Vintage Radio

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The National SW5 Battery-Powered "Thrill Box" Receiver

A classic American shortwave radio from the 1930s

The SW5 with its matching external speaker (above) and reproduction power supply.

High-performance shortwave radios became popular in the USA in the late 1920s and early 1930s, with quite a few manufacturers getting involved. This began happening at a time when home-made receivers were the norm for shortwave reception and manufacturers were just getting to grips with the problems of sensitivity, selectivity, frequency stability and ease of use for such sets.

THE PIONEERS OF shortwave radio manufacture in the USA were Hammerlund, Hallicrafters and National Radio Company, all of which subsequently disappeared from the field. In particular, the National Radio Company was based in Malden, Massachusetts and in 1928, it employed James Millen as chief engineer. His leadership and technical know-how subsequently resulted in a number of very good shortwave receivers being produced, starting with the model SW3 around 1928 and followed later by the SW4 and SW5, the latter produced from around 1930-1932.

This SW series of receivers were all called "Thrill Box". Perhaps that was because they thrilled the user by their ease of use, particularly when compared to other receivers of the era.

The SW5 "Thrill Box"

As shown in the photos, the SW5 shortwave receiver was housed in a metal coffin-style cabinet with a crackle finish (although it looks more like a crinkle finish). The dark brown was very much the colour of choice for most radios of the era.

The three controls are laid out neatly across the front panel, with the regeneration control at left and the tuning control at centre with a numbered dial-scale immediately above it. Frequencies were not directly marked on dial scales at this stage of radio development and so listeners usually made a list of where the various stations appeared on the scale. With the "Thrill Box", several lists were necessary as this is a multi-band receiver.

The final control (at right) is for antenna peaking and this was simply adjusted for best reception of an incoming signal.

As well as these controls, the set also features an on-off switch. This switch is located inside the set, in the front lefthand corner of the chassis.

Changing frequency bands

Despite tuning several bands, there is no band-change switch on the SW5. Instead, in order to change bands, it is necessary to remove two plug-in tuning coils and swap them for another pair that correspond to the wanted frequency band. A selection of tuning coils is shown in one of the photos.

Both the loudspeaker and the power supply are external to the receiver. The set uses battery valves, so power is normally supplied by a bank of batteries supplying 2V for the filaments, -3V and -22.5V for bias, and +67.5V and +135V for the high-tension (HT) rails. The receiver could also be used with an external mains 110V 60Hz AC power supply. This had to be an external supply as unwanted 60Hz hum would be induced into the detector and/or audio transformers if it was mounted inside the cabinet.

It's also worth noting that not everyone used a loudspeaker when listening to shortwave back in the 1920s and 1930s. Instead, many people preferred to use headphones as ship operators commonly did, perhaps because it looked more "professional".

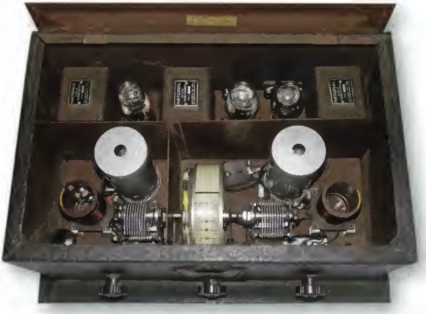
With the four pairs of plug-in coils normally supplied, the receiver can be tuned from 2609kHz to 19,355kHz. Another three pairs of coils could also be purchased which extended the tuning from 2729kHz down to 526kHz, giving seven pairs of coils for a full set (ie, 14 separate plug-in coils).

At least, that's according to some of the literature I have on this set. Other literature indicates that the set could tune from 1.5MHz to 33.3MHz as standard and with additional coils, could tune as low as 90kHz and as high as 35MHz. Whether these are National Radio Company figures or whether enterprising amateurs decided to extend the tuning range is unknown. In my opinion though, it would not be easy to get it to operate reliably all the way up to 35MHz.

Operating ease

Prior to the "Thrill Box" series of shortwave receivers, most shortwave sets were homemade and it usually took considerable skill to get them to perform well. Unfortunately, most had significant deficiencies. There were not many builders who fully grasped and understood the intricacies of radio design during those early days.

However, James Millen was one who did understand and considerable time was spent designing the "Thrill Box" series of receivers to make them easy to use. These sets are the forerunner of the communications receivers that



The lid of the SW5's cabinet is hinged at the back, so that it can be opened to change the plug-in coils for different bands. There are just three front-panel controls: regeneration (left), tuning (centre) and antenna peaking (right).

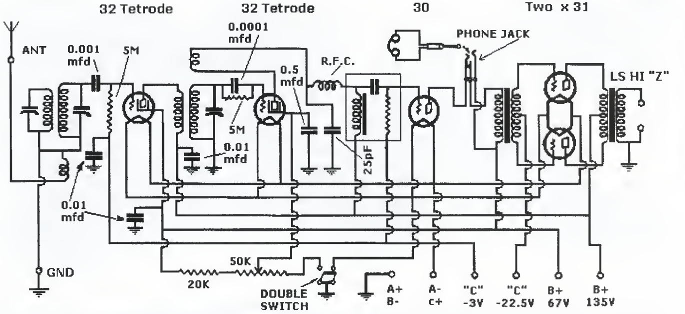


Fig.1: the SW5 receiver is a 5-valve regenerative design with plug-in coils in the front-end to tune various bands up to about 33MHz. Two type 32 valves form the RF and detector stages, while a type 30 acts as an amplifier. The latter then drives a transformer which feeds the grids of two type 31 output valves wired to operate in class-A push-pull mode.

This photo shows just some of the plug-in coils used with the receiver. Four pairs of coils were supplied as standard and additional coils could also be purchased.

became well-known a few years later, eg, the National HRO.

Circuit details

Let's take a look now at the circuit details for the National Shortwave "Thrill Box" – see Fig.1.

In operation, the signal from the antenna coil is inductively coupled into a double-tuned input circuit. One side is individually tuned to frequency while the tuning capacitor in the second tuned circuit is mechanically coupled to the tuning capacitor for the detector stage (few sets had ganged tuning capacitors at this stage of receiver design, ie, around 1930).

In this set, the shaft coupling the two tuning capacitors together goes through a metal shield which separates the RF amplifier and detector stages inside the case (see photo). Note that relatively small-value tuning capacitors are used, ie, around 90pF maximum. This makes tuning the high-end shortwave frequencies easier than when using larger-value tuning capacitors because it restricts the tuning range to 1.75:1.

By contrast, most receivers have a tuning range of 3:1 (ie, the ratio of the highest to the lowest frequency) in any selected band.

In addition, National developed a new type of tuning capacitor to overcome some of the shortcomings in earlier tuning capacitors.

As shown, the RF tuned circuit is coupled via a 0.001μF (1nF) capacitor to the grid of a type 32 sharp cut-off tetrode valve. This amplifies the applied signal and feeds it to the next plug-in coil assembly which forms part of a regenerative detector grid tuned circuit.

The grid leak resistor used here is 5MΩ and this is shunted with a 100pF grid coupling capacitor. The regenerative detector is another type 32 tetrode and the regeneration coupling coil is in the plate circuit. The regeneration level is set by varying the screen voltage of the type 32 from 0-48V using a 50kΩ potentiometer which has its wiper connected directly to the screen.

The output from the detector stage then goes through an RF choke (RFC) to remove most of the RF signal that's superimposed on the audio. It's then fed via a capacitor to the grid of a type 30 triode valve and amplified. The plate circuit of the type 30 is connected via a headphone jack to either a set of headphones or, if no headphones are plugged in, to the primary of an audio push-pull driver transformer.

This transformer is connected to the grids of the two type 31 output valves wired to operate in class-A push-pull mode. The bias on these two valves is -22.5V and their current drain is around 16mA. This push-pull stage then drives the loudspeaker via an audio output transformer.

The nominal speaker impedance specified for use with this transformer is around 1000Ω. However, in order for a normal low-impedance speaker to be used, a 1000Ω:8Ω line transformer has been added to the original circuit. The audio gain of the type 31 valves is quite low at a maximum of 3.8 times, so the preceding type 30 stage has to work fairly hard to drive these valves to a reasonable output.

The valve filaments are rated at 2V and these would normally be powered by a 2V lead-acid cell capable of supplying around 0.45A. The high-tension voltages (67.5V and 135V) are also supplied by batteries and the maximum current is around 23mA.

The bias batteries have virtually no current drawn from them and so lasted many years. In fact, I have seen some bias batteries from the 1930s that still have a reasonable output voltage. The on/off switch opens (and closes) the filament return line to the chassis and disconnects the voltage divider across the 67.5V battery, so that no current is drawn when the set is turned off

Physically, the chassis is laid out in a logical fashion so that there is little interaction between stages. In addition, the various sections of the receiver are shielded from each other in the interests of stability.

Basically, the RF stage is to the right-front of the chassis and is shielded from the detector stage to the left-front. Both RF valves are also individually shielded. The audio amplifier section is at the back of the chassis and is also shielded.

Restoration

The receiver featured here was obtained in very good mechanical condition. Unfortunately, some plug-in coil sets were missing but there are enough to make for some interesting shortwave listening.

A few quick checks of the receiver with no power applied revealed that the grid resistors attached to the two 32 valves were open circuit. These were both replaced, along with the 20kΩ resistor attached to the 50kΩ regeneration potentiometer.

This is the view underneath the chassis. The set is logically laid out and the various stages on top of the chassis are separated by metal shields to prevent interaction between them.

Initially, no circuit was available and it seemed that the "audio transformer" (as marked in the set) at the output of the detector had an open circuit secondary winding. Once the circuit was obtained it was clearly obvious that this so-called transformer was not a transformer at all. Instead, it consisted of an audio choke with a coupling capacitor from the valve end of the winding to the grid of the type 30 audio valve. A grid resistor for this valve was also enclosed in this assembly.

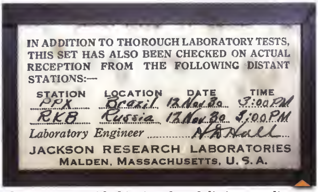
Just why the resistor and capacitor were enclosed in the choke case is a bit of a mystery. In any case, something wasn't quite right here so the unit was carefully dismantled (see photograph). Both the mica coupling capacitor and the grid resistor had failed, so these were promptly replaced. The values of these two parts are not shown on the circuit but both still had their values marked on them.

Further checks revealed that all the mica capacitors underneath the chassis were leaky. As a result, they were disconnected from the circuit and new ceramic capacitors wired in beneath them to retain the original look. In fact, all the fixed capacitors and resistors had to be replaced. Fortunately, no coils or transformers needed replacement as the original types would now be difficult (if not impossible) to find.

A simple numbered dial-scale was used in the SW5 receiver, so users normally kept a list showing where various stations appeared.

Many early radios used very few fixed components (to keep costs down) and the addition of one or two bypass and/or decoupling circuits can often improve the performance. In this set, RF was present on the 135V HT rail (as "seen" by an oscilloscope) and this was eliminated by connecting a 47µF capacitor and a parallel 10nF ceramic capacitor from this rail to chassis. This also provides extra HT filtering.

In addition, a new power supply



The unit came with this signed card, listing two distant shortwave stations that had been received during factory tests.

Left: inside the so-called "audio transformer". The enclosure actually holds an audio choke at the output of the type 32 detector, along with an associated coupling capacitor and the grid resistor for the type 30 valve. Both the capacitor and the grid resistor had failed and were therefore replaced.

lead was made up. This exits from the back edge of the chassis and runs to a home-made mains power supply, as batteries are either very expensive or now unobtainable. This AC mains power supply was built into a case that resembles the original 110V AC power supply, with all the necessary output voltages catered for.

Testing

Having carried out these repairs, it was time to test the receiver. This was done by plugging in a set of coils, connecting a loudspeaker and an antenna and using a signal generator to inject a modulated sinewave signal into the RF amplifier stage.

This simple test revealed that the audio was of good quality at the headphone jack. However, when I subsequently tuned to a local radio station, the audio from the speaker was atrocious. The high-impedance speaker used with the set was perfectly OK, so the problem obviously lay somewhere in the push-pull output stage.

This fault was tracked down by once again injecting a modulated sinewave signal from the signal generator. Checking with an oscilloscope then showed that a good sinewave signal was present at the headphone jack. However, when the scope probe was connected to the plates of the two 31 valves, one showed the expected half sinewave while the other showed almost nothing.

This indicated that that particular type 31 valve was defective and replacing it immediately cured the fault.

It didn't take long for the next problem to crop up. After tuning across the band a few times, the dial cord broke so that also had to be replaced.

This set has one of the early cord-drive systems and the dial-cord used was quite coarse, being much larger in diameter than the dial-cord available today. However, for sets of this vintage, nylon builder's line makes good dial-cord and so that was used to restring the dial.

Performance

These receivers were very good performers for their time. This set is quite sensitive and is relatively easy to tune but is subject to overload on the broadcast band. In my case, a strong local station could be heard in the background right across the band.

The set can also be a bit fiddly to operate, as there is a degree of interreaction between the various controls.

One thing that did puzzle me initially was that the set's performance varied from one band to the other. However, after searching the internet, I discovered that the coil formers used in this set (and many others) up until around 1931 were made of a material that absorbed moisture. This adversely affected the tuned circuits and degraded the set's performance.

Summary

This is a well-built receiver which used the best technology available at the time. It's a pity that the coil formers give problems, since coil formers that didn't absorb moisture became available not long after the set was manufactured.

As stated, the receiver is prone to overload from strong local stations and it has no volume control other than the regeneration control. This probably didn't matter too much at the time, as the receiver (in standard form) only came with shortwave coils and there weren't many strong shortwave stations around in 1930. However, strong local broadcast-band stations were springing up around the country at this time, so overload on the broadcast band would have become an increasing problem (a set of coils for the broadcast band and the low shortwave band were sold as an accessory pack).

Detuning the antenna tuned circuit and reducing the size of the antenna would have helped solve this overload problem, as would placing a 50pF capacitor in series with the antenna or installing a wave-trap in the antenna lead. **SC**