

THE EARLY NATIONAL HRO RECEIVER

by William B. Fizette,* K3ZJW

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The world of the middle and late 1930's, for all its failings, was a very romantic place. The far corners of the globe were being opened up by what William Manchester describes as a "technological watershed".<sup>1</sup> The Boeing clippers of commercial aviation began to fly the Atlantic routinely and were opening up the Pacific. The Douglas DC3 was writing the first chapter of its famous story. The communications revolution was upon us, with, among other examples, the first feature length Technicolor motion picture; Marconi and the microwaves which would be so useful in WW II; the beginning of AP wirephoto service in 1935; *Life* magazine in 1936, and *Look* in 1937. In 1935 we were still in the middle of the great depression, but in that same year we were introduced to the Social Security Act, the beer can, the first night baseball game, and one of the most famous and long-lived of communications receivers, the **National HRO**.  
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The National Company of Malden, Massachusetts had an established reputation as a manufacturer of quality communications equipment, and a marketing organization of a well-established network of franchised dealers. James Millen, the chief engineer, was well known in the exclusive amateur fraternity through his ham activities, his monthly column (actually a paid advertisement) in *QST*, and the quality merchandise he produced. Previous successes had included the **SW3** (August 1931), the **AGS** (July 1932) and the **FB7** (February 1933) receivers. Customers included the United States Department of Commerce and the Civil Aeronautics Board, as well as the growing army of amateurs who were creating an increasing demand for components and receivers.

Some time during the winter of 1933 - 34, the National engineers began working on the new receiver which was to become the HRO. According to one story,² it was to be for amateur use, designed to fill the gap between the **FB7** and the **AGS** in both price and performance. The **FB7**, used mainly by hams, was actually an **AGS** circuit without the preselector. Only a few affluent amateurs owned an **AGS**. Another and more plausible version³ has it that the commercial interests, notably the airlines, sparked the development, taking the position that they wanted to replace their aging **SW3s** with something better than the **AGS** which was currently available. It is documented⁴ that Herbert Hoover, Jr., W6ZH, representing TWA, very likely one of the insti-

gators of the project, visited National early in 1934. It was probably at that time that the design parameters of the new receiver were established, namely, that it was to be state-of-the-art, using elements of design already tried and proven in the **AGS** and **FB7** receivers, plus new features which were in the idea stage.

Hoover agreed to handle the electronics design in his small laboratory on the West coast. He also emphasized the necessity of improving the mechanical design of high-frequency receiver tuning mechanisms. National was strong in mechanical engineering design with a good track record. It is interesting that once the project was underway, a strange situation developed. Two design teams, separated by the width of the United States, were set to work on the receiver. When the mechanical prototypes were completed, they were carried by Millen to California where the electronics were incorporated. This separation of function, with the National M.E. people taking the lead role and working without interference or compromise, contributed significantly to the success of the receiver.

The existing National design expertise, experience, and manufacturing capability with components were invaluable. The IFs and the Lamb crystal filter circuit from the **AGS** were incorporated, as well as small components of National design, including the special R39 dielectric for use in the coil forms. Plug-in coils and a separate power supply...the latter a point of controversy for years...had been established as circuit parameters. The front-panel plug-in coils had worked successfully in the **AGS**, and the National engineers were convinced that they were measurably superior to band-switched coils. However, with four coils for each range the confusion in changing bands was burdensome. Indeed, an attempt was made to resolve this problem in some of the later versions of the **AGS** by mounting the sets of coils upon aluminum plates, and this approach was adopted for use in the HRO. It proved to be eminently practical.

The engineers were aware of the problems of calibration accuracy and backlash in a condenser drive which would give continuous bandsread, but through the efforts of W.

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Graydon Smith⁶ of the design staff they devised a heavy duty gear reduction box with a 20:1 worm drive, heavily loaded with springs to take up backlash. The associated micrometer dial which was capable of reading to one part in 500 was a major innovation, and survives to this day as a unique, highly visible National Company trademark. The epicyclic gearing arrangement, coupled with the gear box, realized an effective scale length of 12 feet for a capacitor rotation of 180°. This in turn necessitated a completely new variable capacitor.

What emerged was a marvel of design. Known as the PW Precision Condenser, it was created specifically for use in HF circuits, and was characterized by very heavy construction. The rotor shaft was $\frac{3}{8}$ " with insulated bronze bearings at the ends to reduce stray current noise, and four radial bearings to maintain a rigid plate alignment. Each rotor was electrically isolated, with intermediate tie plates of molded bakelite. The main frame was "floating", supported solely by its attachment to the gear box with massive pillars. Since the dial was also joined only to the gear box, the capacitor was not affected by any warping of the panel or chassis. Stator insulation was of Steatite, a new and promising dielectric.

The capacitor plates were shaped to give straight frequency-line tuning on the GC ranges, and practically SFL tuning on the BS ranges. The bandspread achieved by the design was no less than 400 of the 500 dial divisions (almost 10 feet) on each ham band; on the 400 kc wide 14 mc band, for example, each dial division represented 1000 cycles.

The coils were fabricated following the established National Company practice of winding the inductances upon precisely grooved forms of R39* molded dielectric. Each coil was mounted upon a special molded block, along with the air trimmer padding capacitors, which in turn were enclosed within rectangular shield cans. The four cans of each coil set were then fastened to a heavy base plate equipped with handles and calibration charts. Instead of the usual prongs of plug-in coils, button contacts on the mounting blocks engaged sturdy spring bronze leaves when the coil drawer was seated in the receiver. A simple and ingenious "switch"...actually a machine screw...took care of the change from

GC to BS models for each coil.

To minimize the effects of heating as much as possible, the coils were located at the bottom of the chassis, double shielded by the aluminum cans and the individual compartments of the welded steel chassis. To minimize variables, the circuit stability was guaranteed only if RCA tubes were used.

Receiver oscillator drift became a problem, and in one effort to counteract the effects of heating, trimmer capacitors were formulated of aluminum plates, brass spacers, and steel studs, so that plate expansion due to heat was balanced by the increased spacing due to stud expansion. In frequency determining circuits, air capacitors were substituted for unstable mica units.

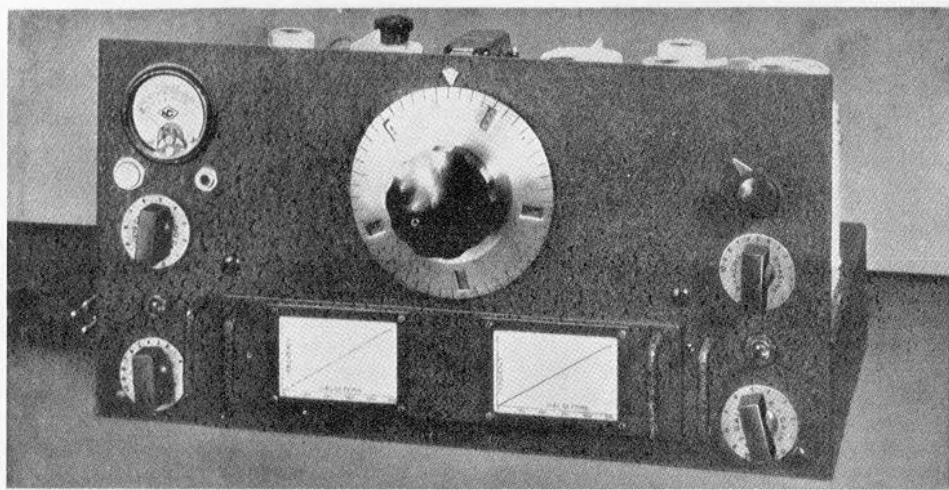
The electrical circuitry was state-of-the-art, and included features such as two stages of preselection, two air-tuned IF stages, a crystal filter, and full AVC action, as well as the new VTVM S-meter carrier intensity circuit. The Lamb variable band-width circuit, consisting of a quartz crystal in conjunction with a variable impedance, was capable of maximum selectivity of less than 20 cycles. Making the four tuned stages track properly was no small task, and readers who wish to delve into the design details and how the problems were solved may want to read the article by Millen in January 1935 QST.⁴

Sound engineering reasons, based upon experience, were the basis for using a separate power pack removed from the receiver by some 5 feet of interconnecting cable. Millen reported⁵ that hum and noise level were substantially lower with an external power pack, and that there was no alternative for the type of receiver represented by the HRO. While the early advertising did mention a version with a built-in power supply "*for those few amateurs who desire it*", it is doubtful that any were ever shipped, and there was no further reference to this model.

Unfortunately for the reputation of the receiver, the use of unsuitable power supplies, usually home brew, led to performance problems. It was absolutely essential to proper operation, for example, that the tube filament voltage be 2.5 V as measured accurately at the tube sockets. There was a substantial voltage drop within the cable (the National-supplied power unit compensated for this drop), and it was not until well after the war, in 1949, that the power supply was made a part

* R39, a special grade of powdered mica molded with a bakelite binder, and seasoned in the molding process.

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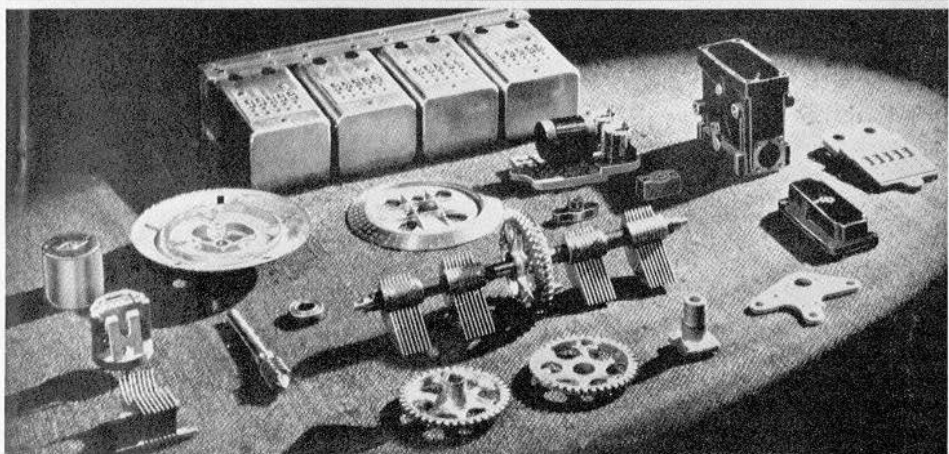
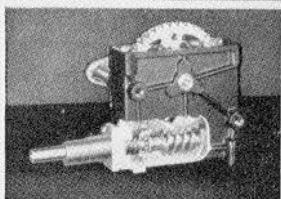
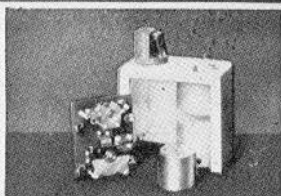
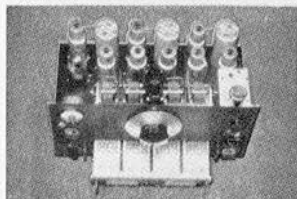
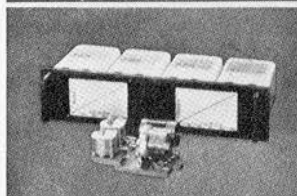


THE HRO

A few of the 59 air-dielectric condensers that make each HRO drift free are illustrated on this page, plus a few of the moldings that contribute to its efficiency, and a few of the machinings that lend it precision.

It is as unique in construction as in performance. Look it over at your dealers.

National  Company



Advertisement of the HRO appearing in the June, 1935 QST.

of the main chassis and the cable eliminated.

In the first advertisement in *National Bulletin**240⁶, it is of interest that the receiver was listed with two AC power packs, a #5897 for the 2.5 V model and the #5886 for the 6.3 V model. Within a short time it was determined that when the 6.3 V tubes were used with AC there was a modulation hum centered around 15 mc, and from then on the 6.3 V model was recommended for use only with batteries. The situation was not reversed until 1939, when it was announced that the new tubes were free of the defect, and an AC pack (#697) was available for use, as long as the B+ voltage was kept within limits. For rack mounting, the AGX receiver power supply, the GRSPU, could be used.

The list price was \$233.00, without tubes, speaker, or power supply, but including the four standard coil drawers. The 2.5 V power supply listed for \$26.50, and when the cost of the tubes was added, it totaled to a small fortune in 1935, even after the amateur discount was considered. Additional coils and a panel for relay rack mounting were also available as extras.

In the October 1934 issue of *QST* the first advertisement of the HRO showed a picture of the shop development model, with its unique dial and massive coil drawer. *Sales Catalog* #240, bound into the same issue of *QST*, gave details enough to make the average ham's tongue hang out. As a tribute to the sales organization, the Delaware Radio Sales Company also advertised the receiver in the same issue, using the same picture, even though first shipments to the dealers were not made until the end of November, 1934. Production models differed slightly in appearance from the first photos.

Inspection of the finished receiver showed a pleasing symmetrical appearance, both inside and out, with the heavy construction in the tuning circuits very evident. The wiring and components under the chassis were neatly arranged, and although in the pre-war models the wiring was not cabled, it did not detract from the appearance or performance. The circuit constants were precise enough that when set for bandspread coverage, each of the existing major bands started at 50 and ended at 450 on the dial, exactly. On the general coverage setting, each coil set covered two ham bands, the first at 50 and the second at 450. The large number of special machinings, castings, and moldings were apparent to

the discerning eye, and later advertisements promoted this feature as contributing materially to the high performance of the receiver.

Changes with time were inevitable, but it is interesting that the few major changes which were incorporated into the receiver as the years went by reflected advances in component technology (tubes, for example) and attempts to stabilize the oscillator. The early models can be recognized by the black chassis, the satin-finished PW dial, the metal encased S-meter, and the white push button under the meter. It is questionable if serial numbers can help in identifying the age or production sequence of a particular set; the writer has been informed that the numbers were assigned in a random sequence to confuse the competition.

Most visible changes occurred during 1935 and 1936, the first two years of production. The chronology is blurred by production lead times, but by December of 1935 the coil charts were the familiar black background with white calibrations, the white PB switch had been changed to the push-pull version, and a dial light had been added. By February of 1936 the plastic encased S-meter had replaced the earlier metal version, and by mid-1936 the round IF transformers were supplanted by the rectangular IFC style.

The "HRO Jr." was announced in February of 1936. This was an attempt to lower the price by marketing a standard HRO stripped down to the basic circuit. The crystal filter and S-meter circuits were omitted, and only one coil drawer covering two ham bands (GC range only) was included. Amateur net with tubes was \$99.00, and the #5897 power pack added another \$15.00. The idea was that the additional parts could be added later as desired, but experience soon showed that the stripped down version was more than adequate for most commercial and ham activities. The original model was now known as the "Standard HRO", and in due course would be referred to as the "HRO Sr."

In March 1937, Millen noted that after two years on the market, the most significant changes was the finish of the PW dial. By 1944 the tech manuals listed at least 10 versions of the receiver, but the appearance was virtually unchanged. And in 1964, 30 years after the introduction of the original HRO, the HRO-60, although changed electrically, was still a recognizable HRO, with the familiar PW dial and the plug-in coil drawers.

Why was the HRO receiver so successful? The answer lay in a combination of superb engineering and fortuitous timing. There occurred within a relatively few years an unparallel expansion of radio communications brought on by the growth of aviation and by the rearming of the major powers for WW II. The military required equipment which was rugged, reliable, and simple to operate, and the HRO engineering easily met these demands. The receiver had been working well for the airlines, with many installed in remote locations and running continuously (some with the PW dials removed). And it received publicity by being used in the Hughes around-the-world flight in July of 1938.⁷ Large numbers were sent to England at the beginning of the European war, and a picture in the *Saturday Evening Post* showed rows of HROs in the War Room of the British Admiralty. When the U. S. entered WW II, the National HRO was being advertised as *an old friend of proven dependability*. By the end of the war, National receivers were being used upon 90% of all U. S. Navy ships, and while no numbers are available, it is assumed that a substantial percentage were HROs. Incidentally, both the Germans and the Japanese copied the design for their own use⁸.

And why was it called the "HRO"? It was first christened the "HOR" receiver, the letters standing for "*Hell of a Rush*", because of the pressure on the mechanical development

team. In due course, the letters were scrambled, it became "HRO", and the designation stood⁴.

A subsequent article will describe some restoration procedures for the HRO.

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Author's Notes:

The writer would like to hear from anyone who has further information relative to the development of the HRO. Names of design engineers and their contributions, problems and their solutions (if any), and stories of general interest would be appreciated.

I I GOOD READING I I

A review:

ELECTRICAL AND ELECTRONICS TECHNOLOGIES

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Do you have a room full of radio books and magazines which you have over the years used for reference? How would you like to have all your scribbled notes in one highly useable form? Such a hard-covered book is the newly published "Electrical and Electronic Technologies" now available for only \$16. The author has compiled the most outstanding radio and electrical events from 1900 to 1940 in chrono-

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