Vintage Radio

By Dr Hugo Holden

The Grebe Synchrophase MU-1 5-Valve Radio

If ever there was a radio that looked like it escaped from the laboratory where H. G. Wells' Time Machine might have been built, the Grebe MU-1 is it. Emanating from the electronics industry in New York in the mid-1920s, it really is an astonishing masterpiece of construction.

Grebe struck a combination of form and function with the MU-1 which, by any standards past or present, was extraordinary. At that point in history, 10 years was a very long time in the electronics industry and many radio companies made their fortunes during that era and then folded. Those that survived then faced the Great Depression of the 1930s.

Alfred. H. Grebe

Alfred H. Grebe (1895-1935) was by all accounts a child prodigy who showed an interest in electrical engineering and radio technology from a very young age. His first factory started out as a tool-shed in Richmond Hill, a borough of Queens in New York. His initial products were items such as simple crystal detectors.

During WW1, Grebe supplied radio apparatus to US Navy vessels and to the Allies. By 1922, the old factory had been torn down and a new, well-equipped facility built which housed two radio stations, WAHG and WBOQ.

The Synchrophase MU-1 radio became available around August 1924. An improved model, designated the MU-2, was subsequently released and this was produced until 1927. It is estimated that over 150,000 MU-1 & MU-2 radios were built over that time.

Grebe manufactured their own tuning capacitors, including an SLF (straight line frequency) type for the MU-1. This type of tuning capacitor used specially-shaped vanes to give a linear tuning response across the 0-100 dial scale. They also made rheostats to control the tube filament current and another type of switched variable resistor called a "color-tone" control. In addition, Grebe designed and built the radio's characteristic "binocular coils".

The Grebe's tuning system is unusual. It has three vertical tuning capacitor shafts fitted with edge controls. The three tuning capacitors are ganged together with a chain drive. This assists tracking and this allows easy tuning and station finding. There is enough chain slack to allow a small mount of fine adjustment.

Unfortunately, the Grebe Company went bankrupt during the 1931 to 1932 period, which was typical of the fate of many companies during the Depression. The company's founder, Alfred Grebe, subsequently died in 1935 at the relatively young age of 40 due to complications from bowel surgery.

Stability and neutralisation

Fig.1 shows the circuit details of the Grebe MU-1. The radio is a TRF type with two RF (radio frequency) stages (V1 & V2), a grid-leak detector stage (V3) and two stages of transformer-coupled audio amplification (V4 & V5), based on the standard 01A or 201A valve types. The RF stages are both neutralised, for stability.

Looking into a triode's grid drive circuit, the input capacitance (Ci) is the combination of the grid-cathode capacitance (Cgk) and the grid-plate capacitance (Cgp). However, the latter is amplified by a factor close to the amplification of the tube (μ) and so the input capacitance becomes:

$Ci = Cgk + (1+ \mu)Cgp$

Basically, the grid-to-plate capacitance value is amplified by the valve's gain. For purely resistive input (grid) and output (plate) loading, this feedback capacitance results in negative

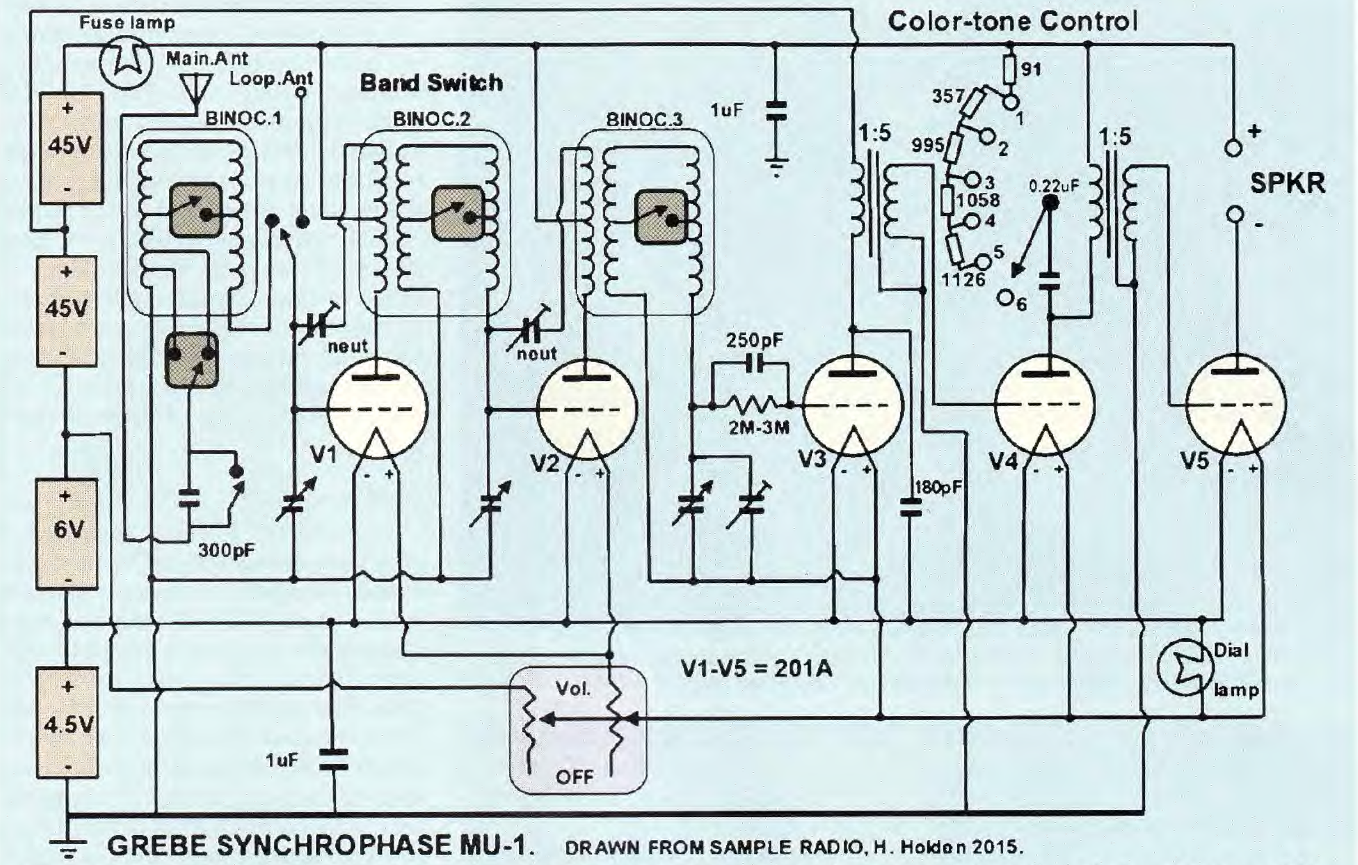


Fig.1: the circuit of the Grebe Synchrophase MU-1. It's a battery-powered, 5-valve TRF radio with two RF stages (V1 & V2), a grid-leak detector stage (V3) and a 2-stage transformer-coupled audio amplifier (V4 & V5). The valves are all 01A or 201A type triodes and the set covers two switched bands: 545-1250kHz and 833kHz-2MHz.

(degenerative) feedback because the signals at the grid and plate circuits are 180° out of phase. This rolls off (or lowers) the high-frequency response because the impedance of the feedback capacitance decreases with increasing frequency, shunting more of the drive signal.

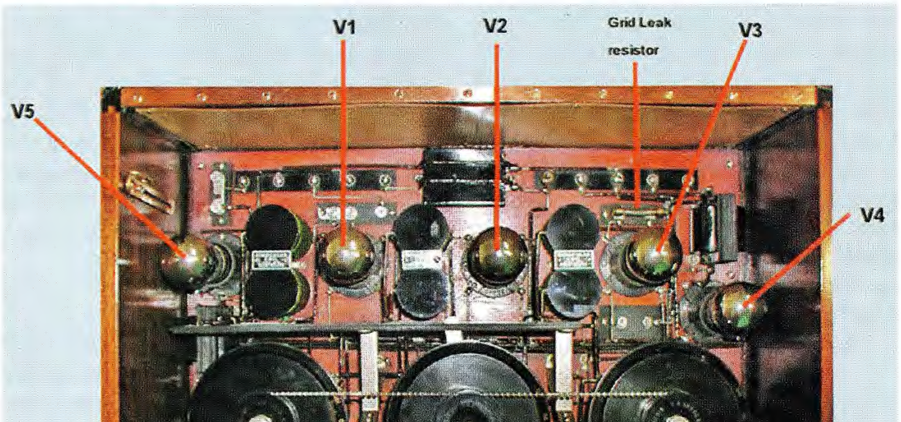
However, when tuned circuits are connected to the grid and plate, they can exchange energy with each other via the feedback capacitance. This feedback can become positive (or regenerative) and so the amplifying stage can become unstable and oscillate. To counter this, "neutralisation" is always required when a triode tube has tuned circuits with similar resonant frequencies in both its plate and grid circuits.

Conversely, no neutralisation is needed if the resonant frequencies of the grid and plate tuned circuits are far enough apart.

In the MU-1, neutralisation of V1 and V2 is achieved by an additional winding on the coil in each plate circuit which feeds back a signal to the grid via a small neutralising capacitor, called a "neutrodon" during the 1920s era. Basically, the signal fed back via the neutrodon to the grid phase-cancels the signal across the grid-plate capacitance (Cgp).

As technology progressed, the screen-grid valve was eventually developed, the screen shielding the plate from the grid circuit. This meant that neutralisation in RF & IF amplifiers based on tetrodes and pentodes was no longer required. However, neutralisation remains a common technique in triode-based RF amplifiers.

Neutralisation was also used in early transistors radios from about 1955-1965. This was necessary because germanium transistors such as the OC45



The three variable capacitors inside the Grebe MU-1 are linked together by a chain, so that they track together when stations are being tuned.

The MU-1's resonant or "tank" circuit is wound with green Litz wire and is divided across two separate coil formers. These are placed side-by-side so that any signals directly picked up by the coils are cancelled out.

were used in 455kHz IF amplifiers and these have a high collector-to-base capacitance, analogous to anode-grid capacitance in a triode.

As with valve circuits, neutralisation also eventually disappeared from transistor radios. Newer transistors such as the OC171 and AF125 (and the later silicon transistors) had very low collector-base capacitances, so neutralisation was no longer necessary.

If a triode valve is deactivated by turning off its filament current, the capacitance amplifying effect is eliminated and the value of Cgp can be accurately cancelled by adjusting the neutralising capacitor. This was the method commonly employed to adjust the neutrodon. It's interesting that this adjustment technique has no counterpart in the world of semiconductors as their gain cannot be deactivated with their collector-base feedback capacitance remaining.

That's because their feedback capacitance is affected by the collector-base voltage, much as it is in a varicap diode. It's simply not possible to deactivate the transistor's gain without altering its DC conditions.

The neutralisation circuit, or the "Neutrodyne" as it was called, was originally designed by Louis Hazeltine and was licensed in the 1920s era by a group of more than 20 companies that were members of IRM (Independent Radio Manufacturers). Grebe was not a member of IRM and was subsequently sued in 1927 but by then most of the MU-1 radios were obsolete. Grebe lost the case and had to obtain a Neutrodyne licence.

At least Grebe did not have to worry about Armstrong's regeneration patent, as it is not used in the MU-1.

Tuning frequency range

The Grebe MU-1 (except for some early production models) has two switched tuning ranges: 545-1250kHz and 833kHz-2MHz. The latter range is achieved using a sliding band switch which shorts out some turns on the binocular tuning coils. However, due to the binocular design of the coils (see below), this doesn't alter their Q to any great extent.

The band switching occurs automatically at either the 0 or 100 setting of the main central tuning dial. It's arranged so that the tuning mechanism pushes the slide switch one way or the other when the central tuning knob passes the end of its range. It can also be switched manually if one opens the radio's lid.

Binocular coils

The MU-1's resonant or "tank" circuit is wound with very attractive green Litz wire and is divided across two separate coil formers, hence the "binocular" appearance. Grebe checked the RF impedance during manufacture to ensure that every strand of the Litz wire had been soldered.

The two coils are placed beside each other and because the windings run in opposite directions, this reduces their mutual coupling. Any signals (eg, from radio stations or due to interference) radiated directly into this coil arrangement induces out of phase signals in the two coil halves and so the phases cancel. There's also limited signal pick-up from radio stations because of the vertical orientation of the coils.

The result was similar to that achieved with coil shielding but with no actual metal shield which always has the effect of lowering the circuit's Q.

Audio system

The detected audio at the anode of grid leak detector stage V3 is transformer-coupled into the grid of audio driver stage V4. This stage is then transformer-coupled to the audio output valve V5.

One notable feature is that V4 has a tone control circuit consisting of a "color-tone" switched variable resistance (based on insulated nichrome wire) and a series 0.22µF capacitor. It's interesting that they made the radio's tone control label analogous to a visual experience like colour. However, it's really not much different than some of the other analogies commonly used, such as "warm" sound or "bright" sound. So I do like the way they labelled this control.

When I received the radio, I noticed during the restoration process that the "color-tone" switched resistor was open circuit due to corroded nichrome wire.

It appears that insulated nichrome resistance wire was, and still is, available in various gauges from wire specialty companies in North America. By contrast, the British & Europeans preferred "Constantan" or "Isotan" wire and this is also still available, either bare or insulated.

Constantan wire is a mixture of copper and nickel and its resistance has a nearly zero temperature coefficient over a wide range. Not only that, it is extremely easy to solder (unlike nichrome), doesn't have the annoying springy quality of nichrome wire and is corrosion resistant.

In my case, I was able to rewind the color-tone control using about 43 metres of 36 AWG insulated nichrome wire which I tracked down in the USA. However, I could have equally well used insulated Constantan wire which is more readily available on eBay.

Volume control

The volume control in the MU-1 consists of a dual-gang rheostat which controls the filament current to all five valves. Power for the filaments is provided by a 6V lead-acid accumulator designated the "A" battery. The other batteries are two 45V types connected in series and together these make up the "B" battery which supplies the HT. This "B" battery supplies 90V to the plate circuits of V1, V2, V4 & V5, while detector stage V3 is supplied with 45V HT (the detector stage will also run from 22.5V if required).

In addition, a 4.5V "C" battery is used to negatively bias the grid circuits of V4 and V5 so that these valves are correctly biased for class-A operation. The loudspeaker is a high-impedance type and is placed directly in the anode circuit of V5 without a matching transformer. Grebe recommended the use of a paper-cone speaker rather than a metal diaphragm horn speaker to improve fidelity.

The two interstage audio transformers appear to be identical in my radio but some models have transformers with different sizes. Grebe made their transformers "in house", including the lamination stampings. They have a primary DC resistance of around 350Ω and a secondary resistance of around 6kΩ. The turns ratio is around 1:4.9, while their impedance ratio is about 1:24.

Grebe filter capacitors

Grebe fitted two box-shaped "non-electrolytic" filter capacitors to the MU-1, one across the 90V B+ rail and the other across the C+ rail. These two capacitors were enclosed in a single case and had a measured value of around 1μF in my radio, although values of 1.5μF were reportedly used in other radios.

Both capacitors in my radio had a high leakage current, so the case was opened and two high-quality 1μF 630V polyester capacitors substituted. These capacitors were simply soldered to the metal strip contacts and held together with fibreglass tape for mechanical stability.

Fuse bulb

Instead of using a traditional fuse, Grebe fitted a 1.5V torch bulb in series with the 90V B+ supply to act as a fuse in the event of a filament-to-plate short circuit in one of the valves. Apparently, this could happen if the cabinet's lid was slammed shut or drop-closed, rather than gently lowered into position. This light bulb "fuse" helped to protect the transformers and coils in the radio from being burnt out by the B+ supply if a short-circuit did occur.

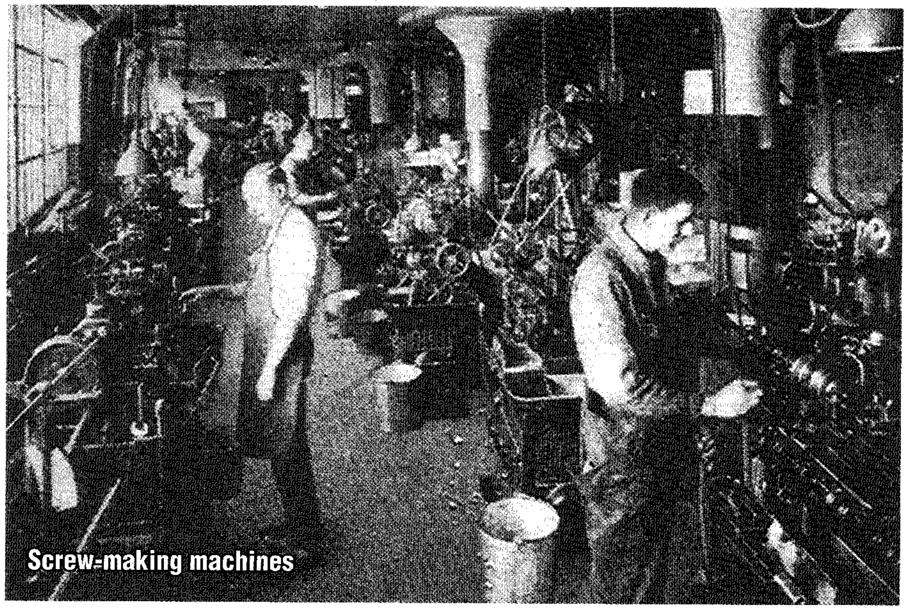
Many Grebe radios also included a 6V dial lamp. This was powered from the filament supply and lit the central knob scale via a small gap between the escutcheon & knob.

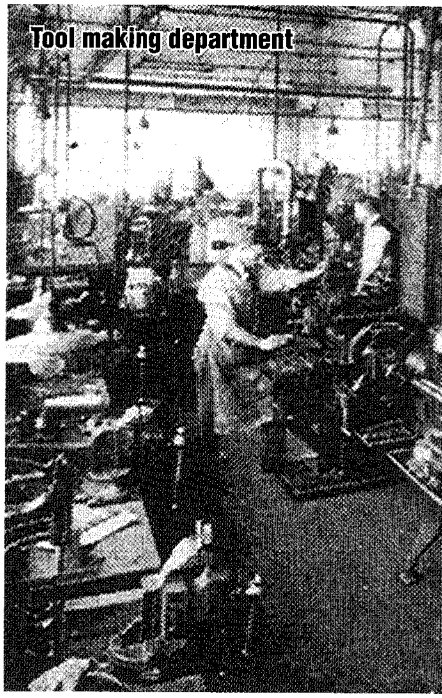
Physical construction

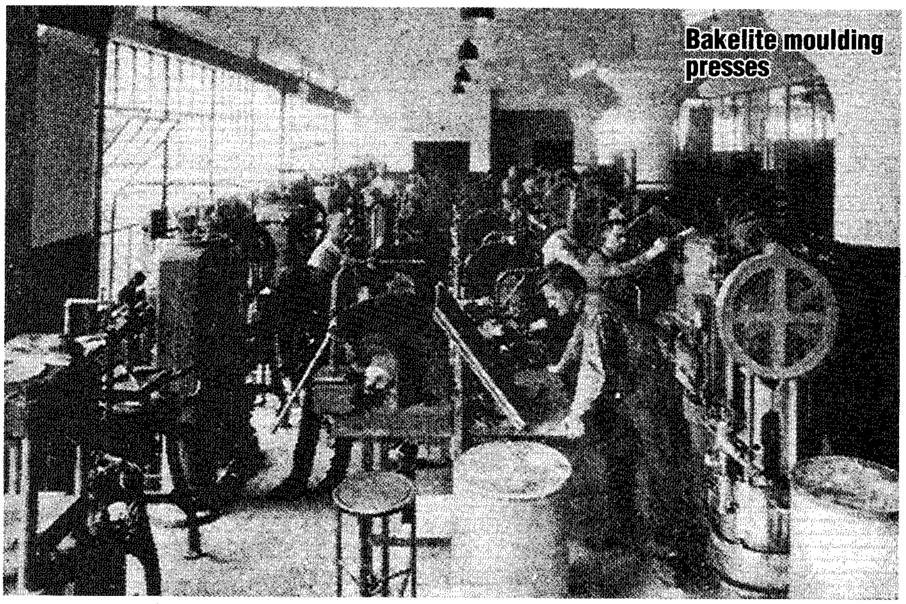
The MU-1's cabinet is made of solid mahogany, while the front panel is made from polished Bakelite with a deep red, patterned appearance. The escutcheons around the edge knobs

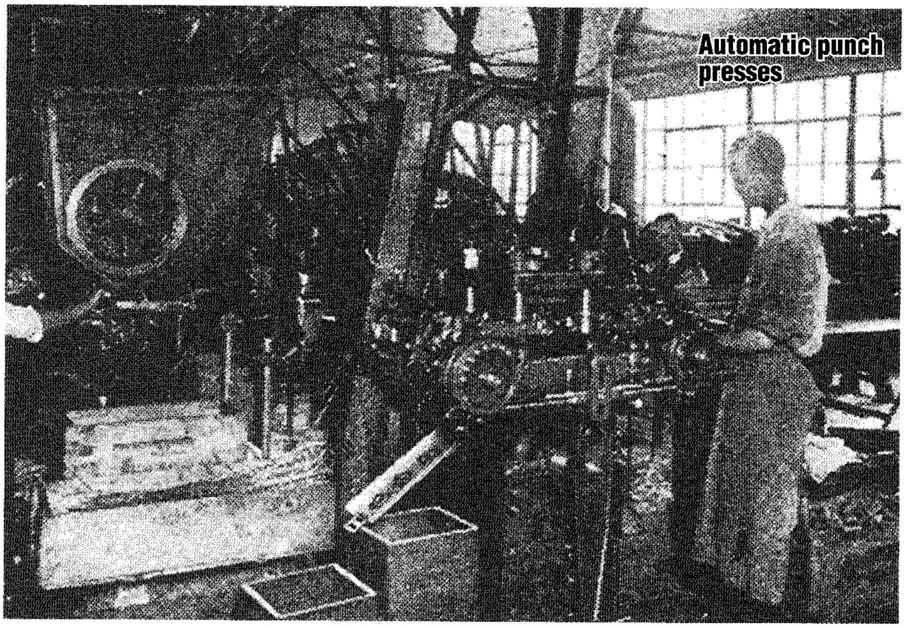
A card attached to the inside rear panel of MU-1's cabinet details the receiver's features, while a second card shows the battery and speaker connections.

The two 1μF bypass capacitors used in the circuit are housed in a box-like case. This photo shows the two replacement capacitors wired in position across the internal metal strips.









Left & above: this group of photos shows various sections of the Grebe Company's factory during the 1920s. Grebe manufactured most of the parts for their radios, including tuning capacitors, coils, rheostats and even Bakelite valve sockets. The company ceased operation during the Great Depression.

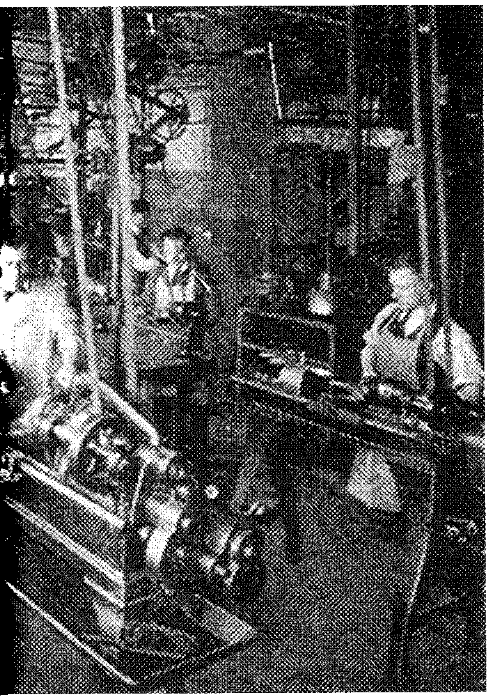
are pressed from brass and were gold-plated and clear-lacquered. These had darkened to black on my unit when I first received it. However, I found I could restore them to a gold-like finish by lightly polishing them and applying a protective lacquer.

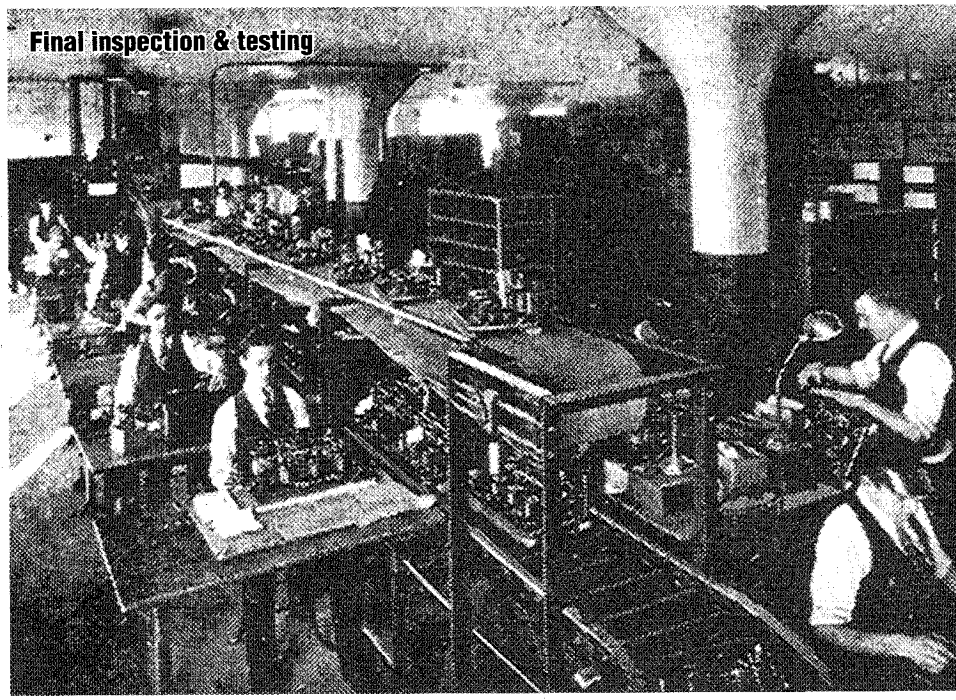
The cabinet finish on my radio was also was very poor and so it was stripped and refinished to make it look new again. As shown in one of the photos, a card attached to the inside of the cabinet details the receiver's features, while a second card shows the battery and speaker connections.

It's interesting to note that Grebe even made the Bakelite valve sockets fitted to the MU-1 and these used special "springy" pins to help minimise microphonics. It appears that two different socket variations were used over the years.

Cryptic serial numbers

Each Grebe MU-1 has a cryptic serial number system which has thus far stumped collectors. It consists of four letters on the instruction card inside and also engraved into the inside front panel and filled with white paint.





Grebe must have had a secret method to decode the manufacturing date or other features from these letters. To date, none of the letter combinations has been found to correlate with the various changes that Grebe made from 1925-1927. If you feel inspired to crack this case, search the net on this topic and buy a copy of "The Code Book". Perhaps the Germans should have had Grebe build their Enigma Machine!

Neutralising the MU-1

It's quite easy to neutralise a Neutrodyne receiver such as the Grebe MU-1.

The first step is to set the volume control mid-way and couple a strong 1kHz (or thereabout) modulated mid-band signal to the antenna. The radio is then tuned to this signal and the generator level adjusted to give a moderately loud audio output.

The first RF valve (V1 in this case) is then removed from its socket and the radio re-tuned for maximum audio output (the audio will now be quite faint). A small amount of paper is then wrapped around one of V1's filament pins to insulate it and V1 reinstalled (ie, V1's filament circuit is disabled).

Using a low-capacitance insulated tool, the small neutralising capacitor associated with V1 is then adjusted to give minimum signal output. And that's all there is to it – the stage is now neutralised and V1 can now be removed and refitted to its socket without the insulating paper.

The same process is repeated to neutralise the stage based on V2.

Grebe's marketing strategies

Because of their high quality, one might think that Grebe radios would have sold themselves and that marketing gimmicks would not have been required. However, Grebe created a fictitious Chinese doctor named "Dr Mu". This referred to the symbol "μ" which is the amplification factor of a valve and, in fact, the "μ" symbol is seen on his hat.

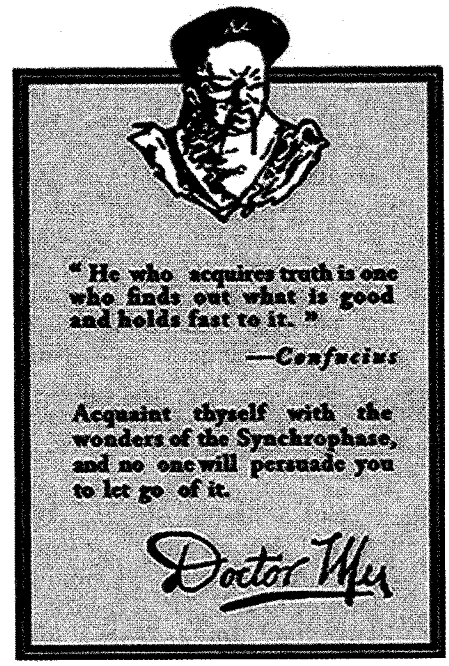
Dr Mu would quote Chinese philosophers and link their wisdom with the quality and value of Grebe radios. Grebe used Dr Mu from the early 1920s to help market all their radio models.

Low audio output

The Grebe radio, like many radios from the 1920s, uses a single 201A valve as the audio output device. This means that its maximum audio output without significant distortion is only about 20mW, depending on the speaker impedance and battery voltage.

One reason for its low output relates to the 201A's high plate resistance. This is around 11kΩ and is a poor match with the speaker impedances commonly used which were invariably much lower values.

By contrast, the UX112A valve, which is basically a higher power version of the 201A, has half the 201A's plate resistance and is capable of delivering 30mW with a 90V supply, or about 115mW with a 135V supply and an appropriately matched load.



A fictitious Chinese doctor called "Dr Mu" was part of Grebe's marketing strategy for the MU-1 Synchrophase.

It's difficult to imagine how Grebe could have improved the MU-1. The physical build of this radio is outstanding, the appearance delightful and the performance nearly as good as a superhet. In my opinion, it has certainly claimed its place in radio history and makes a great addition to any vintage radio collection. **SC**