

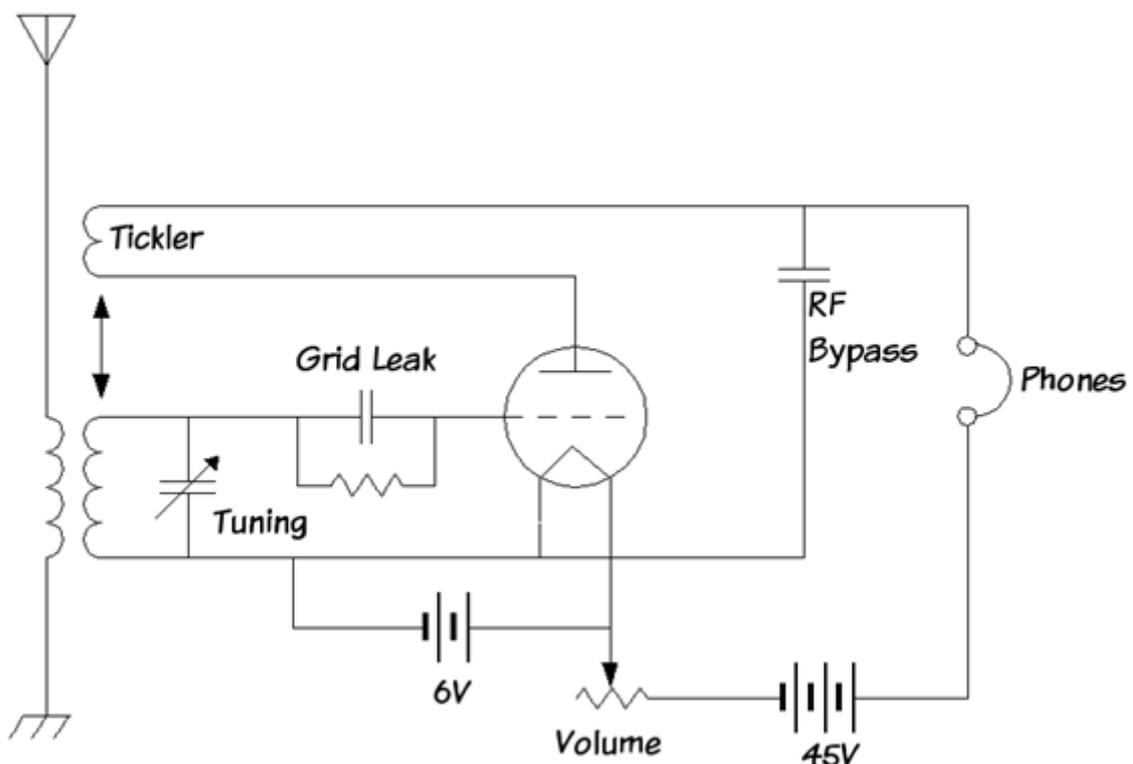
Some Thoughts on Regenerative Receivers

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After having monitored, and occasionally participating, in the discussions on the Yahoo Regenerative Receiver Newsgroup, I thought it might be of interest to throw in both some of my experiences, and professional thoughts. I suffer from being an E.E. by training, having grown up at the tail end of the vacuum tube era, as well as having held an amateur radio license for half a century.

In no way is this paper comprehensive. A Google search will turn up all sorts of things. The purpose of this paper is to provide a starting point for discussion and experimentation for the person new to the field of regenerative receivers, who may be utterly overwhelmed by the plethora of information.

I've always been fascinated by regenerative receivers, with my first one being built from an article in "Popular Mechanics," using a 1T4 and the usual "ticker" coil Armstrong design. In this paper, tutorial, or what you might want to call it, I'd like to look at some of the general design issues. Some of this is based on a discussion of general receiver design considerations that I gave recently before the Nanticoke Amateur Radio club in Seaford, Delaware, as well as discussions with members of the Yahoo Regenerative Receiver group.

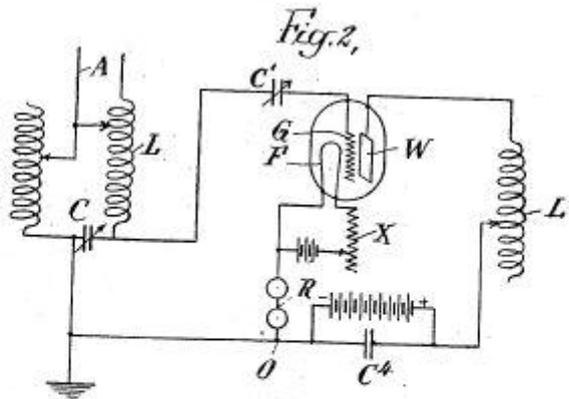
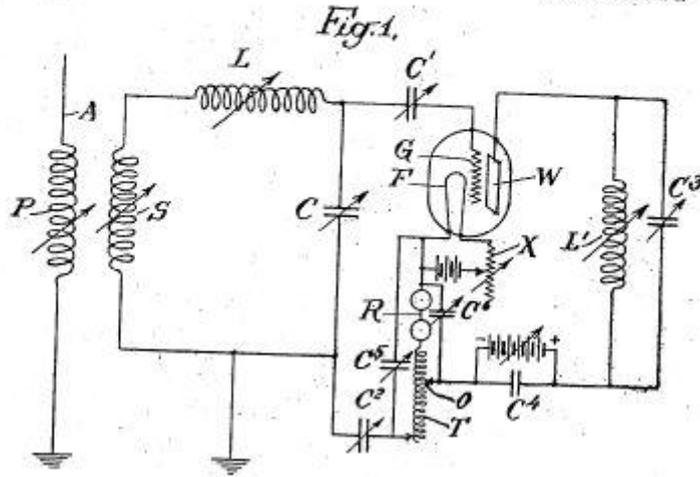


Classic Regenerative Receiver, the base of lots regenerative receivers.

Figure Credit Line: Wiki

E. H. ARMSTRONG.
WIRELESS RECEIVING SYSTEM.
APPLICATION FILED OCT. 29, 1913.

1,113,149. Patented Oct. 6, 1914.
3 SHEETS-SHEET 1.



WITNESSES
L. Bates
W. B. Johnson

INVENTOR
Edwin H. Armstrong
BY
James Davis
ATTORNEYS

Page of Armstrong's Patent of the Tickler Oscillator

Note I.G.: On the base of the Regenerative Receiver Armstrong patented several so called "Tickler Oscillator."

Figure Credit Line: Wiki

Everybody is likely familiar with the original Armstrong design -- tickler coil for feedback, "throttle" with a variable capacitor RF bypass from plate to ground, etc., etc., etc. Keep that in mind, as this discussion progresses. If you aren't familiar with the basic design -- grid lead detector, "tickler" feedback and regeneration control with a variable capacitor, look this up. Actually, Armstrong's original circuit was slightly more complicated, but the scheme I've mentioned covers the basic design.

One needs to keep firm in mind that early receivers, as well as transmitter designs were governed strongly by cost and complexity considerations.

Early vacuum tubes were expensive, and parts generally difficult to come by, and expensive as well. Also, simplicity was a major consideration, as the more complex something is, the less reliable it will tend to be. As a consequence, there were some design compromises that we've been working to overcome over the years.

The following discussion applies to vacuum tube designs as well as their modern cousins with bipolar and field effect devices. They really differ only in the details. Every person has their "pet" designs, of course, as do I. Well, here goes...

Classic Colpitts regenerative receiver may be found: http://www.antentop/012/regen_rx_012.htm

Patent 24231/13 (Dec. 18/13). The telephone receivers are shown at R and are shunted by a variable condenser C_2 . The receiving circuit SCL is connected to the grid G by a condenser C_1 , and to the filament F by a condenser C_2 and the telephones (or other suitable inductance) R. The

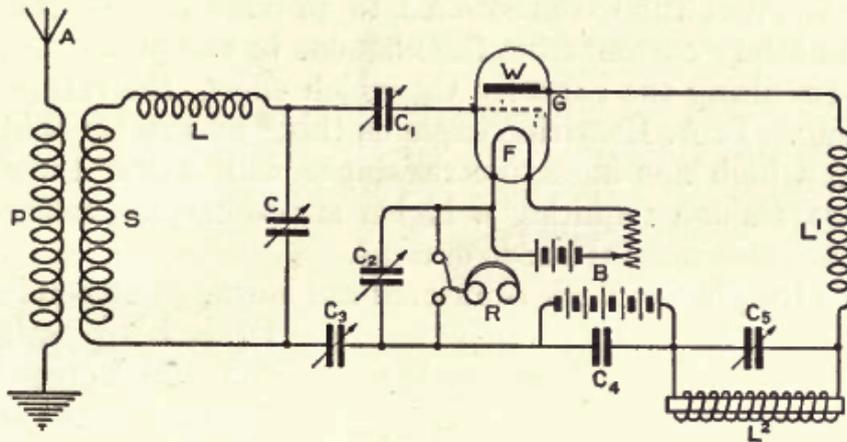


FIG. 137.—One of Armstrong's circuits.

anode circuit includes the inductance L_1 , condensers C_4 , C_5

One of Armstrong Regenerative Receiver

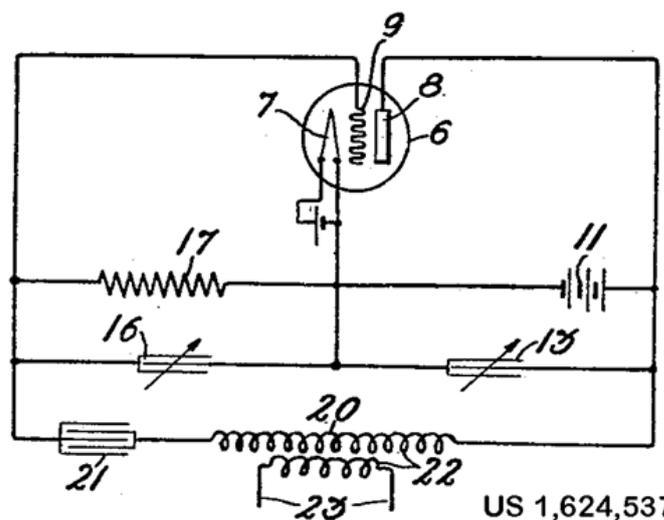
Credit Line: Thermionic Tubes in Radio Telegraphy and Telephony, by: John Scott- Taggart, The Wireless Press LTD, 1921

- Effectively increases the "Q" of the tuned circuit by the concept of "negative resistance." Any circuit that accomplishes this will do the trick. Typically, an oscillator circuit, such as a Hartley, Colpitts, or the like is chosen. One then sets the loop gain of the oscillator circuit by some means to be just below the point of oscillation. Later, it will be seen that there are some clear design advantages to some circuits over the others.
- Runs in "oscillation" mode, if desired, to act as a direct conversion or autodyne detector for CW or Single Sideband signals. The oscillation mode provides the BFO, or course.

2. There is massive interaction with tuning as a function of regeneration setting. If there is a way to separate detection from regeneration, this problem can be addressed. One typical vacuum tube design uses a Colpitts oscillator in parallel with a plate or grid leak detector (my favorite for vacuum tube designs). Another alternative (my Senior EE project in 1960!) was to insert a cathode follower between the tuned circuit and the detector/feedback vacuum tube).

The workings are not dependent on vacuum tubes versus transistors. The real problems in any design at least, are:

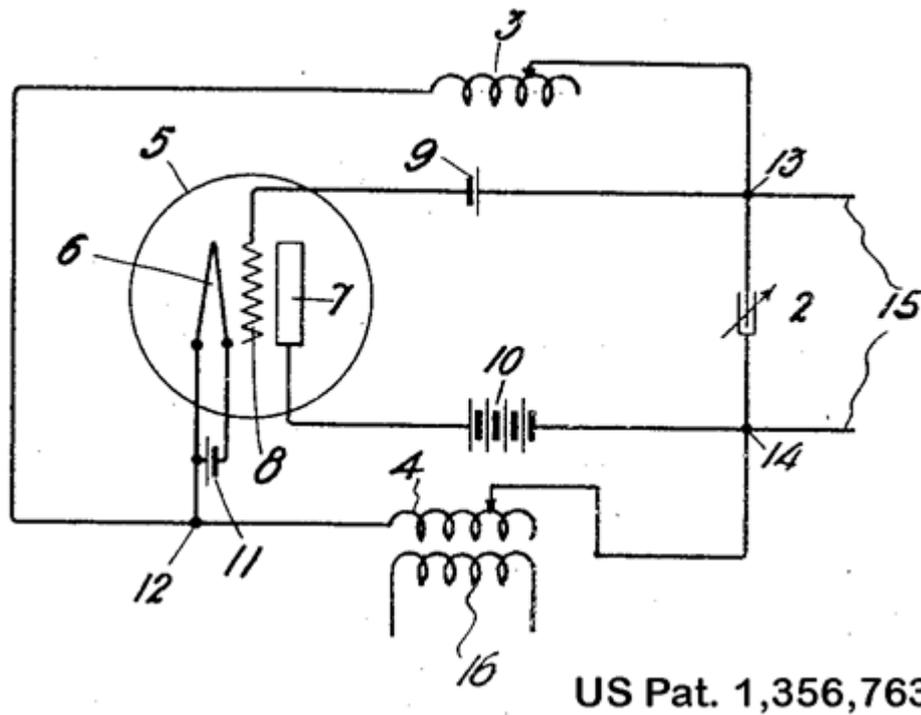
1. Interaction with the antenna, and QRM generated by the receiver itself. "Grounded Grid" or equivalent isolation amplifier does the trick here. An un-tuned grounded gate FET amplifier seems to be the modern choice.



US 1,624,537

Edwin H. Colpitts, "Oscillation Generator," U.S. patent 1,624,537 (filed: 1 February 1918: issued: 12 April 1927)

Figure Credit Line: Wiki



Note from Wiki: The Hartley oscillator was invented by Ralph V. L. Hartley while he was working for the Research Laboratory of the Western Electric Company. Hartley invented and patented the design in 1915 while overseeing Bell System's transatlantic radiotelephone test. It was awarded patent number 1,356,763 on October 26, 1920.

Figure Credit Line: Wiki

3. Smooth regeneration. This is the hard nut to crack. There is no really good answer here, in my opinion. This, plus the interaction problem was one of the major reasons for the decline in popularity of the regenerative receiver, as well as reduced component costs which made superhetrodyne receivers practical. However, a well regulated power supply to the regeneration stage helps a great deal. A Zener or comparable regulator in transistor circuits, or gas discharge tube for vacuum tubes will work well. I note that one commercial regenerative receiver simply uses a separate 9 volt battery for the detector, and a second for the audio amplifier. Now, keeping in mind the "simplicity" issue, we can see where these fit into our design process.

The decoupling of the tuned circuit from the antenna serves two purposes. First, it reduces the interaction of your antenna with the detector tuned circuit. If you have ever hooked an antenna analyzer to a random wire antenna, the impedance is all over the place. Investment in a good antenna tuner, such as the MFJ-16010 is money well spent. Of course, a home-brewed tuner is also feasible, either built-in to the receiver, or as a separate unit. Any of the "QRP" designs will do the trick. The coupling of a resonant antenna into the detector can often lead to "dead" spots in tuning. Hence, the advantage of isolating the antenna from the detector with a "front end."

There is no need to have this front end tuned, but just to keep the antenna interactions from the detector, and reduce or partially prevent radiation from the oscillating detector from producing QRM for other radio users in the vicinity.

When running in "oscillation" mode, or close to it, a regenerative detector is its own little QRP transmitter! For domestic and neighborhood tranquility, the isolation amplifier greatly reduces radiation back into the antenna. It is not perfect, and my two commercial kit regenerative receivers make an impromptu signal generator in the ham shack when needed. An "RF" gain control can be easily introduced to reduce the strength of incoming strong signals, such as some of the major SW stations, like Radio Havana, or the PRC stations.

Along with the simplicity issue, the design for convenient band switching of the detector's tuned circuit is a hassle. If the "tickler" design of the classic Armstrong set is used, then there are either two or three coils that have to be switched. This means at least a three-pole n-throw switch if there is a "primary" coil to the antenna. Three of the six coil points are "ground" for RF, so only a three pole switch is needed. If a coupling adjustment capacitor is placed on the primary side to ground, then at least four points are "hot" for RF. These switches are not only complex, but they are expensive and add a large measure of complexity and increased size to the receiver. There are at least two common alternative solutions:



Torn.E.b

Credit Line: <http://www.radiostation.ru/home/museum.html>

Regenerative Receiver for professional communication **Torn.E.b.** was designed by Telefunken in 1935- 1936 for military use. The receiver was at WEHRMACHT by the end of WWII. The receiver had (may be first in the World) **rotary switch** for the coils.



KUB- 4M

Regenerative Receiver for professional communication KUB- 4 was designed in 1930 in Kozitskiy plant, Leningrad, USSR. The receiver was used everywhere where HF- communication was used- in military and civil. Later, for marine use was designed **KUB- 4M**. The receiver was used at marine and submarine ships. The receivers were in use up to 1945. KUB- 4 and KYB- 4M had **Plug- In Coils**

Plug-in coils -- the classic solution, but clumsy to do, and you have to have some place to conveniently store the un-used coils. My own early sets used these, mostly because I could buy a nice set of short wave and broadcast band coils, versus winding my own coils. If you note pictures of early commercial sets for marine use, there was a coil box near the receiver. The "Sierra" QRP transceiver suffers from this problem.



Plug- In Coils at Radio "Sierra"

Credit Line: <http://www.w0ch.net/sierra/sierra.htm>

By the way, FETs have an advantage as they are high input impedance devices like vacuum tubes, and do not load the tuned circuit to any degree. Both of the two commercial regenerative receivers I have used FETs in the detector and isolation amplifier. The MFJ-8100 has a series of inductors in series with a simple single pole selector switch. The Ten-Tec 1253 uses nine separate inductors, but switches them with a clever PIN diode and counter circuit. Both of these designs use an isolation "front end," which eases the complexity of coupling into the tuned detector circuit.

It is generally agreed that designing a receiver for a single or small range of frequencies is much easier than developing a general coverage receiver. If you can get a 10:1 range of capacitance change with a variable capacitor, for example, then you can expect about a 3:1 tuning range (square root of the ratio of the maximum to minimum capacitance). This problem rears its ugly head especially in the case of varactor tuning, where the capacitance change range is more modest. More about this later, with a couple of "real life" receiver designs.

The usual approach to fine tuning, when using a variable capacitor is to have a "band set" capacitor and then a "band spread" capacitor of about 10% of the value of the main capacitor.

Some Thoughts on Regenerative Receivers

A design that uses only a *single* coil in the tuned circuit such as the Colpitts design is one such solution that greatly reduces the complexity of band switching. Of course, a Hartley oscillator design uses a single tap on the coil, but again, this is an additional source of complexity due to the tap on the coil. The Colpitts design does require a DC return for the cathode in the case of vacuum tubes or source in the case of FET designs.





Hallicrafters S-20R

Credit Line: <http://www.radionewjerusalem.com/Radio/S-20R%20Hallicrafters.html>

In the 1960s, the ARRL handbook showed an interesting receiver along these lines. It used a 1700 kHz IF frequency with the local oscillator between the 40 and 80 meter ham bands. The 1700 kHz IF had good selectivity with a half-lattice crystal filter. The front end was tuned to either 40 or 80 meters, as desired.

As to controlling the regeneration, any scheme that allows you to control the feedback will work. The more common themes:

- Armstrong "RF" throttle - another expensive variable capacitor, plus frequency issues.
- Variable resistor across the tickler coil -- "kill" some of the feedback signal. My original 1T4 regenerative receiver used this scheme.
- Change filament voltage! Used in many of the early directly heated filament tubes.
- Change the screen voltage in a Pentode. Probably one of the cleanest strategies. This is used in the World War II [Paraset](#) design.
- Change the coupling between the tickler and tuning coil mechanically.
- Add a variable resistor in the emitter circuit (Kitchin's design, who uses a Hartley oscillator, and he also uses a separate diode detector). This reduces the loop gain of the oscillator.

Change the plate voltage of the detector.

Again, due to the various interactions, and a desire to get smooth transition into regeneration, some sort of good voltage regulation for the detector stage is essential. This doesn't add any great complexity to the design with the availability of nice integrated circuit voltage regulator chips. Kitchin uses a simple string of diodes to get around 1.5 volts for the detector.

Now, for an analysis of a couple of current commercial kit designs. Where I live in rural "Slower Lower" Delaware, it is hard to get electronic parts other than at the local Radio Shack, unless I do a lot of mail ordering. As a consequence, getting back into radio after a 30+ year hiatus, I opted to go the kit route for my initial efforts in regenerative receivers. There are a couple of clear advantages to kits -- all the parts were there, and the design was liable to work the first time round. Any modifications on my part could be done with ease, either during construction, or later, as I might choose.

For my first regenerative receiver kit, I chose the Ten-tec 1253. As I mentioned, the band switching scheme is quite clever -- it uses a series of inductors switched by PIN diodes and a counter. It also has nine bands. This is mostly due to the rather limited tuning range with the varactor diode, but nine bands is pretty cool. It covers from the low end of the 160 meter band up through 13 meters with a few unimportant gaps. The upper frequencies are a bit problematical, but this is typical of both vacuum tube and solid state regenerative receivers. If you want to go to higher frequencies, and use a regenerative detector, then the Regenodyne approach is a good bet.



Ten-Tec 1253

Credit Line: RigReference.com



Paraset

Note from Credit Line: The PARASET is a small British "Spy set" transceiver supplied during the WW2 to the Resistance forces mainly in France, Belgium and Netherland.

It uses 3 metal tubes :

- 1) 6SK7 - Detector
- 2) 6SK7 - AF Amplifier
- 3) 6V6 - Crystall Oscillator/P.Amplifier

The range covered from the receiver is 3.2 - 8 MHz on AM and CW modes.

The transmitter is cristall controlled and works on the same receiver range.

The power output is around 5-7 W on CW mode only.

The set were supplied by a 6 Vdc vibrator type PSU.

Credit Line: http://www.qsl.net/ik0moz/paraset_eng.htm

Fine tuning on the Ten-Tec 1253 is done with an additional voltage control on the tuning varactor. This is a quite satisfactory solution, in my opinion. You just have to remember to return the fine tuning control to the center position before you move up or down the band when scanning for additional stations.

The only clear problems that I experienced with the Ten-tec 1253 were:

- Lack of a shielded antenna connection - I added an SO-259 connector to replace the binding post. A random length wire can be attached through a banana plug.
- Ugly tuning knob - a trip to Radio Shack fixed this.
- I added the "enhanced sensitivity option." I might want to re-think this. With it, the regeneration setting is somewhat "twitchy."
- Calibration required borrowing a signal generator from a friend. I have to consult a chart for the band coverage. I simply stuck a chart with the tuning ranges to the top of the receiver.

The second regenerative receiver kit I built was the MFJ-8100. They take a slightly different tack in the design. They use a series of inductors with a simple multi-position switch to tap into the inductor string for band switching. They, as do Ten-tec, use simple ferrite miniature inductors, except for one that is a toroid that you have to wind. All the inductors in the Ten-tec 1254 design are miniature ferrite inductors.

MJF-8100 uses a nice variable capacitor with a vernier reduction drive for tuning. This "feels" better than the potentiometer used in the Ten-tec 1253. The tuning is a little "fast" on the upper bands, but acceptable. I admit to being a traditionalist on the issue of real variable capacitors. I am not sure God intended us to tune circuits with varactors. The MFJ-8100 has five bands to cover most of the same range as the Ten-tec 1253, but this is due to using a variable capacitor instead of a varactor.

- Again, lack of a shielded antenna connection. I added an SO-259 connector on the back panel. I did retain the supplied binding post for the antenna, however.
- Lack of external power supply connection. A power jack from Radio Shack and a SPDT toggle switch took care of this. I can use an external 9 volt battery. There are eight screws to remove to get the case apart to change the battery, so an external battery is handy.
- Exact calibration can effectively be done at one point. I zero beat to WWV at 15 MHz. At worst, dial seems to be off by +/- 200 kHz at the lowest or highest tunable frequencies. I made a couple of dots with a marker for CW portions of the 40 and 20 meter bands for CW QRP monitoring.
- Headphone only operation. A small external speaker/amplifier from Radio Shack took care of this. I might add a more robust internal AF amplifier, as there is plenty of room in the case. A small speaker could be fitted as well. A project for the future...



MFJ- 8100

Credit Line: http://www.radiomuseum.org/r/mfj_mfj_8100.html

- The RF gain control is internal. At some point, I might put a 10K Ohm potentiometer on the back panel to replace the internal control, which is accessed through a small hole with a screwdriver. However, I find that with either the Ten-tec 1253 and MFJ-8100 that I rarely have to adjust the RF gain control unless I have a very strong station.
- I found it useful to "tie" the toroid down to the circuit board after final adjustment with a dab of hot glue from a glue gun. Very handy stuff.

Both receivers are sufficiently stable for CW and SSB reception. The Ten-tec 1253 seems to show a small amount of warm up drift. I have no idea why this should be. It goes away in about 10 minutes. The best bet seems to be to run it from an external power supply and leave it running all evening.

I have found that external battery operation (12 volt gel cell for Ten-tec 1253 and 9 volt battery for MFJ-8100) is the best bet. The usual "wall wart" or converted PC power supplies generate too much hash at HF for good clean reception.

Both receivers benefit from the use of an antenna tuner to optimize the matching between the antenna and the receiver input impedance.

For further reading and study, Google is your friend. A very good discussion of regenerative receivers can be found in the paper by Ramon Vargas at

<http://cidtel.inictel.gob.pe/cidtel/contenido/Publicaciones.php?autor=rvargas>

Some Thoughts on Regenerative Receivers

The seminal article by Charles Kitchen is to be found in the November/December 1998 QST. He has an extensive discussion, and shows both photos and schematics of an excellent complete solid-state regenerative receiver.

Also, some very nice material on direct conversion and Wheatstone bridge regenerative receivers can be found at:

<http://mjrainey.googlepages.com/radio>

A good source of early books on vacuum tube receivers and the like can be found at :

http://www.pmllett.com/tecnicl_books_online.htm

I'd like especially thank Rob Grasing for some suggestions on modifications to the Ten-tec 1253 and the source for some of the links that I have suggested, as well as on-going discussion during the development and writing of this paper. It is always good to have a "second set" of eyes during a writing project.

I look forward to hearing from other members of the group for their insights on a always fascinating topic.

73
/paul w. ross
W3FIS



Russian Military/Spy/Partisan 3- tubes Transceiver "**Sever.**"
Regenerative RX + Xtall TX. Produced: 1940- 1945
Band: RX/TX: **3.62-12.25/3.62-6.25**
Credit Line: <http://www.cqham.ru/trx/sever.html>