

BEETHOVEN “BABY 555” A REGENERATIVE PORTABLE RADIO FROM 1937.

(H. Holden, Nov. 2025)



REGENERATIVE RADIOS:

(Note: The word Valve is used mainly in this text to describe a Vacuum Tube as this is a more popular term in the UK & Australasia, in America though, the preferred term is the Tube)

These should not be confused with a TRF radio. TRF Radio Receivers were very popular in the 1920's and 1930's era. Basically they were analogous to a Crystal set but with active stage amplification. No positive feedback was used. They were simply a chain of tuned bandpass Amplifiers and a Detector to recover the Audio modulation.

The John Reinartz radio design was reviewed in Silicon Chip, October 2025 Vol 38, No.10 on page 94. It is a Regenerative radio not a TRF. By definition the feedback around V1, the Tuned Stage made it a typical Regenerative Radio. The mutual coupling between the two coils L2 (the reaction coil) and L1, the tuned coil and their polarity,

results in positive feedback, which guarantees the process of regeneration. The tube also behaves as a detector, because grid-filament (grid-cathode) current on peaks provides some rectification. This results in the audio signal component being recoverable after filtering from the anode circuit of V1. As noted in the text of the Reinartz article, a good name for V1's operating mode is a "Regenerative Detector"

Multiple regenerative radio construction articles appeared in Radio and Hobby magazines of the 1930's era. A particularly popular one in Australasia was the Hiker's One. This radio would run from a 6V B+ because it deployed a Space Charge tube. That made it a popular choice for young children because no high voltages were involved and their parents did not have to buy them expensive 45V or 90V B+ batteries either.

The basic advantage of a regenerative radio is that a very high signal gain can be acquired from one active stage alone. In essence this made the regenerative design highly attractive from the point of view of economy. Of course there is always a "price to pay" for the miracle of regeneration. It can be difficult to control it. As the regenerative stage is pushed further toward frank oscillation, the bandwidth narrows and just before oscillations or "Howling" begins, the recovered audio modulation becomes muddy and lacking in high frequency components.

This was the challenge for designers and manufacturers of Regenerative Radios in the 1920's and 1930's era: How to make the radio usable for the average member of the public. The user may have had a limited radio technical knowledge and have difficulty in being able to manipulate the regeneration control to acquire a good rather than frustrating result. The Superhet radio to come later did not have this problem.

THE BABY BEETHOVEN 555:

The Baby Beethoven model 555 portable radio had its origins in the UK. It was offered to the public in the time zone around 1936 to 1937. It is a regenerative receiver and it also uses the PM2HL valve and its equivalents, such as the HL2K and VT-50, as does the Reinartz derived radio in the Silicon Chip article does.

The basic process of regeneration results in "Q multiplication" in a resonant circuit. This happens because of energy injection, by positive feedback, at the operating frequency which overcomes circuit losses. With Q increase, the process narrows the bandwidth, increases the gain and improves the selectivity too.

A good regenerative radio can be nearly as good as a Superhet radio for gain and selectivity. With just the right amount of regeneration that is. This is somewhat

analogous to what we now have come to call “Goldilocks Circuits” because everything has to be “just right” for a good result.

In a regenerative circuit design, the designers strive to ensure that the control of the regeneration is smooth, in that the positive feedback introduced gradually, so that the user control doesn't result in the stage abruptly going into frank oscillation. If that happens the high level oscillations simply heterodyne with the received carrier and a lot of howling occurs.

Of note the “Super-Regenerative” radio is a little different again, the oscillations are set up to be blocked at a subsonic frequency, higher than the audio spectrum but much lower than the carrier frequency. This type of radio also can develop astonishingly high gain levels for a single stage, but the zero signal noise is often very high. Interestingly enough, this design has persisted through history much longer than the plain regenerative receiver. It is often used in the receiving end of short range remote control systems in home automation. It was used extensively in cheap children's transistorised walky-talkies because the Super-regenerative stage, with only a small change, readily oscillates and makes for a good transmitter. The Super-Regenerative receiver is the topic of another article.

The ideal amount of regeneration in the regenerative radio is tricky, to the extent that the required magnitude of positive feedback is practically difficult to keep uniform on different parts of the tuned band. It can also be affected to an extent by the strength of the received station. This is why, in the Reinartz circuit, the other Gang of the tuning capacitor was deployed to modify the regenerative energy injection across the tuned band, to help even that out.

Due to the difficulty of making smooth regeneration controls, manufacturers to some extent had difficulty in marketing regenerative radios to the public. Many circuit variations, such as the one in the Reinartz radio were devised to help improve the function of the regeneration control. Generally, the regeneration control, while it can also be a Potentiometer, was more often a Variable Capacitor instead. This control was seen from the radio user's perspective as being a Volume Control. Most regenerative radios, for this reason, did not have an actual volume control potentiometer in their audio amplifier chains.

The regenerative stage can also act as the AM detector as well, as it does in the Reinartz design or the popular Hiker's 1 radio and in the Beethoven 555 and it acquires the name Regenerative Detector or Regenerative Grid leak Detector.

The Misnomer of the Grid Leak Detector, or Leaky Grid Detector:

The “Leaky Grid Detector” terminology seems to be an endless source of confusion, probably because it was not aptly named.

The load resistor, of the AM detector, is responsible for discharging the capacitor between charging peaks of the RF carrier wave. The charging of the capacitor is via a *diode function* on RF peaks. The load resistor, of this lightly filtered half wave rectifier system, came to be called the “Grid Leak Resistor” This is a function it served too, but this was completely unrelated to actual demodulation of the amplitude modulated RF carrier wave.

In the vacuum Valve (tube), electrons tend to accumulate at the Grid and develop a space charge around it. If there is no DC path at all for them to “leak away” a negative charge and voltage builds up on the grid and this can cut off the valve by repelling electrons back to the cathode (or filament if that is the emitter). This can take the anode current to near zero. If very high R value grid resistors are used, in the range of 3 Meg to 10 Meg or more, the grid current passing via the resistor, although a very low current, in the order of a few hundred nA or less can result in a DC bias for many tubes in the order of 1 to 3 volts, thereby establishing some negative voltage at the grid.

This grid current method can be helpful biasing the tube, it is often done when Cathode bias is inconvenient and the cathode is better grounded. For example when the valve also has an integral Anode electrode to act as a diode with the Cathode and it is preferable that the Cathode is at common/ground potential.

Some have wondered why it was, that occasional circuits from the 1920's era, including ones seen in Patents, showed valves with absent grid resistors. And the circuits worked without any grid resistor. There were two reasons; One was that the grid electron current was very low in early valves and that capacitors and insulating materials of that era were not as perfect as what we have in modern times. Leakage resistances, even in the range the range of 10 Meg to 100 Meg Ohms, allowed the grid's electron charge to dissipate well enough, so the valve never became “cut off” in practice. As a result the circuit appeared to function in many cases, with no physical resistor at all.

And perhaps the second reason was that when these Patents were applied for, Mr. Einstein was no longer working at the Patent office to detect that this was a Physical Science oversight, in that just because something “worked” in practice, did not mean its design was correct or complete.

While it is correct that electrons pass via the grid resistor and as a result the tube can develop some negative grid bias this way, especially if the grid resistor is over a few

Meg Ohms, this part of the circuit behaviour in the “grid leak detector” is little at all to do with its function as an AM detector.

As noted, the resistance, as it is in all diode based AM detectors is the “load resistance” which discharges the filter capacitance between charging peaks by the RF carrier. It is a half wave rectifier circuit with minimal filtering. The circuit of the RF coil, feeding diode and a resistor load and filter capacitor is the same for any AM detector. The diode itself in the grid leak detector case is simply in the circuit position of the grid-cathode (or grid-filament) of the valve.

One other point of confusion with grid leak detector schematics is that the load resistance, discharging the filter capacitance, has two possible return options. Either option makes little difference to the detector’s function because the average voltage where the resistor returns remains as that of *the DC potential of the driving coil*, unrelated to the AC signal on it. So the resistor can return to either side of the driving coil with no other effect on the function of the detector.

In all cases however, the *discharge time constant* of the RC filter, being charged by “diode” conduction (which is generally a lower source resistance than the resistor value) sets the upper frequency limit that can be resolved via the detector without distortion. This is because as the modulation frequency gets higher, or the modulation depth gets higher, the capacitor cannot discharge quickly enough to *track* the modulation envelope present on the RF carrier before the next carrier peak arrives.

In the grid leak detector, the valve’s grid-filament (or grid-cathode) performs the rectification and the triode section simply amplifies the voltage across that “diode” An inverted an amplified version of that “diode’s” voltage appears at the valve’s Anode circuit. When the RF carrier is filtered off the Anode signal, only the audio component remains.

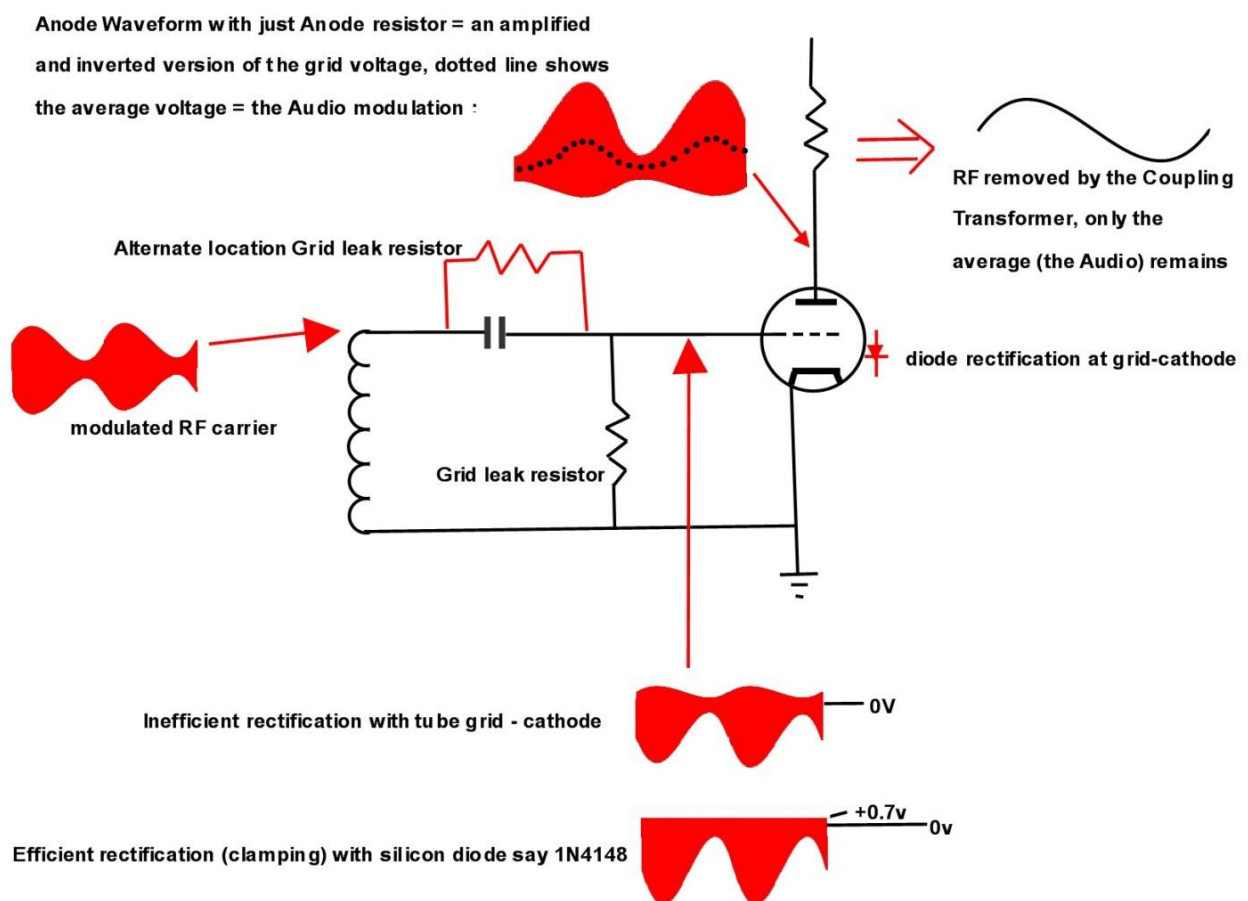
The highest audio frequency that a diode-R-C detector can resolve, without any failure to track the modulation envelope without distortion and peak clipping beginning to occur, when the modulation level is 50%, is $0.275/RC$, where R is the resistor value and C the capacitor value. In 1920’s radio designs, values such as 3 Meg and 100pF gave a fairly poor result for high frequency audio recovery. The detector’s distortion and high frequency roll off started to begin initially at least around about 1kHz at 50% modulation.

By the post war period, the AM detector situation had improved and RCA had moved to values such as 100pF with 250k, and the figure was then around 11kHz. But in a vintage TRF radio example, popular in the 1920’s a 250k value would be a somewhat heavy load and would have damped the driving tuned resonant circuit, lowering the gain and selectivity. The trouble was, in the early days, there was much more of a quest for gain than fidelity, additional valve stages were expensive.

In the Reinartz radio though, since the detector was regenerative, the losses of increased loading of the tuned circuit could have been overcome by the additional energy injection of regeneration and the 3M resistor in the grid of V1 could likely have been lowered to the 250k to 470k area to improve the detector's high frequency audio fidelity. The change in V1's dc bias conditions would be very low.

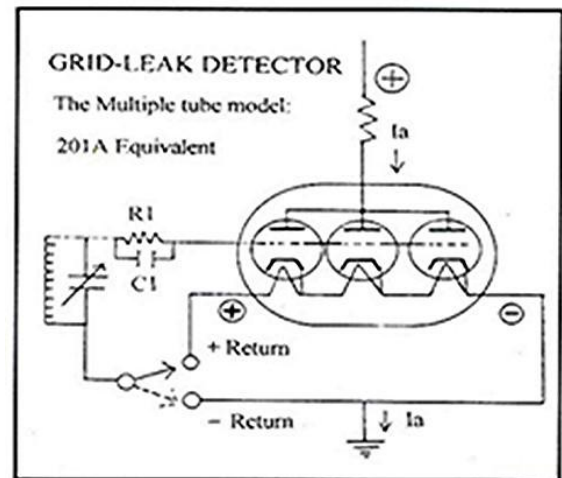
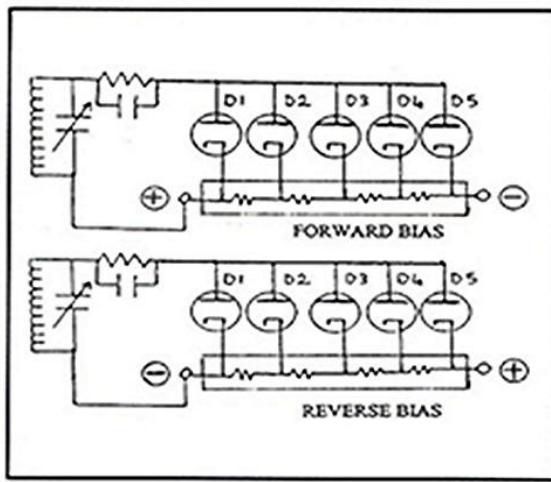
In most practical Grid Leak Detector circuits using directly heated (filament) valves, to encourage the tube to draw grid current on the positive going peaks of the RF carrier, the grid is often made a little positive with respect to the average "cathode" voltage. The grid to filament potential in a directly heated tube is distributed along the length of the filament. The usual configuration is to return the grid resistor or the RF coil to whichever side of that the resistor is connected to, to the positive side of the filament connection, for that reason.

The diagram below explains the Grid-Leak detector using an indirectly heated tube (separate cathode) example:



In directly heated (filament) valves, it can sometimes be awkward to figure out how the valve is biased because of the voltage distribution along the filament can create some confusion.

However each point distributed along the filament can be regarded as a discrete cathode emitter. Therefore the situation can be modelled as a series of indirectly heated tubes (as many as you might imagine) with their cathodes connected along a voltage gradient equivalent to the filament's power supply as shown in the diagrams.

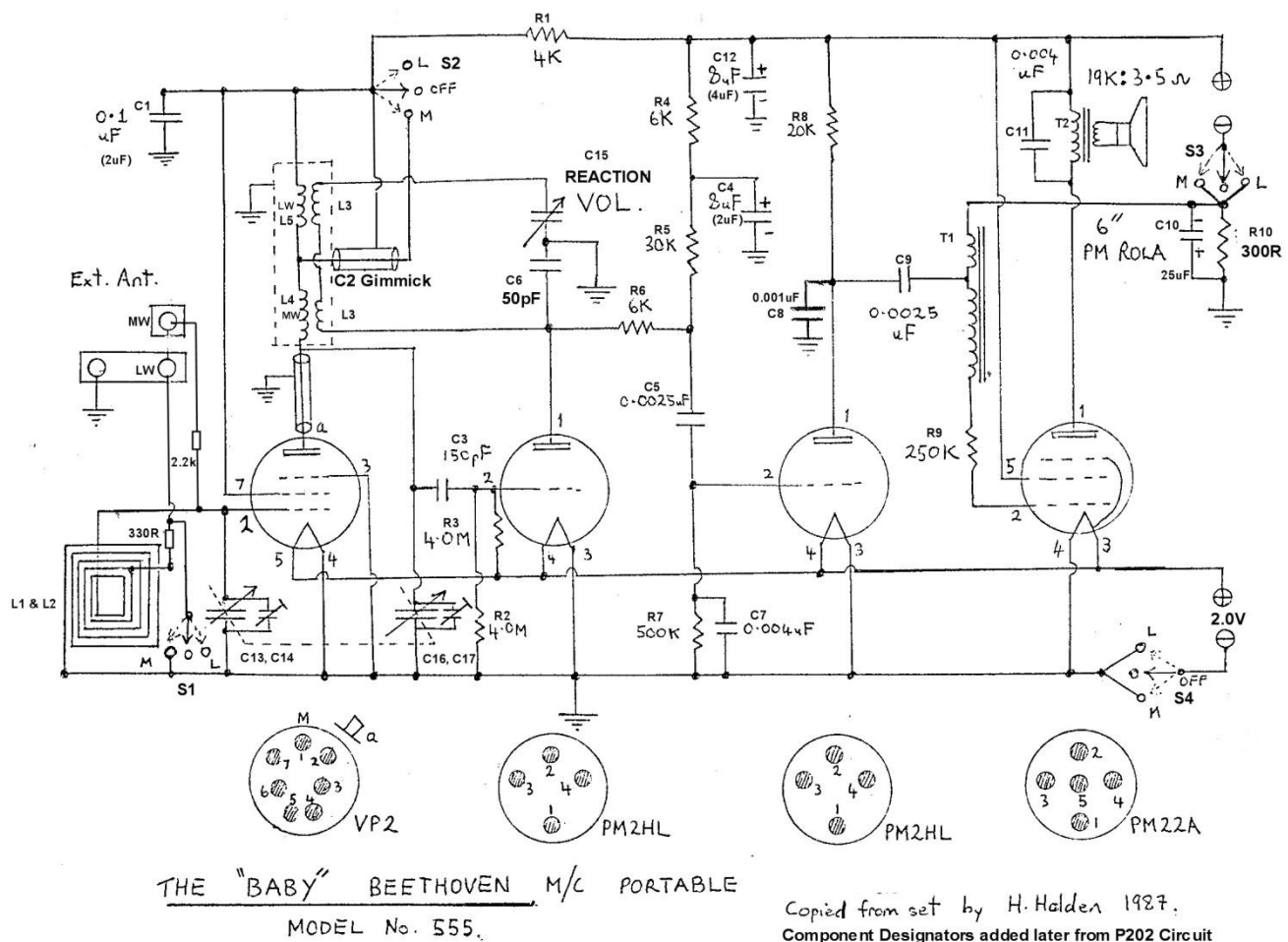


The models above are useful when considering the implications of the voltage distribution along the filament wires of directly heated valves.

Back to the Beethoven 555:

The Beethoven 555 receiver was moderately advanced for the time and they solved the smooth regeneration control issue very well. I found it difficult to to acquire the exact schematic, so initially I traced it out by hand as shown below, way back in 1987.

Later I found a schematic of a very similar set the Beethoven P202, the only apparent major difference being a slightly different cabinet and it sported a power lamp. I subsequently added the P202's component designators to my hand drawn schematic.



In my 555 radio there were some resistors added in the switching circuit of the MW and LW Frame Antenna, perhaps not original. And some of the capacitors shown had alternate values, C1, C12, C4, but of course these may have been altered in the past during servicing.

One notable feature is the Audio Inter-stage transformer. In this case capacitively coupled and used as an Autotransformer. This arrangement gives higher voltage gain for less total turns (less copper & less Iron) because the primary voltage is in series with the secondary and as a result the autotransformer can be made more compact & lightweight.

However, it is worth noting that general transformer theories of impedance matching and power transfer and the traditional equation set for audio output or power

transformers do not actually apply to typical valve inter-stage transformers driving a valve in Class-A. (It does in class B where power transfer is required).

This is because the grid of the Audio output valve, operating in a Class A condition, never draws any significant current.

The equations which do apply are those of the Damped Tuned Coupled Resonant Circuits. In the interstage transformer case, the damping is normally provided by the the Anode (plate) Resistance of the driving valve, though in some cases it can be added to the primary or secondary windings.

When the proportions of Inductance, winding self Capacitance and Mutual Coupling and damping are correct, the interstage transformer can possess an astonishingly flat response in the audio frequency spectrum, tapering off at the upper and lower ends.

If the balance of factors is not correct, there can be a significant peaked response.

The equation for a Valve interstage Audio Transformer's Frequency Response is very hard to come by, it is available here, where I resolved it (with help from Terman) on pages 11 through 17 of this article:

https://www.worldphaco.com/uploads/THE_GREBE_MU-1.pdf

The schematic of the Beethoven P202 (a near exact match for the 555) is shown below.

The P202 dates to 1937, the Baby 555, probably that year or 1938. Apparently the P202 cost 7 Pounds and 7 Shillings in 1937, which, using the pre-decimal inflation calculator appears to be in the order of \$830.00 AUD !

"TRADER" SERVICE SHEET 762

REVISED ISSUE OF
SERVICE SHEET No. 249



THE Beethoven P202 Baby Portable is a 4-valve battery operated portable receiver of small dimensions, containing its own frame aerial. Provision is made for the connection of a pair of headphones and an external aerial, while there is a ruby pilot light in the centre of the speaker grille. A turntable is fitted to the bottom of the cabinet. Release date and original price: July, 1937; £7 7s. complete with batteries.

CIRCUIT DESCRIPTION

Tuned frame aerial input L1, L2, C13 to RF pentode valve (V1, Mullard metalised VP2) operating as RF amplifier. Provision for connection of external aerial, if required.

Tuned anode coupling by L4, L5, C16 between V1 and triode detector valve (V2, Mullard metalised PM2HL) which operates on grid leak system with C3 and R2, R3. Reaction is applied from anode by coil L3 and controlled by C15. RF filtering in anode circuit by R6 and C6.

Resistance-capacity coupling by R5, C5, R7 between V2 and triode AF amplifying valve (V3, Mullard metalised PM2HL). Fixed tone correction in grid circuit by C7 and in anode circuit by C8.

Auto-transformer coupling by R8, C9, T1 via RF stopper R9 between V3 and beam tetrode output valve (V4, Osram KT2). Fixed tone correction in anode circuit by C11. Provision for connection of headphones across primary of internal speaker input transformer T2. GB for V4 is obtained from drop along resistor R10 in HT negative lead.

COMPONENTS AND VALUES

CAPACITORS		Values (uF)
C1*	V1 HT decoupling	2.0
C2	V1 LW fixed trimmer	Very low
C3	V2 CG capacitor	0.00015
C4*	V2 anode decoupling	2.0
C5	V2 to V3 AF coupling	0.0025
C6	V2 anode RF by-pass	0.00005
C7	Fixed tone correctors	0.004
C8		0.001
C9	AF coupling to T1	0.05
C10*	Automatic GB by-pass	25.0
C11	Fixed tone corrector	0.004
C12†	HT circuit reservoir	4.0
C13†	Frame aerial circuit tuning	—
C14†	Frame MW trimmer	—
C15†	Reaction control	—
C16†	V1 anode circuit tuning	—
C17†	V1 anode MW trimmer	—

* Electrolytic † Variable ‡ Pre-set.

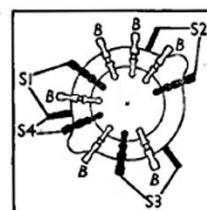
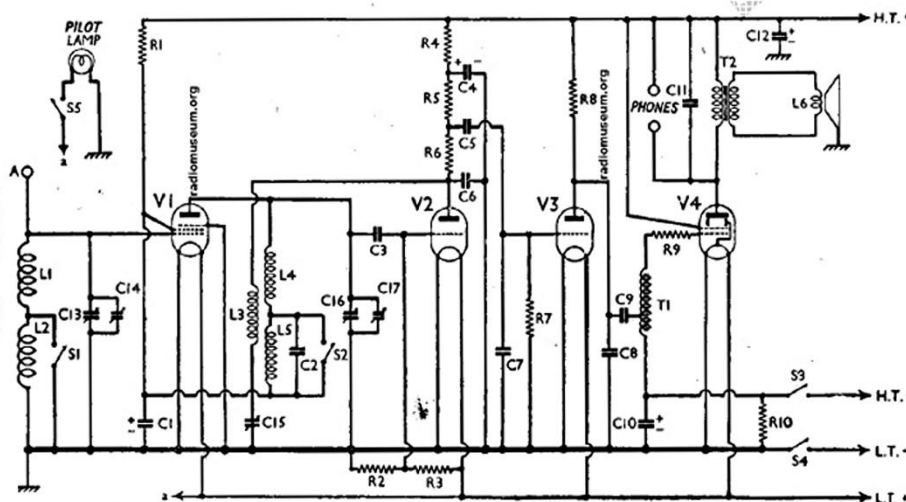
RESISTORS		Values (ohms)
R1	V1 HT feed resistor	4,000
R2	V2 grid leak and filament pot. divider	4,000,000
R3		4,000,000
R4	V2 anode decoupling	6,000
R5	V2 anode load	30,000
R6	V2 anode RF stopper	6,000
R7	V3 CG resistor	500,000
R8	V3 anode load	20,000
R9	V4 CG RF stopper	250,000
R10	Automatic GB resistor	300

OTHER COMPONENTS		Approx. Values (ohms)
L1	Frame aerial windings	2.2
L2		12.2
L3	Reaction coil	4.1
L4	V1 anode circuit tuning coils	3.25
L5		28.0
L6	Speaker speech coil	3.0
T1	Intervalve auto-trans., total	5,000.0
T2	Speaker (Tri.)	580.0
S1, S2	Input trans. { Sec.	0.2
S3	Waveband switches	—
S4	HT circuit switch	—
S5	LT circuit switch	—
S6	Pilot lamp switch	—

VALVE ANALYSIS

Valve voltages and currents given in the table below are those measured in our receiver when it was operating on an H.T. battery reading 80 V on load. The receiver was tuned to the

Valve	Anode Voltage (V)	Anode Current (mA)	Screen Voltage (V)	Screen Current (mA)
V1 VP2	75	0.6	75	0.2
V2 PM2HL	45	0.7	—	—
V3 PM2RL	60	1.0	—	—
V4 KT2	80	3.0	80	0.7



Left: Circuit diagram of the Beethoven battery portable P202. The associated valve base diagrams are in col. 2 overleaf.

Above: Diagram of the switch unit, drawn as seen from beneath and in front of chassis.

The tubes used in the 555 and P202 are 2 Volt heater types, the VP2 RF Pentode used as an RF amplifier. The job of the regenerative grid leak detector is allocated to V2, a PM2HL. The grid return voltage of V2 has been set to the centre of the filament voltage

with the the two 4 Meg resistors R2 & R3 and sits at an average voltage of +1V above common.

However, as noted using the previous analysis of what this means in terms of a discrete cathode surface emitting model, this is equivalent to a “zero bias” condition for V2 because half of the filament’s structure is negative with respect to the grid and the other half of it is positive with respect to the grid’s average potential. The Grid’s electron current will shift the grid a little in the negative direction, because the Thevenin resistance is 2 Meg Ohms and a small standing negative grid bias results from that.

The PM2HL is a metallised version of the common triode such as the HL2K or VT-50. The metallization makes for a helpful shield at the regenerative detector stage.

The Triode V3, another PM2HL, deployed as an audio amplifier does not require a shield. For this tube in my radio I used the VT-50 because of its narrower profile, and there is not a lot of room in the battery compartment.

The Audio power output tube is the PM22A. This has multiple equivalents and is listed as a KT2 for the P202 version.

The photo below shows the interior view of the 555:



I had to make up the batteries which run it. The 2 Volt battery is composed of two groups of 3 parallel C sized Ni-Cd cells in series. A 1 Ohm 10W ceramic dropping resistor is used Inside that same battery enclosure to get the under load voltage close to 2 Volts.

The 90V battery was created from 72 AA sized Ni-Cd batteries in series. Because of their current delivering capability I incorporated a fuse inside that battery. The original battery for the radio was actually an 80V type though I did not find that out until years later when I found the P202 schematic. Interestingly the original 2V cell was described for the P202 a 14Ah “Celluloid jelly acid” The Eveready label was put on the 90V battery for a bit of fun.



The speaker in this set is a good size at close to 5.5” diameter on measurement and it has an Alnico Magnet.

The KT2 or close equivalent PM22A is a capable output valve (for a battery – valve radio) and can deliver 340mW. The specifications are shown below.

One good place to find out equivalent tube types is in the original Mullard valve manuals. The manuals even suggest what possible substitutes could be made with small modifications which is very helpful, if you cannot find an exact equivalent:

PM22A

FILAMENT

V_f	2.0	V
I_f	150	mA

DIMENSIONS

Max. Overall Length	117	mm
Max. Diameter	41	mm

LIMITING VALUES

V_a max.	150	V
V_{g2} max.	150	V
p_a max.	1.0	W
I_k max.	10	mA

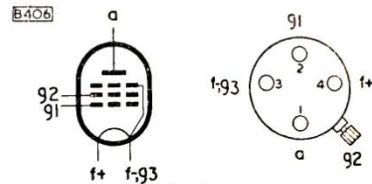
CHARACTERISTICS

V_a	135	V
V_{g2}	135	V
V_{g1}	-4.5	V
I_a	5.6	mA
g_m	2.2	mA/V
r_a	150	k Ω

REPLACEMENT FOR:

K70B, KT2, KT24, P225 (5-pin), PEN220, PENB1, PP2, PT2, 220HPT, 220OT—Direct.
 KL4, PP2s—Change base.
 PEN230, PM22, PT240, 220PT, 230PT—Adjust bias to -4.5V at anode and screen voltages of 135V. Load resistance=19k Ω .
 Y220—Bias may require adjustment.

OUTPUT PENTODE



Base connections for 5-pin version as PM22D below.

OPERATING CONDITIONS

(As single valve class "A" amplifier)

V_a	135	V
V_{g2}	135	V
V_{g1}	-4.5	V
I_a	5.6	mA
R_a	19	k Ω
V_{in} (r.m.s.)	3.0	V
P_{out}	340	mW
D_{tot}	10	%

MEDIUM IMPEDANCE TRIODE

PM2HL

FILAMENT

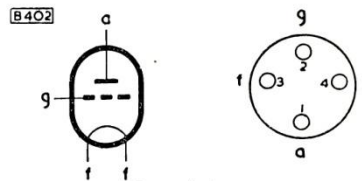
V_f	2.0	V
I_f	100	mA

LIMITING VALUES

V_a max.	150	V
p_a max.	750	mW
I_k max.	5.0	mA

CHARACTERISTICS

V_a	90	135	V
V_g	-1.5	-1.5	V
I_a	0.5	2.2	mA
g_m	0.8	1.4	mA/V
μ	30	30	
r_a	37.5	21.5	k Ω



The metallised version has the metallising connected to pin 3.

DIMENSIONS

Max. Overall Length	102	mm
Max. Diameter	36	mm

REPLACEMENT FOR:

B228, H2, H210, HL2, HL2K, HL210, HR210, K30A, K30C, K30D, K30K, L2 (Ediswan-Mazda) L2/B, L21, L210, LL2, PM1A, PM1HF, PM1HL, PM2DL, PM2DX, SD2, 210HF, 210HL—Direct.

K30B, PM1LF—Change grid bias to -1.5V.

HL22, HL23, LL2s—Change base.

HLB1, LD210, 210LF—Bias may require adjustment.

The PM2HL replaced the PM1HL, the parts are functionally equivalent and there are many substitutes including the HL2K, which we also know, from the Reinartz article and other sources is equivalent to the VT-50.

The photo below shows the VT-50 next to the metallised PM2HL and also the earlier shaped PM1HL which had more of a Balloon shaped envelope.



The VP2 is a Pentode. At this point in history Pentodes were “futuristic parts”. The design confers properties well in advance of a Triode.

One major advantage of the Pentode is isolation between its Anode circuit and its Control Grid. This means, that unlike a triode with its high Miller (feedback) capacitance, you can place a tuned resonant circuit in Grid and its Plate circuit of the Pentode, of the same frequency, however, due to the shielding provided by the screen grid, the two resonant circuits will not exchange significant energy with each other and not oscillate, as they do with a triode, unless neutralization is employed.

This is how it is possible, with a resonant circuit in both the Grid (frame antenna) and Anode of the VP2, tuned to the same frequency and acting as a tuned RF amplifier that it does not burst into high level oscillations. To prevent the tuned coil in the VP2's Anode circuit, feeding back to the Frame Antenna, inside the radio's cabinet, since this coil essentially sits inside the middle of the frame antenna, the coil is very well shielded. That in itself is quite a remarkable feat, to help keep the VP2 RF amplifier stage stable.

VP2

VARIABLE-MU R.F. PENTODE (OBSOLETE)

FILAMENT

V_f	2.0	V
I_f	180	mA

DIMENSIONS

Max. Overall Length	139	mm
Max. Diameter	49	mm

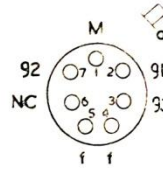
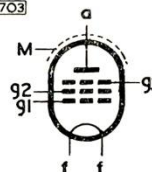
CAPACITANCES

C_{in}	10.7	pF
C_{out}	6.3	pF
C_{a-g1}	0.007	pF

LIMITING VALUES

V_a max.	150	V
V_{g2} max.	150	V

8703



Brit. 7-pin

OPERATING CONDITIONS

V_a	135	V
V_{g2}	135	V
V_{g1}	0	V
I_a	3.0	mA
I_{g2}	1.25	mA
g_m	1.5	mA/V
r_a	400	kΩ

REPLACED BY: KF35—Change base and top cap connector. Reduce screen-grid voltage to 60V.

The signal is passed from the VP2 stage to V2 which is the regenerative detector.

In Valve work & circuitry, if you see a modulated carrier passed to the grid circuit of a tube, and an audio signal is recovered from the anode circuit of that tube, there are only two possibilities in how that can work. It requires a non-linearity in the way the signal is processed or amplified.

The common method (as explained above) is the circuit named as the Grid Leak Detector, albeit poor naming. In this case rectification occurs at the grid- filament (or grid-cathode) and the signal at the plate resembles an inverted & amplified facsimile of the *negative half* of the carrier carrier RF wave and the audio modulation recovered when the carrier is filtered off.

However, it can be in, some cases, that if the detector tube is correctly biased, then instead, the positive going halves of the carrier wave are preferentially amplified by the RF voltage applied to the grid. This happens because the curve, or bend, in the function of anode current versus grid voltage. In this case the signal at the anode of the tube looks like an amplified inverted version of mainly the positive half of the carrier wave. And that is called an Anode Bend detector.

For these reasons, in the boundary between the two forms of AM detection, Grid Leak versus Anode bend, there can be no detection at all. And in this instance, a perfectly symmetrical modulated RF carrier would appear at the Anode and filtering the RF off that would reveal no audio signal at all.

So the question often becomes; if you see a valve AM detector circuit, how do you know if it is a Grid Leak Detector style or an Anode bend detector? The answer is fairly simple. In most anode bend detector circuits, the grid-filament or grid-cathode of the tube is fed directly by the output coil of the previous stage. In the Grid Leak case, there is always what appears as a “coupling capacitor” that relies on being charged by grid current and discharged by a resistor. It is not really a coupling capacitor though, more analogous to the energy storage capacitor in a half wave rectifier system.

Restoring Metallized tubes when the Metallisation fails:

With very vintage metallised tubes, in many gases the conductive paint has bubbled of and fractured and fallen away from the glass surface. Fortunately there is a good method to restore it. Jaycar sell a highly conductive Colloidal silver paint, which has excellent adherence to glass. It looks Silver in character. You can paint it on with an artist's brush, after the remains of the old paint is removed. It is made by Kemo Electronics GmbH.

Once that is done you can use spray metallic Silver or Gold paint over it to restore the original appearance. The photo below shows a restored PM2HL. This often results in loss of the original label, so it is better to re-label the tube on its base:



Radios with either Ferrite Rod or Frame antennas are very directional. The manufacturers of the 555, put a Lazy Susan like spinning base on the radio. This runs very smoothly as it is supported by ball bearings:



For convenience the manufacturers used a removable handle with "Lift the Dot" fitting. These were used in the Automotive industry for attaching soft tops to convertible cars. The Leather handle had perished. The one shown is a reproduction I had made back in the late 1980's. The Speaker grille on the radio, at a glance looks like a plastic, but it is made from a high strength woven string (not cord) that appears to have been varnished. It has stood the test of time very well. To quote from the movie Mouse Hunt: A World without string is Chaos.



The photo below shows the radio with the back fitted. The rectangular steel spring metal clip slides under two screw heads to help retain the back.



In this era, the user had a large number of radio stations to select from, if the dial is anything to go by.

Interesting feature of the 555:

There is something intriguing about the design of the 555. Not obvious at first.

Generally the output from a regenerative detector (or a grid leak detector) is passed either via an inductor or via an audio inter-stage transformer to the next stage to assist in filtering the RF off the signal and leave the audio remaining.

In this radio, no inductor or transformer is present and there is simply an RC network feeding V3, the first audio amplifier stage. This made sense, the radio was already heavy enough as it was and there was certainly motivation to save weight and to get rid of at least one of the normally heavy iron cored inter-stage audio transformers.

I had wondered what the bandpass frequency response of this R-C network would look like over the audio frequency spectrum. For example if it had a uniform amplitude peak

voltage of 1 Volt applied and it was swept over the audio spectrum. Then the peak signal value, developed across the 0.004uF capacitor and 500k resistor was plotted, for audio frequencies. This sort of thing is dead easy to measure with a signal generator & scope, with the practical network, but I wanted a theoretical proof.

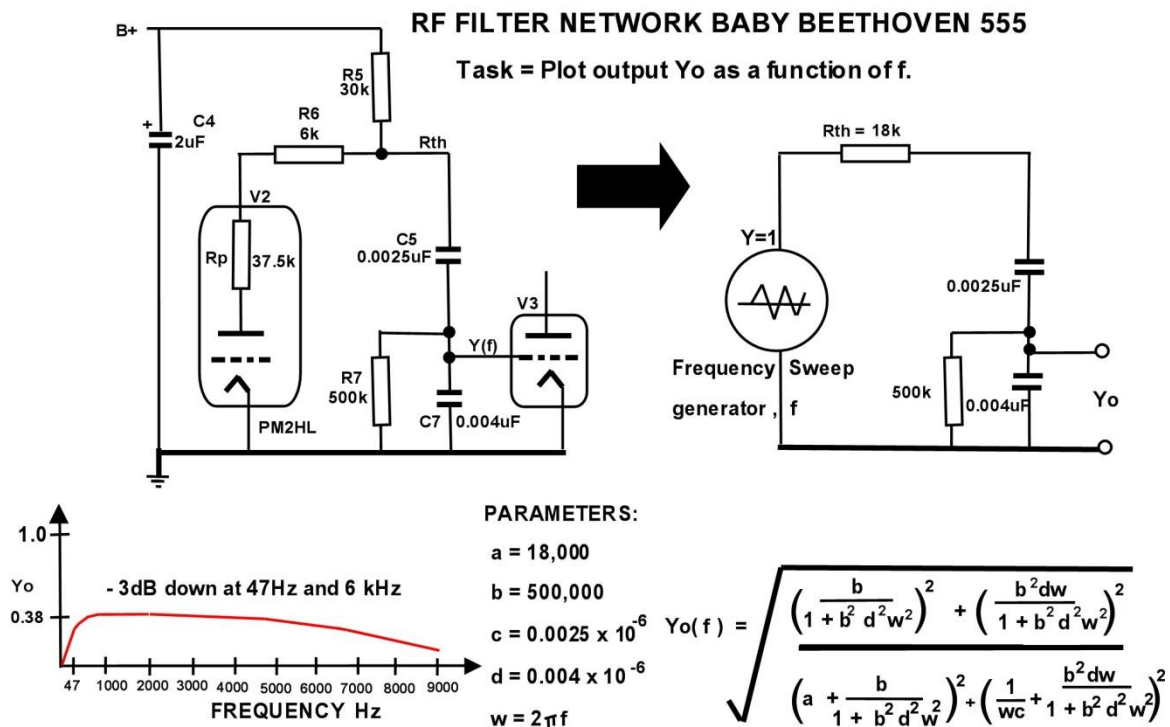
Old School versus Spice:

This was in the days prior to a Spice engine. Once the equation was derived for it which was a lot of work, it came out more complex than I initially imagined. It took a while to work out the output values from discrete frequency values with the calculator.

I decided to see if I could run this equation through a graphing program in my University's mainframe computer and get a plot that way. The assumption was made that the source impedance driving the filter (the Thevenin resistance) would be in the order of 18k, because this represents V2's anode (plate) resistance of around 37.5k in series with R6 (6k) and those in parallel with R5(30k).

After some work a plot was produced and it demonstrated that the band-pass response was remarkably similar to an actual inter-stage transformer. Except for signal amplitude loss rather than signal gain that the transformer provided.

I don't have the original print only hand written notes on aged paper, these are a tidy copy of them and the equation:

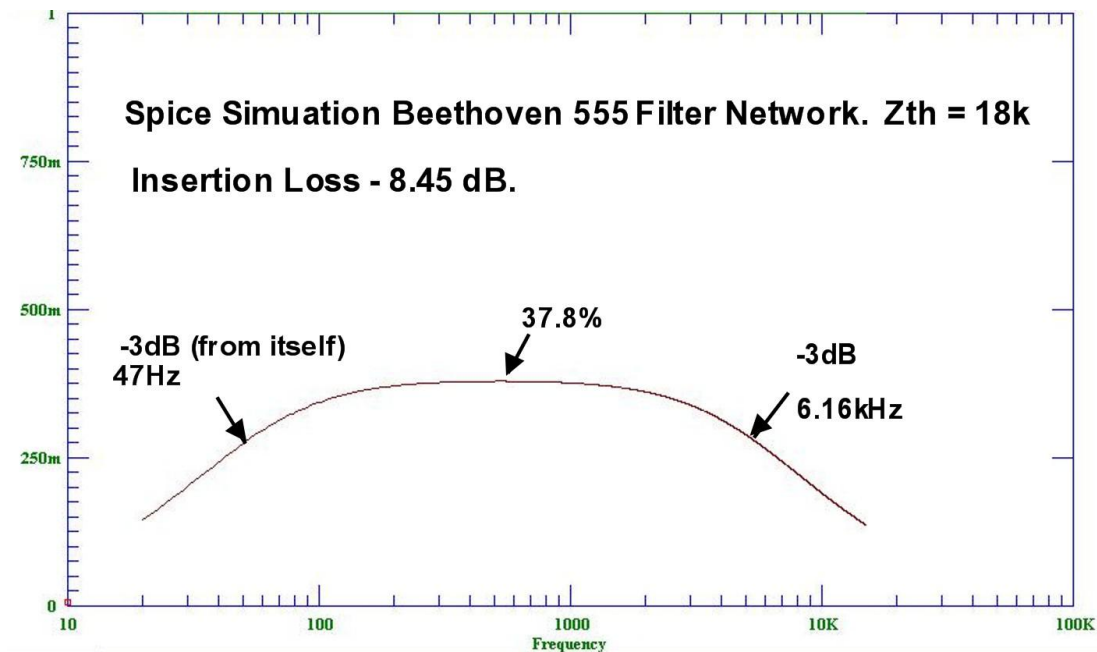


Then decades passed since I resolved this and Spice Engines appeared. Running the circuit through Spice now gives the same result as plotting the equation, except it is about a hundred times easier.

I'm certain this equation is accurate now, because it predicts exactly the same values when run at 47Hz, 1000Hz and 6kHz as the Spice simulation does. If you have a spare few sheets of A4 paper and a calculator you can check it out.

The network behaves as a BPF over the audio frequency spectrum with about an 8.45 dB insertion loss. This is made up for by the Audio pre amplifier PM2HL valve V3 and the PM22A output tube V4. Also the fact that the front end of the radio has the VP2 RF amplifier Pentode helps its case.

This is an interesting demonstration on the value of items such as the vintage valve interstage audio transformer with a typical 1:3 to 1:5 step-up ratio and a similar audio bandpass response. As noted though, the transformers are heavy, and not ideally suited to a portable radio like the Beethoven.



In Vintage Valve Radio repairs, some have repaired radios where the interstage audio transformers have gone open circuit and replaced them with an RC coupling network to get "sound to come out of the speaker" However, clearly from this analysis there is likely

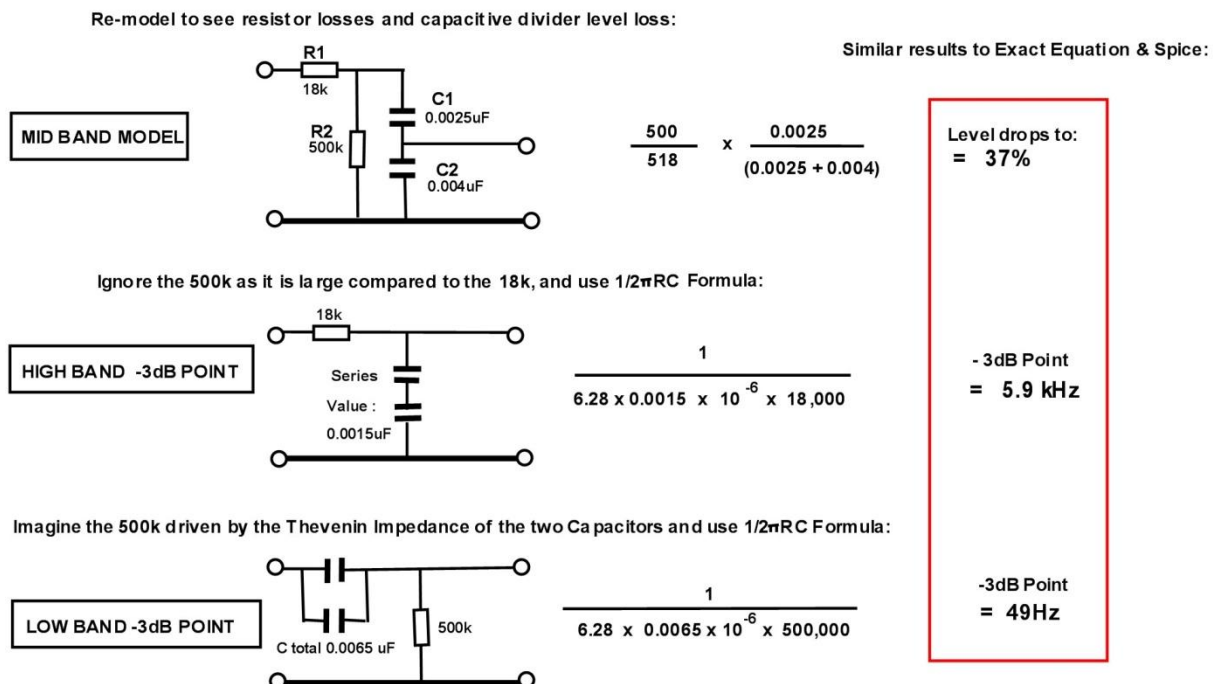
a substantial drop in gain, more than the ratio of the typical 1:3 transformer itself, that is, if the RC filter is crafted to have a similar band-pass characteristic to the transformer.

What to do if you do not have the Equation for the RC-filter network or a Spice Engine or a signal generator and scope to test the actual network and you want to know the Bandpass Characteristic?

Fortunately there are equivalent circuit tricks. While you cannot plot a graph from these, you can derive the mid band output value and the upper and lower -3dB points as follows.

Since the capacitors divide the voltage up by the ratios of their Reactances you can just re-model the circuit a little and say the voltage is divided down by the Resistances a factor of $R2/(R1+R2)$ and by the Capacitances as $Xc2/(Xc2 + Xc1)$ and because the reactances are inversely proportional to the capacitances that is the same as saying the capacitors divide the AC voltage by a factor of $C1/(C1+C2)$.

Also the -3dB points are easily found from the usual $1/2\pi RC$ formula. Not as accurate at Spice, or the exact equation because the circuits are not exact equivalents, but “good enough” to give you an idea what the filter is doing.



Summary:

The Beethoven 555 is a remarkable MW & LW band Regenerative radio from the pre-WW2 era.

The manufacturers had largely solved the issue of user controlled regeneration. The radio is well made and has stood the test of time. Efforts were made to reduce its total weight by eliminating one interstage transformer, in favour of an R-C filter. The gain loss was made up with a two stage audio amplifier and a front end RF pentode, so that up to 380mW could be available to drive the speaker.

Regenerative radios though, from the commercial perspective, were destined to become far less common than Superhet types. As time passed by, the cost of valves came down and Pentodes were not the only revolution. Superhet portable valve radios appeared with a Converter valve. This combined the function of the Mixer & Oscillator into one valve. Then with one IF Pentode, one combined diode detector & triode valve and one audio output Pentode the radio was complete. In other words the same four valve count as a radio like the Beethoven 555. However, the ease of use and performance of the Superhet radio, which out-classed the regenerative designs.

History has shown that regenerative designs remained popular with home constructors. This was because of the large amount of signal gain from a one valve regenerative detector stage, the economy is hard to ignore. In many cases one valve was enough to drive a set of Headphones directly and even enough to drive a small speaker with only one or two additional valves added.

It is fair to say, looking back, the regenerative radios of early years demonstrated remarkable innovation on the part of the designers and even today, it is fun to restore these radios or experiment with their operation and study their operating principles.

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