AWA Review

Meissner *Regenerated*

ABSTRACT

Could Alexander Meissner, an Austrian engineer working for the Telefunken Company of Berlin at the turn of the 20th century, be the real *Vater der Regeneration*? On the American side of the pond at least, it seems that the various contributions of several players including Armstrong, Meissner, Langmuir, de Forest , Round, Franklin and even Tesla's assistant Fritz Lowenstein, have been weighed and the regeneration litigation has been long settled. History has shown that De Forest got the legal nod while Armstrong got the heartfelt scientific and technical endorsements. Meissner however, never got the recognition that he might have in the litigation and subsequently in print because of the outbreak of World War I. His work deserves a fresh look in the context of the years between 1911 and 1914 when regeneration was discovered and applied in practical circuits using the early valves.

There has been a lot of excitement of late in the AWA community concerning the patent litigation and final outcome of the battle over deciding just who the "Father of Regeneration" was. Most of us now know that deForest is the legal recipient based on a final Supreme Court ruling on 21 May 1934 and that Armstrong is the sentimental and as many think (including the IRE in 1934), the rightful holder of that title. I want to introduce another contender, Alexander Meissner, an Austrian Engineer/ Physicist. I will set the historical stage and introduce a series of patent schematics all from the 1912-1914 period and will attempt to explain the significance of each. I also like building the old circuits I will bring some of that into the story too.

First let me first say that there is very little record of the exact thinking or intent of the inventors in the published notes, patents and judgements, and the wording of the patents are clouded by plenty of extra lawyer-inspired jargon. Also, I do not speak German although I have been to Germany several times and I had some help--my son takes German in school and actually just got back from Neustadt Weinstrasse on a student exchange. I had some guidance and fantastic reference material sent over to me by Hans Thomas Schmidt, from Germany. Hans did not give me too much hope on being able to understand the circuits in context in some of the German sources he recommended. "I think, a translation into English can be difficult. There are a lot of special vocabulary and you can understand them only in context with the electrical function."(1)

Finally; legally in many of the discoveries, the omission of even a single word can change the entire outcome of a court decision. So rather than trying to interpret the patent text or decisions, instead I will attempt to let the circuits themselves speak to us.

A NEW TRANSMITTER

I became interested in building some of the early valve oscillator circuits when I began participating in the AWA's 1929 Bruce Kelly QSO Party a few years ago. I had a lot of enjoyment building up the TPTG and Colpitts oscillators and putting them on the air. It is interesting how this contest has encouraged folks to get back on the bench and recreate the old time circuits. I remembered some of the radio journals that I had access to in high school in the early 1970's, in my hometown Canton NY, visiting the St. Lawrence University library. I vaguely remembered the illustrated schematics of the DeForest and Marconi radiophone circuits.

St. Lawrence itself is actually historic in radio terms in that it had one of the first operational AM radio stations in the country. WCAD was broadcasting on 360 meters on the college campus in 1922. The College Station was later granted KSLU by the FCC to honor this historic station (only one of very few K calls issued east of the Mississippi).(2) This meant that radio physics was taught in depth and they had an extensive collection of early radio books.

When I wanted to do up a new transmitter for the *Kelly* four years ago, I looked back, not at *QST* but at these older patent and journal sources. Any experimentation into these old circuits invariably leads to questions, lots of trial and error and even some smoke. Not every detail is revealed in a patent diagram! Two years ago I showed up in the contest with something called a Meissner Oscillator, which caused some kind of commotion (Fig. 1). People had heard of Collpits and Hartley, but who was Meissner and what was a *Meissner Oscillator*? Was it even legal to use one of these in the contest? Looking at my schematic you can see that this oscillator is a bit different, but at least the keying and antenna coupling look familiar to those of you that have built up some of the old time transmitters.

Before we get into the circuit, it might be a good idea to investigate this radio pioneer, Meissner, who some say was cheated out of his rightful place as the *Father of Regeneration*. Hold it! We just got finished arguing about Lee deForest and Edwin Armstrong and now you want to bring in a third player? Actually beyond Alexander Meissner (Telefunken Co.), a few more people were in the fray, including H.J. Round and C.S.Franklin (both Marconi Co.), Irving Langmuir (General Electric Co.) and finally Fritz Lowenstein (Tesla's head assistant). Somebody in this crowd of giants is the real guy, no doubt.

Of course Fleming's *valve patent* (3) and Fessenden's *heterodyne patents* (4) along with deForest's Audion *device* (5) are the critical pieces that actually fueled the explosion to come in 1912.

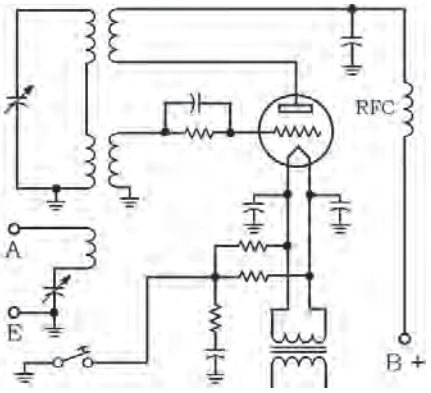

Fig. 1. Meissner Oscillator built by the author.

RADIO AT THE DAWN OF THE VACUUM TUBE

In the early 1910's when vacuum tubes were first being considered for use in detector amplifiers (sometimes called *relay valves*), it was already established that the most reliable wavelength for transatlantic radio communications was 5000 – 8000 Meters (35 – 55 kHz). This is where Marconi's large shore stations operated at the time. (6) Ship to Shore and Ship to Ship operated above this between 300 and 600 m. Damped wave transmission was already mature and several reliable ways of producing radiotelegraphy were already in use. These included the various spark and arc systems and much work was progressing on large high frequency alternators. Telefunken would have machines capable of producing 100 kW on 2000 meters by the end of 1912 based on a novel ferroresonant frequency multiplication scheme. These were developed mostly to communicate with the far-flung colonies of an emerging world power - Germany. (7)

Radiotelephony on the other hand was still novel and fairly difficult to produce with the spark gear or machines, although by this time several manufacturers had produced sets including Telefunken in Germany. These radio-*phones* had a microphone that was usually cleverly insulated so that the operator did not receive an RF burn to the mouth. This was required because of a simple connection of the microphone in series with the bottom of the antenna tuning or coupling coil ground connection. The other system called *loop* or *absorption* was being used as well. These were fairly primitive amplitude modulation methods.

Radiotelephony is by nature, more suited to shorter range applications where lower power can be useful. Indeed all of the early valve demonstrations were made quite dramatic by stressing the use of the new technology as a commercial radiotelephony avenue. By 1910, radio broadcasting had already been conceived, thanks to Canadian-American engineer Reginald Fessenden and his 1906 music broadcasts. So it makes sense that the first use of the new vacuum tube technology would be to promote improved radiotelephony, not radiotelegraphy.

It is also interesting that shorter wavelengths were used in the Meissner experiments. Beyond dramatics, modest power and higher frequencies allowed the use of smaller coils (and antennas) allowing the production of portable tabletop demonstrators (and patent models) to be developed. Meissner used 600 meters (500 kHz) for most of his experiments in 1913. (8)

MEISSNER BIOGRAPHY

Alexander Meissner was born on September 14, 1883, in Vienna. His father was a writer and theater critic from Pommern. After high school, he studied electrotechnology and mechanical engineering at the Vienna University of Technology and later physics at the University earning the doctor of technical science degree in 1902. In 1907, he started working at Telefunken in Berlin.

He was promoted to intermediary between engineers trained in industrial engineering and the few real scientists. He improved the design of antennas for transmitting at long wavelengths, devised new vacuum tube circuits and amplification systems, and developed the heterodyne principle for radio reception. In 1911 Meissner de-

Fig. 2. Alexander Meissner

signed the first rotary radio beacon to aid in the navigation of the Zeppelin airships.

After 1912, a consortium of firms from AEG, Siemens & Halske, Telefunken and Felten & Guilleaume had bought the Lieben tube patent. With this tube Meissner invented a feedback high frequency generator in 1913. In 1912-13 he produced a flurry of new radio circuits some of which we will concentrate on in this article. Many of his later patents in the 1920's show new circuit ideas, which are quite ingenious like double balanced and push-pull crystal sets, foreshadowing modern integrated radio circuits.

Before the war, Telefunken and Marconi had negotiated a German –British patent parity agreement. During World War I however, the patent protection of Britain and the USA was suspended and many of his patents had to be re-registered post-war with much later dates. Thus he was basically thrown out of the 4-party regeneration patent battle by a technicality! After 1928 Meissner served as a professor at the Technical University of Berlin. In 1930, he entered the research institute of AEG; altogether he attained over 200 patents and by World War II he was quite renowned. He was married and had a son. He died on January 3, 1958, in Berlin. (9,10)

Let me summarize that Meissner was an engineer with additional background in physics with skills in radio and amplifier design. (8) His genius also included antenna and antenna superstructure design, quartz crystal structures and the development of early radio direction finding techniques and transforming them into real systems. As an example, the German geolocation guidance stations, which guided the Zeppelins, were based on his rotating beam beacon concept. (7) This clever system used directional beams, but also synchronization and timing and thus it is the grandfather of both LORAN and GPS.

THE LIEBEN VALVE

The hot new radio devices in 1910 were the American, Lee deForests's Audion *hard valve* and the German, Robert von Lieben's *soft valve*. One of Miessners first tasks for Telefunken was to try to evaluate these new valves for use in improving radio circuits and developing commercial applications. (7) DeForest had a beautiful patent on the Audion. But since there was no high license fee on the Lieben valve, and it had been made available to Telefunken through the patent sale, that device was what received the most attention from Meissner. Telefunken had a policy of fast development and profitability. As

many new radio circuits as possible were to be developed and put into protection and *production*. Telefunken and his boss Count Von Arco did not want Meissner to study or explain the circuits and effects in a running dialogue as with deForest and Armstrong; they expressly wanted him to drive profits. (7)

Fig. 3. The Lieben Valve

Photo Courtesy H.T. Schmidt Copyright 2009

Some more detailed information on the Lieben valve can be found on Hans Thomas Schmidt's website (1) Telefunken was not the only licensee of the Lieben's patents. The were three other manufacturers, Siemens, Felten and Guillaume (later TeKaDe) and AEG. The patents can be seen on his homepage and also the consortium trust between the manufacturers and Robert von Lieben. A very significant patent is the first Lieben patent from 1906, which decribes audio amplification in a vacuum tube with electrostatic or magnetic control.

Before the winter of 1913/14, pumping a valve to a hard vacuum was not yet possible. All earlier pumps worked with mercury. Von Lieben obtained and used a rotating mercury pump from Wolfgang Gaede, invented 1905. In 1913 Gaede invented the molecular pump which finally made high vacuum tubes (hard tubes) possible. One of the first of these new pumps reached the USA very early. (1)

Let's take a look at the technology in the Lieben valve. The Leiben valve or ("translated literally as Love Relay") is a *soft* valve meaning it is not a high vacuum *hard pumped* device like an audion but it is in fact a mercury vapor or thyratron triode, with an imperfect vacuum. This valve, from 1906, was originally designed to be used like a relay for weak telegraph signals. A small positive signal on the grid causes the tube to conduct in its plate. In its original form, it is not regarded as a linear amplifier but was later adapted to the amplification of wireless receiving sets and finally in 1913 applied as an oscillator and regenerative detector by

Meissner.

"It must be at once mentioned that these are not high vacuum bulbs, an atmosphere of mercury vapor being purposely provided by the small piece of mercury amalgam shown sealed into the small side tube at the bottom of the tube sometimes called an *appendix*. The result of this vapor and the oxide-coated Wenelt (heated) cathode is that the tube in operation shows a continuous blue glow. The filament is a (wound) platinum strip, about a meter (3 feet) long in all, 1 mm. (0.04 inch)

Fig. 4. Lieben Valve detail.

Photo Courtesy H.T. Schmidt Copyright 2009

wide, and 0.02 mm. (0.002 inch) thick. It is thinly coated with a mix of calcium and barium oxides, and is brought to a bright red heat by a current of about 2 Amperes from a 28 to 32 volt storage battery, the current being regulated by a 5 ohm variable series resistance." (Note: necessary control, regulation and filtering circuits such as rheostats are usually left off patent diagrams for clarity). Considerable heating power is, therefore required; and the source of this power must be an extremely constant one. The plate circuit is fed from a 220-volt source, which may be an ordinary dynamo with choke coils in the supply leads to cut down on the incidental noises." (11,12) (Note: again never shown in the patent diagrams but one wonders how you would use a dynamotor to run a receiver without filtering!).

The zigzag cathode, punched aluminum grid and spiral plate structures all look technically excellent, showing the quality commercial construction possible at Telefunken, even on new device types.

"The best operating point is usually where blue ionized mercury vapor begins about one to two cm over the grid. While operating the tube it could be necessary to heat up the sodium amalgam (sodium-mercury alloy) in the *appendix* of the tube to raise the vapor pressure of mercury in the tube for better performance. Later Lieben tubes had a grid made of wire instead of the punched aluminum plate. The Lieben tube with the sheet metal was named "Kraftverstärker". Both variants had also been built in a smaller version of about 195 mm height."(13)

RELAY (AURAL) AMPLIFIER

It was soon demonstrated that the reliability and "range" of damped wave telegraphy communications could be increased by a factor of 10 (20 dB) with a single audio amplifier valve attached to a high performance tuner and detector. This was a tremendous

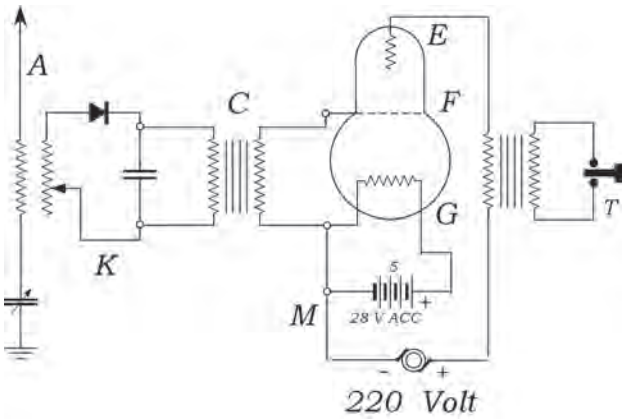

Fig. 5. One of Meissner's Amplified Receivers

*The Lieben Valve is heated with 28 - 32 VDC with rheostat. The Plate voltage is supplied by a filtered Direct Current Dynamo.

advance for spark. Several patents are published in 1911 and 1912 based on the Audion and Meissner applies the high gain Lieben Valve with similar success.

Certainly the amplification of crystal detectors using vacuum tubes for aural reception was an important advance and several groups were working on this feverishly including deForest. But there also was quite a controversy as to what technology, gas relays or electron relays, was the best approach for amplified radiotelegraphy reception. With a gain of over 30, the Lieben valve not only drove headphones, but in cascade it could actually be used to drive sensitive mechanical relays. In November 1911, before the *oscillator*, Meissner was using the Leiben valve to detect and amplify spark transmissions.

RF AMPLIFIER

Amplifying the RF before a crystal detector proved to be even more effective since it allowed two or more tuned circuits to be used in cascade before the detector, with the amplifier valve canceling out the losses. It was noticed that this amplifier sometimes was stable with predictable gain, sometimes produced tremendous gain and sometimes oscillated. Lee deForest later argues that he spent a summer trying to keep his Audion from "howling"! If you remember the Barkhausen criteria, you know that you need only an amplifier gain of just over one and proper feedback and phasing to maintain continuous oscillation.(14) Even a diode can be made to oscillate due to negative resistance. So high gain devices like the Audion and Lieben valve

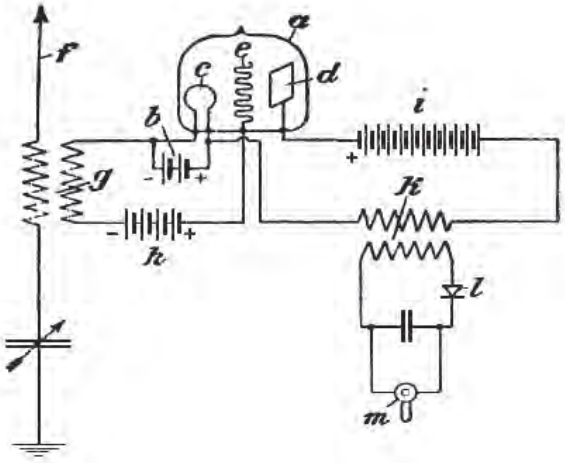

Fig. 6. HF Amplification - Otto von Bronk DRP 271059 Patent

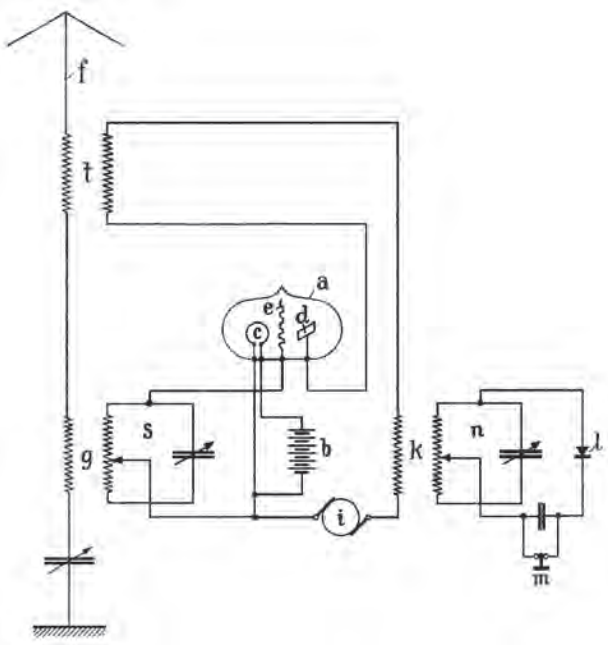

Fig. 7. Meissner (Regenerative Preselector) DRP 290256

were no doubt oscillating wildly in laboratories all over the world in 1912, and I might add - mostly by accident!

A schematic from Otto Von Bronks *Deutsches Reichspatent* DRP 271059, HF –amplifier, dated 1911 is shown below (Fig. 6). This was an early use of the Lieben valve as an HF (High Frequency) amplifier. Below this I show Meissner's *regenerative* RF amplifier DRP 290256 dated 16 July 1913 (16), (Fig. 7).

This radio circuit is an amazing accomplishment and Meissner in his patent, claims that it has improved performance over Von Bronk's HF amplifier. Regeneration is used to both increase the gain and the Q of the front end. There are no fewer than three tuned circuits between the antenna and the detector. This circuit looks very effective and if you wanted to have some fun, it is worthy of adapting to the 1AD (one active device) Contest, sponsored by the Birmingham Crystal Radio Group, where it might possibly cause quite a commotion! (17)

1913 OSCILLATOR PATENT

Let's look at Meissner's first regeneration *oscillator* patent, issued in Germany, which is DRP 291604 of April 10, 1913 (18), (Fig. 8). This is an oscillator, plain and simple. Looking at the circuit, you have no doubt that this design exactly defines the inductive feedback oscillator, which is today called the Armstrong Oscillator or sometimes simply the Blocking or Tickler Oscillator on this side of the pond.

The method of self-excitation of the valve Meissner originally termed "backcoupling"

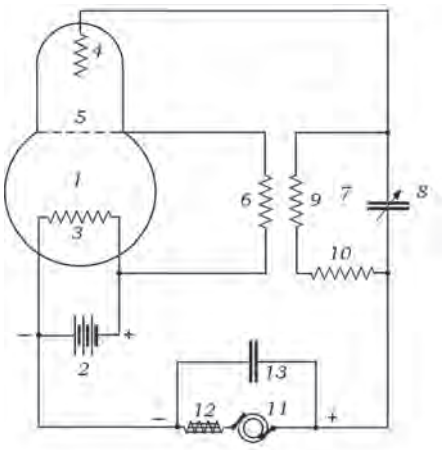

Fig. 8. April 10, 1913 Patent Oscillator

(Ruckwirkung). It has since become successively known as "retroaction", then "reaction" and finally regeneration. The use of retroaction is not entirely due to Meissner since Strauss, who collabo-ratedwith Lieben and Reisz, first mentions it in an Aus-

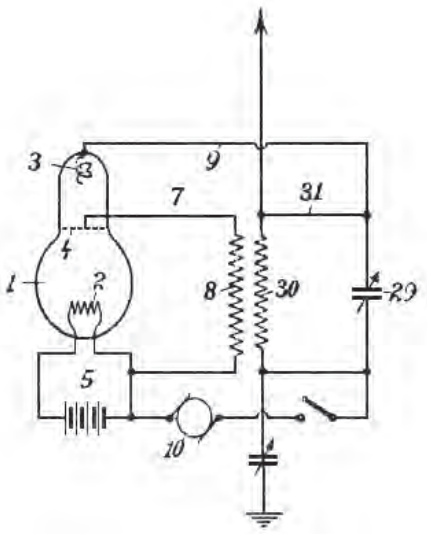

Fig. 9. Simple Tuned Plate Meissner Oscillator from a later (1914) Patent

trian patent of 11th December 1912. Stauss however, merely applied such retroaction for intensification of received signals (audio and RF regenerative amplification) and apparently did not consider the valve as being capable of use for generation. Armstrong, by a U.S.A patent of July, 1914, also protects the use of retroaction for valve generators. (7)

Notice how not all of the plate tank inductance is used for feedback. The tank has been split into two coils and only one coil is in retroaction. This is typical of the early Meissner oscillator designs and it finds its way into the receivers. Later Meissner designs also show 4 coils with two involved in feedback and a simplified version showing only two coils in the more familiar Tuned Plate version (Fig. 9).

If you study Armstrong's first regeneration patent you see several very complicated circuits, some of which are inductive feedback types, some which are no doubt, TPTG oscillators, and a couple that have both at the same time! So I would put forward a notion that the first Armstrong Oscillator could just as well be the TPTG as the inductive feedback type. In any case, both are shown and both are described in the Armstrong patents. According to Meissner, the Armstrong retroaction patent was filed after knowledge of his own discovery. Notice that the Meissner circuit is lacking grid leak or grid bias control.

The early soft Lieben valves that Meissner used in his 1913 experiments did not hold up to use as an oscillator and the life of such a valve could be as short at 20 minutes of key down transmission (with no grid biasing).(7)

But actually this thinking is not entirely true. The Lieben valve was used with a negative grid voltage, even though this is hard to see in the diagrams. The grid was indirectly connected with the negative end of filament bias. The filament was heated up to 28V DC so consequently *most* of the filament wire has a more positive potential than the grid. (1)

The working time of the early Lieben valves was very short. They only operated at ratings for approximately 1 hour, but after removing, hanging the bulb upside down and cooling it, further use was possible. The addition of temperature control added to stability. (1)

In any case, Meissner was able to use the system to demonstrate radiotelephony communications over a 36 km distance in 1912 us-

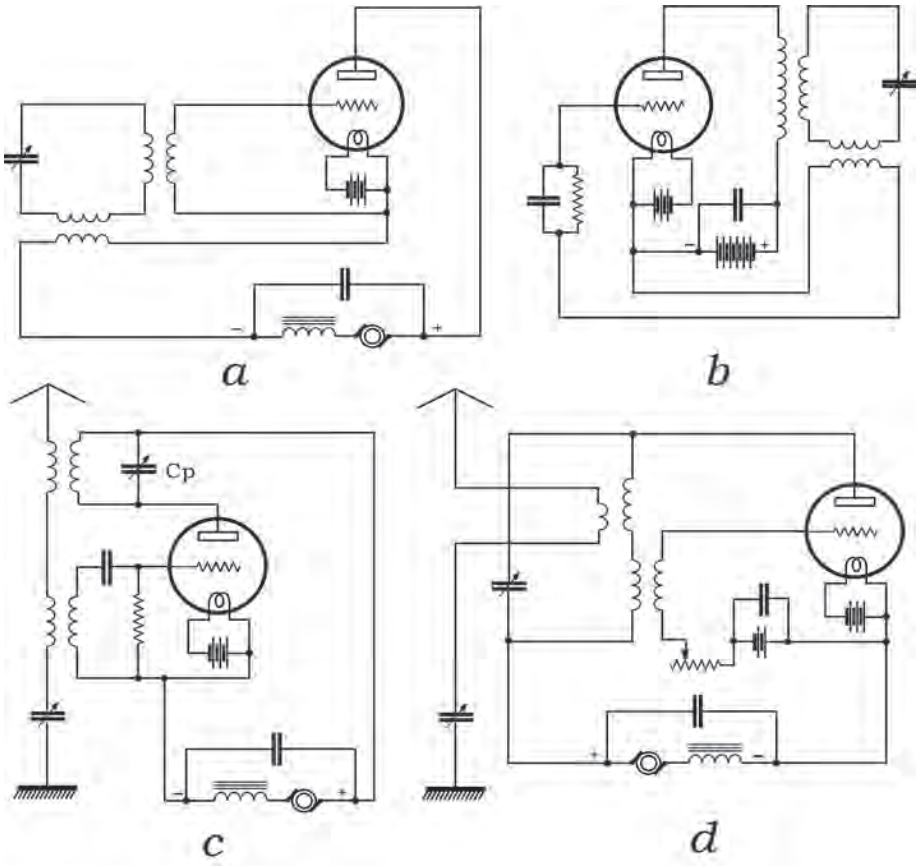

Fig. 10. Meissner Oscillator Variations

ing a 12 Watt oscillator based on the Lieben valve using a plate potential of 220 VDC.(7)

One more interesting point on the Lieben valve from Hans: The lieben tube was not a good high power transmitter tube. The output power was too low. It was mostly (likely only) used as modulator tube in machine transmitters or as external oscillator for heterodyne detector receivers. The last of them were used in the SS Vaterland (later Levanthian). On this ship the valve was also used as an audio amplifier. (1)

In the variations diagrams in Fig. 10, I show a couple of ways to grid leak stabilize the oscillator (b and c) and a fixed *bias* method (d). Fixed bias or adjustable fixed bias as pioneered by Franklin in 1914 is appropriate and after 1915, basically all Meissner oscillator variations show grid bias control. Notice in c and d that the oscillators are an open type. (19) That is, they are supplying power to the antenna (load) with a great effect on the tuning. The natural resonance of the antenna can be used to tune the oscillator alone. The plate and grid coils in effect are both ticklers in that the resonance of the antenna and loading sets the oscillation frequency. Practically speaking, a plate capacitor (Cp) or a grid capacitor or both can be added to force resonance in a more controlled manner. In

the radiophone circuits of the early 1920's typically they resonated the plate or grid but took power from the plate tank. For CW however, this coupling is best done from the cold side of the tank as with all self excited oscillators, a link giving the best compromise on note and stability, especially into a modern 50-Ohm antenna match.

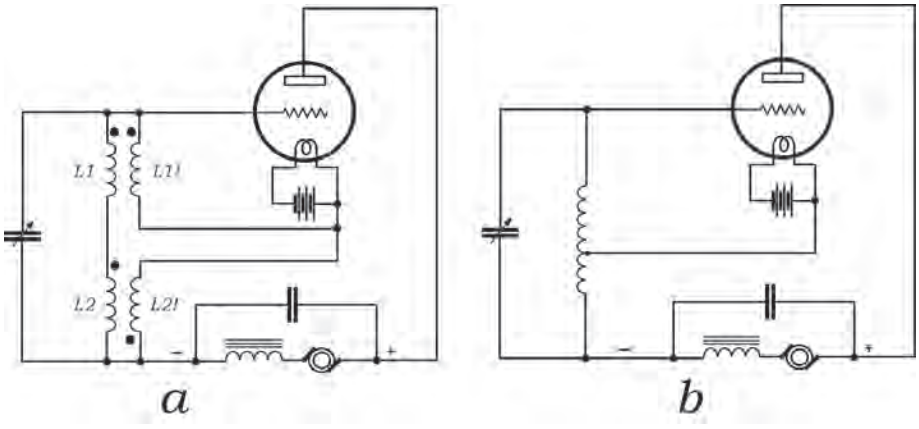

Fig. 11. Meissner compared to Hartley

MEISSNER'S OSCILLATOR

The Meissner type has the three critical LC oscillator characteristics of adequate gain, correct phase shifting (for positive feedback) and a frequency-determining circuit (resonant tank). These characteristics make it a stable continuous wave, low phase noise, oscillator. It actually is a very flexible circuit being a 4-port (or point) oscillator rather than a 3-port system like a Hartley or Collpitts. This means that the feedback can be adjusted independently of the tank inductance and Q and greater output and stability can be achieved over a wider frequency range. Notice that in some of the diagrams, 3 or 4 coils are involved. This splitting of the inductance allows the feedback to be independently applied in a more controlled manner. Thus, layout can be optimized, and the power can be taken off the plate circuit from an inductor that is not involved in the feedback process. The result is tremendous stability. The General Electric and Marconi Radiophones extensively use the 4-coil system throughout the late teens and early 1920's under license. Later, designers dispense with these and you generally see only two coils. The Meissner was preferred for communications receiver local oscillators throughout the 20th century, where a stable output over a wide range was required. Most hams of course followed the *Handbook* and the simpler to build single coil transmitter circuits like the Hartley. Speaking of *Hartley oscillators, consider the simple transformation below.

HOW IT WORKS

The operation of the Meissner oscillator is basically thus. Let us consider the classic Meissner 4-coil version shown in Fig. 11 (a).

* It is fairly apparent that the Hartley is derived directly from this version of the Meissner. For an example of a famous amateur radio station that used the Meissner circuit in the 1920's: see http://www.qsl.net/w5afd/5afd.html

Notice how the plate and grid each have a coil much like a tickler coil. They are each independently coupled to the tank circuit in two pairs with one in anti-phase. Again, the grid and plate coils are neither magnetically coupled to each other nor to the other coils in electrical series with them. In fact the upper and lower sets of coils can be at right angles to each other or on separate decks of the transmitter. Resonance of course depends on the total series inductance of the two tank inductors and the standard resonance formula is adjusted to be:

$$f = \frac{1}{2\pi\sqrt{[(L1 + L2)C]}}$$

where L1 and L2 are the inductors in series on the tuned tank side. In a practical **closed* oscillator circuit, the actual oscillation frequency will be slightly different (lower) from the value provided by this formula because of stray capacitance's, internal losses (resistance) and loading of the tank circuit by the feedback coils. The load, which could be another (especially un-neutralized) valve stage, could also greatly effect the actual operating frequency. Most importantly and finally, in an *open* oscillator circuit where the load (i.e. a resonant antenna system) determines the primary operating frequency, *it* dominates.

Back to the operation of the oscillator...First we consider the grid at zero potential in respect to the filament. When plate voltage is initially applied current flows to the plate, and an electromagnetic field is generated in the entire composite plate coil. (Even though L1 and L2 are in the negative side of the power supply, they are still in the plate circuit.) Based on the inductive ratio between L2 and L2!, some inductive (magnetic) feedback will energize the tank to the resonant frequency. This through the 180-degree phase reversal of the two-coupled windings forces the grid negative through its top coupling network made of L1 and L1!

The grid being negative with respect to the filament stops current flow into the plate. Thus the plate LC energy collapses on itself and again through a phase reversal it drives the grid circuit, but this time positive which starts the whole cycle over again. During every cycle, the grid potential oscillates back and forth between two extreme limits. The idea is that the plate current is in phase with the grid voltage. This is the positive feedback condition. (19)

It is also important that we understand the coupling effect and why Meissner took such great care to control it. Suppose the circuit shown is oscillating. If the coupling coefficient of the two magnetically coupled coil sets is gradually reduced, a given alternating grid potential in the coil L1! will require a gradually increasing alternating plate current flow in the tank coil L2!. In other words the *looser* the plate to grid coupling, the *stronger* the oscillation required for inducing a given grid potential. The oscillation thus increases with decreasing coupling coefficient, until the plate current varies over the entire portion of the characteristic curve of the valve. A further decrease in coupling can no longer support more plate current and eventually the power will begin to

* a *closed* oscillator is one that has its frequency determining components onboard - that is , it does not depend on external loading or tuning components to function.

drop off until oscillation finally ceases all together. On the other hand if the coupling in both networks is made tighter and tighter, eventually the plate current reduces to a level that the oscillations will also cease. So it is apparent that there is an optimal amount of coupling that is very important in achieving stable high power output. When we take power from the oscillator, we must replace it. (19)

As described before, some grid bias naturally occurs with the high filament voltage but there is a problem with the circuit in that the grid is not completely cut off because there is no grid leak or fixed bias and this causes over dissipation and the possibility of the oscillator not starting properly. So the modern versions from 1914 on, all show grid (gate, base) bias control.(20)

"A frequent bone of contention in radio patent litigation is the grid leak. (See Patents, U.S. 1,282,439, Br. 147,148 to Langrnuir; and U.S. 1,377,405 to De Forest.)In a somewhat lesser degree, questions arise regarding the " C " battery or the application of a steady voltage to the grid of a triode. (See Patents, Br. 1,482/11; U.S. 1,038,910 to Von Lieben et al; U.S. 1,231,764 to Lowenstein; U.S. 1,282,439 and Br. 147,148 to Langmuir; Br. 13,248/14 to Round; and U.S. 1,426,754 to Mathes.)" (21)

The Meissner oscillator is an example of how a non-linear device (the Lieben valve) can produce a sine-wave output that is not distorted. Although class C operation is nonlinear and many harmonic frequencies are generated, only one frequency receives enough gain to cause the circuit to oscillate. This is the frequency of the resonant tank circuit. Thus, high efficiency and an undistorted output signal can be obtained.

HETERODYNE RECEIVER

The newer (new in 1910) continuous wave transmissions coming from undamped sources such as alternators had no tonal quality that a crystal detector could demodulate. Vaccum tube oscillators would have a similar continuous signal nature. Several clever ways of post detection *remodulation* were developed using a *ticker* or slipping contact detector, a motor driven rotating ca-

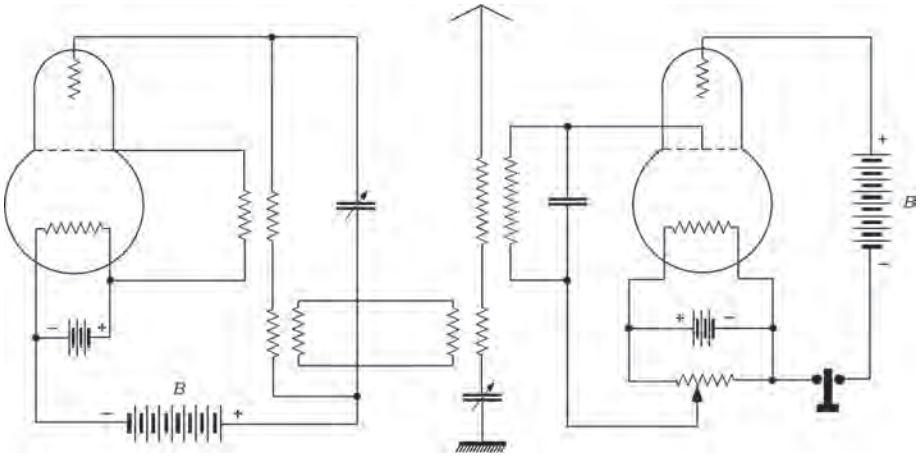

Fig. 12. Heterodyne Reception (Using 1911 Detector and 1913 Oscillator)

pacitor and finally a tone wheel. A more sensitive and pleasantly stable CW demodulation system was the beat receiver or heterodyne method. The original heterodyne technique was pioneered by Canadian inventor-engineer, Reginald Fessenden. Fessenden made his discovery in 1902, before the vacuum tube oscillator.(4) He was forced to use an alternator or a somewhat unstable "singing arc" as his BFO, so the clever technique was limited to very low frequencies. Recalling this and in Meissner's own words in a translated address from 1953, (22) he talks about the discoveries of 1912 in regard to the "Machine Transmitters" that were also called alternators. These devices were limited in frequency but produced almost perfect CW tone. (The text is in German but I have attempted a translation ... *Author*)

"During spark reception with a simple detector, the tone of the radio characters is clearly perceptible in a headphone; but everything remains quiet with the receipt of an undamped continuous wave telegraphy transmitter with a detector. Only at the beginning and end of each Morse signal one hears a quiet cracking. One improvement is a way that scrambles the DC developed in the detector with the receipt of a transmitter by a circuit breaker thus producing an alternating current audible in the headphone. But when atmospheric disturbances occur, it is nearly impossible to hear the characters. The machine transmitter was finished, but we had however no acceptable reception procedure for satisfactory reception of continuous wave. In the excitement we found a yellowed, forgotten patent of R.A. Fessenden from the year 1905. (23) Interference tones should be produced with a telephone, which consisted of two closely aligned generator decks. Through the one the receipt stream went through the other the frequency somewhat deviating auxiliary generator. The mechanical reciprocal effect between the coils fastened on diaphragms produced an interference tone.

For us it was an illumination at that time, when we came on the thought to make the interference procedure technically useful by it that we mixed the two oscillations in an electric circuit and rectified them with a detector. So we had the interference tones in a normal telephone. But our local generator existed in a large 10-KW machine in more than 50 m distance of the receiver. The interference tones were for us like magic, particularly when atmospheric disturbances occurred. But they varied with the number of revolutions of the machine. We had to find a new technical solution at this point. We found it: the hererodyne, the Lieben valve with feedback, the small tube generator arbitrarily adjustable in the frequency. It was added to each receiver. Interference free reception was now the norm. Thus at that time the tube transmitter in its first implementation saved the machine transmitter. Later the machine transmitter was displaced by the tube transmitter as it developed both in power and sophistication."

In this description Meissner describes a beat frequency alternator station of 10 kW located near the main transmitter which, could actually service remote receivers! This certainly is an innovative beat frequency oscillator (BFO) *service* approach. He goes on to describe how difficult it was to get the beat oscillators stable enough for useful heterodyne re-

ception before the valve oscillator's existence.

At Telefunken, in 1912 it made a lot of sense to experiment with the Lieben valve as a possible high frequency BFO. After the oscillator Patent in 1913, Meissner used the oscillator to produce stable heterodyne reception and filed major Lieben valve circuit patents in 1914. Many heterodyne reception demonstrations followed. (24)

This schematic (Fig. 12) is a composite of two published schematics that I have sewed together. I have no original showing how Meissner actually connected the two circuits. He may well have used a crystal set rather than a Leiben plate detector but this connection makes the most logical sense to me, since it leverages the valve technology to the greatest effect for Telefunken. A modern version of this circuit might use a 12AU7 and of course would include grid bias. Better yet we would inject the BFO energy in a place so as not to cause re-radiation as with a multigrid tube or even utilize a balanced mixer topology. Meissner focuses on this subject in later patents.

REGENERATIVE DETECTOR

One must admit that Meissner's Regenerative Detector Patent DRP 290257 of 16 December 1913 shows a very nice schematic of a regenerative receiver.(26) Again there is nothing incorrect, odd or hard to understand about this circuit diagram (Fig. 13). It is the prototype of the modern regenerative circuit, complete with tickler in the plate circuit, throttle condenser and audio output transformer. The four-coil approach would provide excellent performance on a modern regenerative design. The valve receiver aided by retroaction increases gain and selectivity by hundreds over the crystal detector or even surpasses the crystal detector aided by

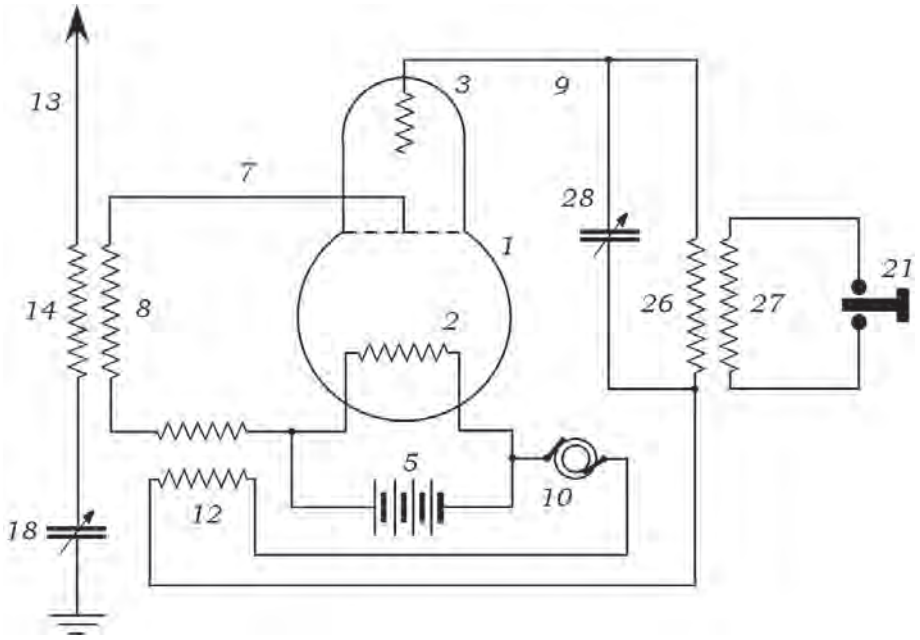

Fig. 13. Meissner Regenerative Receiver of 1913

a simple one-step audio or RF stage. Take a careful look at the DeForrest and Armstrong patent diagrams compared to this one. (27,28) Because the Audion oscillates so readily, they no doubt both functioned as drawn, but they sure do make you scratch your head compared to the clarity of this circuit!

THE TECHNICAL BATTLE ENDS

Soon after 1914, all of the inductive feedback circuits from most of the major manufacturers pretty much start to look the same. The technical battle has ended for this oscillator and manufacturing begins on all kinds of radio gear just in time for World War I. The legal battle over these circuits is already in full swing! Ultimately four parties seem to have a major claim to regeneration. But again, Meissner's claim being one of the strongest is simply thrown out due to the onset of hostilities of World War I.

" The patent situation as regards to retroaction is interesting. The first patent embodying retroaction applied for in Great Britain was that of Telefunken Company due to Meissner. This was shortly followed by application for a similar patent by the Marconi Company and Franklin, the only difference being that magnetic coupling was used in the first application and direct coupling in the later. Should the Telefunken-Marconi agreement to exchange patents, now that the war is ended, again become effective, this complication would have little effect, but otherwise the situation offers great legal possibilities. (7)

CONCLUSION

Most of the early circuits from 1914 on use a form of feedback, which Americans simply call *Armstrong* and Europeans call *Meissner*. That is, a grid coil and a plate coil in magnetic coupling for positive feedback, with either one or both tuned in association with an active device. In fact we now know that in 1912 several people (companies) were simultaneously developing this form of oscillator using various valve technologies at their disposal. Add to this that the developments were coming so fast that it is hard to tell who exactly the father of the circuit was.

If the Meissner Oscillator looks a lot like an Armstrong Oscillator, that is because the final evolution of each has turned out to be identical. In other words a tuned (Grid, Plate, Gate, Drain, Base, Collector) *Armstrong* is the same as a tuned (Grid, Plate, Gate, Drain, Base, Collector) *Meissner*. In Europe the Meissner name prevails and in the USA, the Armstrong name prevails. As a minor point of difference, some texts call the tuned grid version the Armstrong and the tuned plate version the Meissner.

But the clarity and exactness of the Meissner schematics speak volumes. These reveal a professional engineer; a scientist who understood the potential of several critical radio technologies seemingly all at once. He produced at least 3 concise working radio circuits based on the feedback invention, which could immediately be put into production. My intent was not one of malice; it was to simply introduce you to another important contributor with which you may not be familiar. Nothing changes of course. We still have our opinions on who the "Father of Regeneration" might be. But now that we have *Regenerated* Meissner, we may once again

be forced to dig deeper.

APPENDIX 1 SELECTED QUOTED SOURCES:

"C.S. Franklin, returning from a visit to Germany with samples of the Leiben-Reisz valve, brought back the news that Alexander Meissner of Telefunken had claimed to have found a way of making this type of valve act as a generator of continuous-wave oscillations. This information was at once exciting and alarming because both Franklin and Round were on the threshold of similar discoveries. Unknown to any of them, Armstrong in the United States was working on parallel lines. In the event, Meissner won the race, taking out a patent on 9 April 1913. C.S. Franklin's Patent was registered in June; Armstrong's in October and H.J.Round's in May 1914." (6)

"This situation needs some qualification however. Without wishing to detract from Meissner's brilliance as an engineer, it is on record that the apparatus he used was very inefficient. The Wehnelt cathode used in the Leiben-Reisz valve lasted only a few minutes in the circuit and the power output was very small. Round, although legally almost a year behind Meissner in terms of a patent, had in fact given a demonstration of valved radiotelephony between Marconi House and the Strand and Savoy Hotel in 1913. The Circuit he used was much more efficient and embodied an important innovation, notably that of a grid capacitor with a high resistance across it (a grid leak) and of a resistance in the anode circuit to limit the current flowing though the valve (negative feedback), thereby preserving it from the effects of excessive ionization." (6)

"In 1913 he was the first to amplify high-frequency radio signals by using a regenerative (positive) feedback in a vacuum triode; this principle made it possible to build radio receivers more sensitive than any earlier type. In June 1913 Meissner used this electronic circuit to transmit speech." (9)

"To Meissner must also be paid the credit of realizing in 1913 the possibility of using the 3-electrode thermionic valve for transmission, a result of which was closely followed by Armstrong in the United States in a few months." (7)

" In 1913, by the use of the Lieben tube, Meissner of Telefunken Company (Germany) succeeded in the oscillation of wavelength of 600 m, output power of 12W, and consequently carried out the wireless telephony with a distance of 36 km. This is known as the first utilization of continuous oscillation by a triode in wireless telephony." (29)

Juni 1913: Wechselseitiger drahtloser Sprechverkehr zwischen Nauen und Berlin (37 km) mit Meißners Röhrensender (mit Lieben-Röhre). Damit begann die "Ära des Röhrensenders". Marconi erkannte Meißners Priorität an: Meissner "employed the oscillating valve for the first time as carrier-wave generator for transmitting speech".(30)

"There was an engineer who had applied for a patent on the regeneration circuit prior to Armstrong. He was the German engineer Alexander Meissner, who filed a US patent on a regenerative circuit in March 1913. Langmuir, a well-known scientist-engineer at GE, applied for a patent on 29 October 1913, the same day when Armstrong filed his patent. De Forest applied for a patent on the ultra-audion (a re-

generation circuit) in 1914, but his patent was not accepted by the Patent Office, because of Armstrong's previous patent. Therefore, de Forest and others filed an "interference proceeding" to the Patent Office, and a proceeding for the four parties involved – Armstrong, de Forest, Meissner, Langmuir – began". (31)

"The Year Book for 1923, which is published by a Marconi subsidiary in London, credits the invention of the self-heterodyne to Meissner of Berlin 1913, whereas it was specifically patented to H.J. Round in Britain by Patent No. 28,413 of that year, and Meissner expressly disclaims it. (Br. Pat. 252/14.) Nevertheless – and despite the further disclaimer of the British patented inventions of Franklin (13,636/13) and Armstrong (24,231/14)- Meissner's specification carries claims which appear to cover all three. If the reader is fond of mental exercise he will enjoy studying the latter (amended) specification in the light of the others mentioned therein... Whether or not the U.S. Patent Office differentiates or will differentiate, between the use of the "feed-back" circuit for the (a) generation of oscillations for transmitting purposes, (b) generation of oscillations for "heterodyne" reception, and (c) amplifying received signals, the author does not know." (21)

"The first to use the triode in a transmitter appear to have been Round in England, and von Arco and Meissner in Germany; but such use does not appear to have been specifically patented anywhere, unless, perhaps, in the latter country." (21)

"The use of a triode valve as the generator of oscillations was not appreciated until 1912, again by Meissner, then employed by the Telefunken Company, who arranged an inductive coupling between the grid and anode electrodes and so achieved CW oscillation at a frequency determined by the anode-grid coupling circuit. At first the use of the oscillator was confined to low power applications, again using a "soft – valve", resulting from the inadequate evacuation of the glass bulb, which left residual gasses effecting its operation." (32)

"The first reference in the records of the British Patent Office to the use of a triode as a useful generator for transmission purposes, seems to be in the specification of Br. Pat. 252/14 * to Von Arco and Meissner."

* BR. PAT. NO. 252. Date of Application, January 5, 1914, Accepted, August 19, 1915, Improvements in and relating to Relay Arrangements for Alternating Currents (19)

"Our national record in wireless telegraphy, apart from the financial side is a sorry one. None of the new ideas that revolutionized the subject during the past seven years can be regarded as having their origin or full development in this country. The conception of beat reception is American. The thrree electrode thermionic relay is American. The method of generating oscillations by aid of the thermionic relay was invented (probably independently) in Germany and the United States. The control of high-frequency currents by magnetic relays is likewise of German and American origin. The multiplication of frequency by aid of the properties of iron is French, Italian and German." *Electrician*, Editorial, p228, 21st February, 1919. (7)

And of course the famous:

"In August (6 Aug 1912), he (deForest) connected the output circuit of one audion to its own input circuit, and according to his own description, he obtained regeneration or feedback amplification, as well as sustained oscillation. From lee de Forest's entry in his notebook, April 22, 1912 & August 6, 1912, ibid." (31)

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ABOUT THE AUTHOR

Michael Murphy, WU2D, has been playing with radio circuits since he was in middle school in the early 1970's. An amateur radio license soon followed and over one high school summer vacation period, he built just about every basic circuit he could get his hands on including all of the basic oscillator types, regenerative receivers and other radio circuits.

This was a transitional time in electronics and the switch from vacuum tube to solid state was underway and Mike learned both hand in hand. He obtained two engineering degrees in 5 years of college in the State University of New York system and Rochester Institute of Technology, with co-op experience. Graduating in 1980, his first job was in the special products engineering group at Motorola. This group catered to the undercover police customers and to the three letter agencies. This basically steered him into the police and military gear design business, working for a number of companies. He has designed a lot of body worn gear, both audio and video devices and plenty of disguised devices. He is presently pursuing a Masters in Systems Engineering at Stevens Institute of Technology.

Over the years Mike has written for *QST*, *Electric Radio,* and lately for the *AWA Journal*. "I was once challenged to come up with a crystal controlled regenerative receiver. Chuck Kitchin and I collaborated on that one and we published it in *QST* in 1997. My most popular article was done last year. It was *Secrets of the Dead Command Sets* in *Electric Radio*. I must have received a hundred e-mails and letters – everybody loves those things".

Mike was drawn in to the AWA four years ago by the Bruce Kelly Memorial 1929 QSO Party and he went nuts building up the gear and perfecting antennas for that contest. He finally won it last year along with the Linc!

Michael J. Murphy