founded. The rigs have now been in service for many months and no adjustment or retuning has been required during the entire period. Feedback is conspicuous by its absence, either in the r.f. or audio.

As far as amateur transmitters are concerned, there has been little constructional data given along commercial lines. The writer has had occasion to examine many amateur transmitters, and in most cases, the methods used in planning and laying out the various sections has been taken as "a matter of course" and results have been more or less dependent upon the quality of the parts used. On the other hand, several of the stations visited showed that careful consideration had been given to all of the units with the result that these transmit-



The control console and speech amplifier.

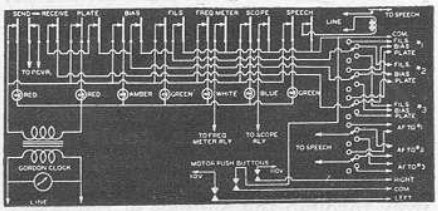


Diagram of the control console.

ters operated with a minimum of adjusting after the rig was once properly tuned.

It is but little more costly when constructing a new transmitter to follow the proven layouts, such as are used by the makers of commercial transmitting equipment. Even if the builder does not care to purchase expensive broadcast type cabinets, he can construct them out of wood and a material such as tempered Masonite and line the insides with sheet metal.

We all have read, with deepest concern, the unfortunate electrocution of several of our fellow amateurs and electricians during recent weeks. We certainly can prevent or reduce this terrible danger in our own shacks by completely enclosing the power units in a closed cabinet and by providing a rear door equipped with interlock switches so that as the door is opened, the primary circuits will be broken.

All of the transmitters shown in the illustrations at the writer's station are so built that safety is provided at all times against possible contact with any high voltage circuits. In addition, all relay circuits operate in cascade so that plate voltage cannot be applied before the filaments are in operation. Both overload and underload relays are used to protect the equipment at all times should the antenna blow down or other unforeseen conditions occur.

In this, the first of three articles which will describe each transmitter individually, we shall cover the 1 kw. 10-20 meter installation at the station with the various control and speech circuits.

Mechanical Design

Each cabinet contains a complete transmitter, both for c.w. and phone operation. The cabinets are of standard dimensions along the commercial sizes. The panels are each 24" long and ⅛" thick and are made of aluminum. The corner styling-strips are of stainless steel and cover all of the mounting screw heads when in place. The mounting holes are spaced the standard distances for both amateur and Western Electric mounting dimensions, so that either type panels may be used. The cabinets are six feet high and 26 inches wide overall.

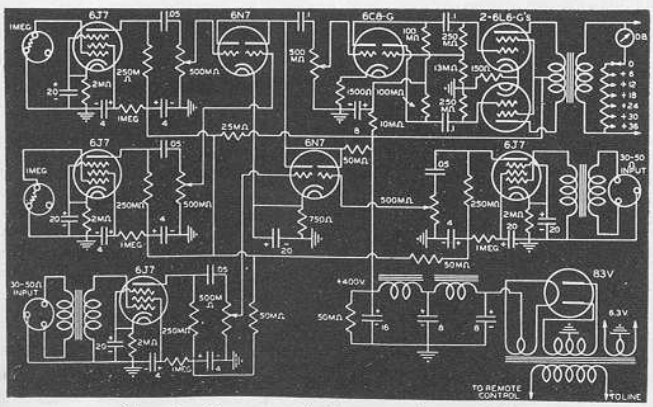
The chassis measures 22" x 16" and side brackets are provided on the inside channels so that each base may be slid into the cabinet from the front, in drawer fashion, and ample support for the weight is had from these heavy brackets. Receptacles are mounted on the rear side of all chassis so that all connections may be made through cables and plugs for all but the meter circuits. Feed-through insulators are mounted for connecting terminals for the meter cables as these carry the high voltages through the ignition cable where the higher insulation breakdown is required.

The cabinets and panels are finished in platinum grey wrinkle and may be cleaned when necessary with soap and water. The insides of the cabinets and the backs of the panels are finished with an aluminum spray that is very durable. Plenty of ventilation is provided by means of the large grills in the top and bottoms of the steel doors. Pyrex glass windows are mounted back of the cutouts as shown to help to keep out the dust. In hot weather, it is advisable to either remove these, or to install a small fan in the top of the cabinet to draw out the hot air from within.

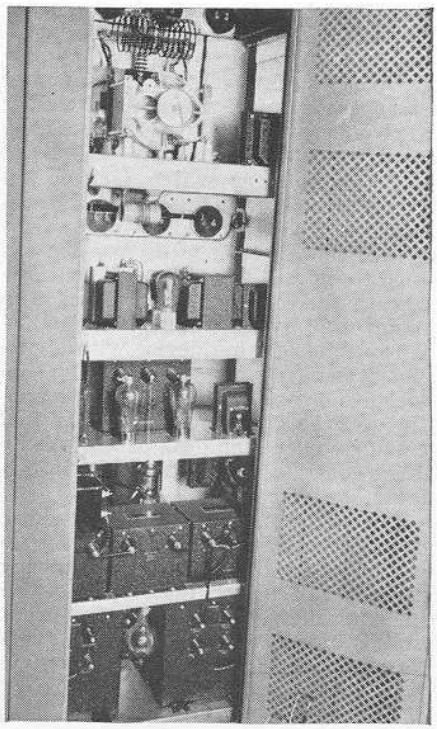
Keying of the largest rig is by means of grid-controlled rectifiers in the high-voltage supply. By placing a bias on the tube grids, current will not pass through the tubes until this bias is removed when the key is down. This method has proven to be very satisfactory in high-power operation.

The meters shown in the illustration are: from left to right, Lower panel; Osc. plate current (0-75 d.c. ma.), Doubler plate (0-75 d.c. ma.), Driver plate (0-200 d.c. ma.), and Modulator plate (0-500 d.c. ma.). The top panel contains the following meters: Final filaments (0-10 d.c. ma.), Plate volts (0-2500), Plate current (0-750 d.c. ma.) and Grid current (0-250 d.c. ma.). Filament voltage for the eight pilot lights is taken from a separate transformer that is mounted on the inside channel of the cabinet.

The radio-frequency line-up is as follows: RK49 Jones oscillator, using 40 meter fixed and variable crystals, an RK25 pentode buffer-doubler, working on 20 meters, an Eimac 35T driver on 20 meters, or as a doubler on 10 meters, and a pair of Eimac 250th Hi-mu triodes in the final stage. The external speech equipment at the operating position includes: four type 6J7 mixers and first audio, two 6N7 electronic mixers, a 6N7 in the third stage as a phase inverter, and a pair of type 6L6G's operating class "A" in the output. A 500 ohm line goes to the transmitter cabinet and into a line-to-grid transformer and then to the modulator grids.



Circuit diagram of the speech amplifier.



The rear of the kw rig.

A total of four power supplies are used at the transmitter: one for the final amplifier, one for the modulators, one for the excitor stages, and the bias supplies. The unit for the final high-voltage supply also may be termed a dual-supply as provision is made for supplying the rectified voltage in the form of C bias for the grid-controlled rectifiers. By referring to the schematic diagram, this can be explained in the following manner: A control grid is placed as a valve within the electron stream of the rectifier. When a negative bias is placed on this grid, and if this bias is high, the tube will reach its cut-off point in the same manner that a class C amplifier operates. Now if this bias is removed, the current will be permitted to flow in the rectifiers and plate voltage will appear at the filter.

It is imperative that the key jack or relay be insulated to withstand the full plate voltage of the rectifiers. The bias transformer is one used as a replacement for broadcast receivers and will deliver a few hundred volts to the grids. This value was not found to be critical as long as the voltage is high enough to cause cut-off to the tubes.

Design Data on the 1 kw Unit

The transmitter in the center operates on the amateur 10-20 meter bands and the tank circuits are designed for peak efficiency at these frequencies. In order that the transmitter could be used for a wide range of frequencies within the two bands, it was decided that both variable and spot frequencies be used. The problem of adjusting the variable crystals was solved by using a small tuning motor in conjunction with a selector switch at the transmitter end and by using a slip arrangement and cable drive to the two variable crystals so that as the reversible motor operates, the drive would be

transferred to the units in the order chosen for a given coverage. The crystals are so arranged that one outside frequency is connected to the number one position on the selector switch, the next one to the number two position, etc.

As the selector switch reaches the last position, the motion is transferred to the driving pulley on the variable crystal and when the rotation has been completed the cable will continue to turn due to the slipping action. The motor used by the author is a Utah 24 v. reversible tuning device with a special worm reducer to cut down the speed to one r.p.m. The complete control for this crystal section is had from the operating desk as are all the other controls for the complete installation.

Following the commercial designs, crystal control is used only to insure a minimum of frequency drift during operation. The oscillator operates on the crystal frequencies and the output tank is tuned to the center of the band. No further adjustment is required in tuning the tank to the other portions of the band. An RK49 tube is used in the oscillator at low plate voltage to insure stability and provides more than sufficient output to the RK25 doubler. This tube is always used as a frequency multiplier, on both 10 and 20 meters.

The capacity chosen for the doubler tank is best suited for the range covered, and should not be more than the capacity shown. The doubler is entirely conventional and needs no lengthy discussion.

The driver should be able to furnish at least 125 watts for efficient performance to the final amplifier and this can be obtained from the 35T operating at a plate potential of 1500 volts. This triode is an excellent performer at the higher frequencies and was selected for this stage as it met all of the requirements of easy drive, small physical size, ease of neutralization and adaptability to wiring where it is convenient to mount the condensers above the chassis.

A combination of both grid-leak and fixed bias is used on the driver in order to insure protection to the tube should the excitation fail. A split-stator tank should be used in this circuit so that neutralization will hold for both of the bands covered. The tank coil is of the air-wound type with swinging link so that the proper degree of coupling may be had to the following tubes.

Comparisons of several types of links showed the greater amount of r.f. was transferred when using concentric cable between stages than when using twisted pair. Furthermore, the use of this cable permitted the shield to be grounded, and this in turn added further isolation between stages. The concentric was home made from a regular kit and may be constructed to any length desired.

The modulated amplifier operates at one kilowatt input on both bands and uses Eimac 250th triodes. These tubes *idle* at this input and, inasmuch as they only have 2000 volts on the plates, they may be driven to high efficiency in the higher frequencies for phone operation. Much planning was done on this stage in order to keep the lead lengths as short as possible. The use of the propeller type condenser added to the general simplicity of the final, as the neutralizing condensers are a part of the assembly and may be located right next to the tubes where the connecting leads will be shortest.

The tank coil is mounted above the condenser as shown. To be able to make a symmetrical assembly dictated that the front panel controls be laid out to offer the most in eye appeal without upsetting the circuit layout. This was accomplished by the use of flexible cable and pulley drive. One can appreciate the advantage of being able to see the tubes while in operation, especially if the metal plate types are used, as the dissipation within each tube can be estimated and loading can be adjusted so that each plate in a push-pull stage attains the same color. By observing this color of the plates, with reference to the manufacturers' ratings, we may tell whether or not the stage is balanced. The two 250th's in this transmitter operate at exactly the same orange color and i n t e n t i o n a l misadjustments showed an immediate color change between the two when one tube was loaded heavier than the other.

Variable r.f. coupling is provided by means of a swinging link and the output is fed into 72 ohm concentric cable to the antenna relay and then to the 70-foot antenna cable feeder. Loss at this position was reduced greatly after removing the twisted pair previously used and it was possible to use far less coupling at the transmitter tank than before.

The grid tank condenser mounts underneath the chassis and is driven by means of a flexible cable and shafts. The grid coil is underslung beneath this condenser and is link-coupled to the 35T driver on the exciter chassis.

The December 1938 revisions of amateur regulations (FCC Rules and Regulations) state that the operators have means of measuring the input to the final amplifier when running 900 watts or more. This has been met in this transmitter by providing a plate voltmeter which also serves as the bleeder to the power supply. This meter has been checked for accuracy and from its permanent use the input to the rig may instantly be determined in conjunction with the milliameter. Note that eight meters are used on each transmitter to offer proper check of all stages without resorting to a series of jacks or switches. This also follows the design of commercial units, and the flexibility of such a system is only appreciated after using one or two meters for the entire transmitter as is done in many cases. These meters are all of four-inch diameter and are illuminated from the front.

Modulator Equipment

One of the features of this rig is the excellent regulation of plate voltage

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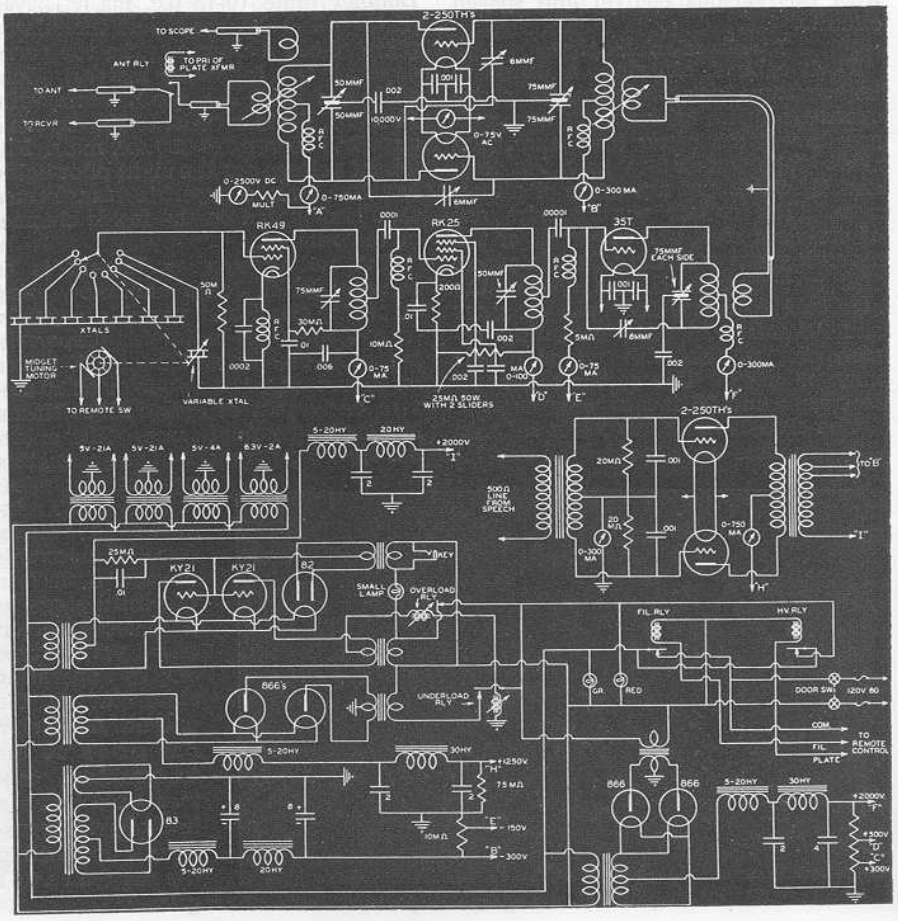

The use of a d.c. blocking condenser in the ground circuit as shown in Fig. 9 does not change the condition of Fig. 8. Contrary to what most hams believe, the blocking condenser does not appreciably change the d.c. voltage across the tuning condenser. If a .001 blocking is used and the tuning condenser has a capacity of .0001 for each side the voltage across the tuning condenser is 10/11 of the plate voltage. There has been a reduction of but 1/11 or 9%. For all practical purposes, we can state that the condenser must be designed to withstand the d.c. plate voltage plus the r.f. voltage.

When parallel plate feed is employed as shown in Fig. 10, the d.c. voltage is effectively removed from the tuning condenser. As shown in the equivalent d.c. circuit, the plate blocking condensers are subjected to the d.c. plate voltage. Since the coil is grounded at the midpoint, no d.c. voltage can exist across it and the tuning condenser. Consequently the tuning condenser need withstand only the r.f. voltage.

By grounding the rotor of the condenser only, the d.c. voltage is placed on the tuning condenser as shown in Fig. 11. The d.c. circuit shows that for .001 mfd. blocking condenser and .0001 mfd. tuning condensers, 10/11 or 91% of the d.c. plate voltage is placed across each section of the tuning condenser. When this arrangement is employed, plan on a condenser that will handle the d.c. as well as the r.f. voltage.

Combining Figs. 10 and 11, we get a circuit as shown in Fig. 12. This circuit is the same as Fig. 10 except that a double section condenser is used with a grounded rotor. Since the coil is also grounded, no d.c. voltage appears across the tuning condenser, so it must have only sufficient voltage rating to withstand the r.f. voltage across the tank circuit.

When designing transmitter tank circuits it is well to take the beforementioned factors into account, for by eliminating the d.c. voltage from the tuning condenser, condensers with smaller plate spacing may be used with equal effectiveness. However, it is not the purpose of this article to recommend the use of a circuit only because the condenser may have a lower voltage rating. There are many other factors in the design of transmitter tank circuits, and sometimes to obtain other benefits it may be impossible to keep the d.c. voltage off the tuning condenser. If these benefits are of sufficient value to offset the increased expense of the condenser required, then it is advisable to forget about keeping the d.c. voltage off the tuning condenser.

In many transmitters built by the writer and many of those described in radio publications, it is possible to save considerable money by keeping the d.c. voltage off the tuning condensers—and this can be done without sacrificing transmitter performance.

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Model KW Rig

(*Continued from page 30*)

to the various units. The one big bug in amateur class B phone transmitters, that operate on high power from the house mains, is the blinking of the lights caused by the rise and fall of the plate current to the modulators. The type 250th tubes make excellent audio modulators in either class AB or B, and the former was selected to reduce the range of plate current swing normally encountered in the latter application. The total plate current *variation* is reduced to less than 100 ma. and there is no blinking of lights. Of course there are other factors that enter into the design of good regulation and these will be covered in later paragraphs.

The modulators are shown in the lower window where observation may be made in the same manner as was described for the final. The two modulators operate at an orange color and circuit balance may be observed as before stated. It is imperative to use separate power supplies to the final and to the modulators if maximum performance is to be realized. The plate current to the modulated amplifier does not vary more than 1 ma. in this transmitter when operating on phone at maximum input and this is made possible by using choke-input filters to all stages and by the use of class AB modulators.

There are several ways that we can attack the problem of wiring; point to point, cabled, and haywire. The latter does not insure efficiency and should be disregarded. Point-to-point wiring is best adapted to r.f. circuits, and cables are well suited in carrying the power leads and those that terminate at the meter panels. The writer uses automotive ignition cable for these latter connections and they are designed to withstand a 10,000 volt breakdown. Filament cables are made to the larger tubes with number 10

soft drawn copper wire which is enclosed in a heavy spaghetti tubing.

Ground returns to chassis are made at one point only per stage so that no difference in potential will occur. A complete analysis of correct wiring may be had by referring to the March 1939 issue of RADIO NEWS, page 33. All chassis in the three transmitters are made of auto-body steel and these are first copper plated and then cadmiumed for a neat finish. Lockwashers are used under all screws and nuts so that vibration will not cause any connection to become loose.

Current readings for the various stages are: Osc. plate 30 ma., Doubler plate 40 ma., Driver plate 100 ma., Final plates 490 ma. The overload relay trips on any current in excess of this amount and cuts the primary to the high-voltage transformer. The class AB Modulators have a static plate current of 300 ma. and rise to 400 ma. for full output. Line voltage is set to 115 by means of a 5 kw. autoformer. The modulation transformer is protected by an underload relay so that plate voltage cannot be applied to the modulator tubes until they are drawing proper current and in turn offer the proper impedance load to the secondary of the transformer.

Many a class B transformer can be saved from breakdown if this precaution is taken in any amateur transmitter operating on phone and is cheap insurance when the cost of a replacement is considered.

Power Supplies

It is always good practice to design the power supplies for *continuous* operation and never for *intermittent* service. Plenty of capacity should be used in the filter networks to insure a hum-free carrier and this applies particularly to the modulator power supply at the output. The large transformer shown in the bottom of the cabinet on the right hand side is the high voltage plate transformer. The rectifiers are underslung between this and the modulation transformer. The filament transformer for the two rectifiers and the two filter chokes for the high voltage are mounted on two channel irons above the rectifiers.

The bulk of the weight is thus kept at the bottom of the assembly and eliminates the need for a chassis to hold this weight. The control relays may be seen mounted on the side of the cabinet above the plate transformer. Pilot lamps that operate on the line voltage are used for filaments, bias and plates. The line and control wires are all contained in BX conduit for safety as well as the additional shielding provided by its use.

The exciter unit contains its own plate and filament supply on the same chassis and consists of a two-section filter with choke input.

All units with the exception of the bottom portion are removable and connections are made by means of amphenol cables and plugs to each chassis. In this way a section may easily be removed for making any changes with-

out disrupting the remainder of the transmitter.

Control Console

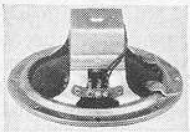
All of the circuits at the station are controlled from this console, and the connecting cables are all long enough so that the desk may be moved to different parts of the room for a change of scenery. The use of key switches makes for rapid changeover. All of the associated equipment for the transmitters is controlled from these switches and the selector switch. A complete picture of the sequence may be had by referring to the schematic diagram of the control panel.

It is not within the scope of this article to cover all of the details in the construction of all of these units and I have merely tried to bring out the more commercial appeal as far as construction is concerned. Perhaps the illustrations can tell the story to best advantage, as, after all, the basic circuits are all tried-and-proven and have appeared many times in print.

Later articles will describe the other transmitters used at this station.

What's New in Radio

(*Continued from page* 34)



make a line of replacement speakers and Uni-match transformers for the trade. These units are designed so that the speaker and its transformer may be used as a replacement in practically any radio. A proper impedance match is a universal feature of the transformer. A rotary switch is supplied on the terminal strip and it is only necessary to turn this switch to the proper point for correct match to the output of the set being used. Further details may be had from the manufacturer.

National Radio Institute, of Washington, D. C., are celebrating their twenty-fifth anniversary. Twenty-five years ago, Mr. James E. Smith began teaching a group of four men in a wireless class. In those days the public thought of radio as a plaything or a passing fad, and saw no possible future for it. Today radio is a $912,000,000 industry and employs 345,000 people in its various branches.

QRD?

(*Continued from page* 36)

good story, true or. . . . With stories like these under his hat, we'd also like to hear from Tim Furlong.

* * *

NOW that wintry weather is fully upon us (ah, for the life of a yacht operator who is now basking in the warm sunshine of southern climes) the east coast vessels are keeping the ops on their toes with their gyrations. One never knows what his next move will be. But whether it rocks beamways or from stem to stern, or whether or not it is okay in every seam perfect spar, there's always the ever-present possibility that some other vessel or plane might be in need of help. So the cans are kept on continuously . . . in spite of Automatic Alarm equipment. That was a very nice piece of work on the part of the *Esso Baytown* which rescued the passengers of the British flying boat *Cavalier*. If not for the coolness and operating ability of the radiop of the *Cavalier*, every one would have gone to an icy-water grave. As it was, three were lost. . . . So stick to your cans, just in case.

* * *

IT was a pleasure to hear from "Ham" William Drebert, Moravian College for Men. To get into the Airways, one must pass a civil service examination. Details of the time and place of examinations can best be obtained by writing to the *Department of Commerce, Washington, D. C.* The aviation companies must be contacted separately. As for ship berths, the field is rather well filled and a second class ticket without any previous experience would have to first get "apprentice" experience before you could possibly take a boat out by yourself. Good luck to you.

* * *

LETTERS occasionally come over the desk that require a straightforward answer. In other words, "no beating around the bush." There are a lot of chaps who believe that some of the men holding down various jobs on ship stations and broadcasts don't know, as one fellow puts it, "the difference between a modulator and an egg-beater." He moans that they're holding the billet while he's still on the available list. Well, brother brass-pounders, all I can say is that if these "know-nothings" have the berths, then they must have their tickets to operate. And if they have their tickets, then they must know their stuff, because I've never heard of an *RI* who could be bribed. As a matter of fact, the nephew of an *RI* was flunked because he was given some extra questions, in addition to the regular examination, which he couldn't answer. So instead of thinking the other guys don't know what it's all about, it's a good idea, instead, to take that time to build up our own knowledge.

And now that '39 is well under way, let's hope for peace and good shipping from all ports . . . so with 73 . . . ge . . . GY.

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Video Reporter

(*Continued from page* 14)

and recommendation. As the FCC remarked, the Journal Company's application is the first looking to establishment of an experimental program service for reception in the home as distinguished from fundamental research or technical experimentation in the art of developing television apparatus. The Commission has previously issued a number of licenses for technical experimentation only.

The proposed standards for television transmission were recommended to the Commission recently by the Radio Manufacturers Association. The Commission has taken no action upon the recommendation. Some manufacturers and experimenters have expressed opposition to the promulgation of standards.

World's Fair Television

RESPONDING to the rapidly mounting interest in the advent of public television, which is expected to coincide with the opening April 30 of the New York World's Fair 1939, the Radio Corporation of America announced a decision to almost completely revise its exhibition plans at the Fair in order to increase the scope and effectiveness of the television presentation.

Original plans for the RCA exhibit building drawn up more than a year ago, provided six ground-floor rooms where television was to be viewed under conditions simulating those of the home. Because these accommodations are now looked upon as inadequate, RCA is redesigning the ground-floor arrangement to greatly enhance the utility of the available space.

One phase of the revision which has been agreed upon, however, is the retention of two of the original viewing rooms for the