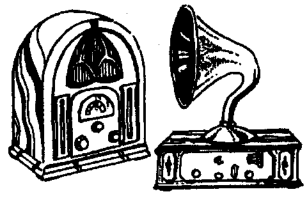


Vintage Radio

by PETER LANKSHEAR

The Browning-Drake receiver

One of the best remembered radio names from the 1920's is 'Browning-Drake', a receiver which combined simplicity with what for its time was a first rate performance. While most of its contemporaries had production lives of little more than a year, the Browning-Drake design was popular for much of the decade. As with the IBM personal computer [illegible] recently, there were also more 'clones' made by others than the official versions...

By the outbreak of World War I, valve receiver technology had advanced to the stage where stable detection and low frequency amplification were possible. However there were limitations to the sensitivity and selectivity of the grid leak detectors that had become standard.

The newly discovered *regeneration* helped, but it became clear that the only way to improve receiver sensitivity was to increase the strength of signals presented to the detector. Large aerials and efficient tuning coils helped here, but the need now was for satisfactory pre-detection amplification of signals. Although the radio spectrum at that time was confined to frequencies below 1MHz, the triode valves of the period could provide very little RF amplification before becoming unstable — especially at higher frequencies, where signals were weakest.

The major problem in achieving useful RF amplification was the bypassing of signals by unavoidable capacitances. Of course, the best solution was to make use of these unwanted capacitances by including them in tuned circuits coupling the valves. However the tuned RF amplifier then ran into another problem. Triode valves have sufficient inter-electrode capacitance that with tuned circuits connected to both anode and grid, there is sufficient energy transferred internally back to the grid to cause them to become vigorous oscillators.

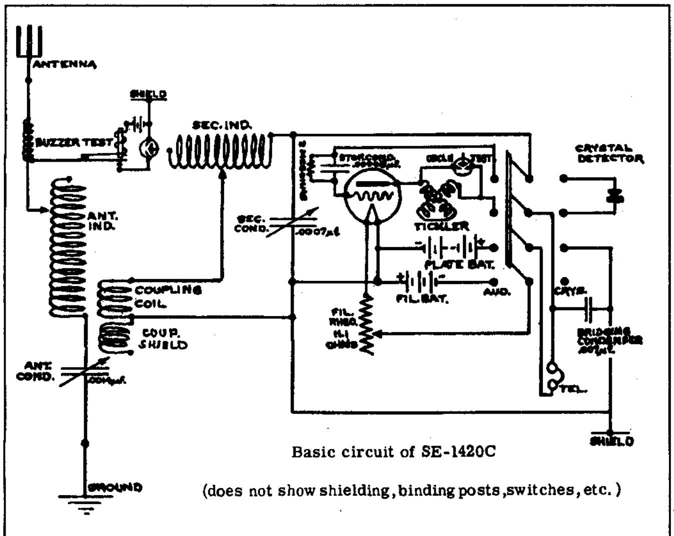
Initially there were two solutions. One was to follow audio amplifier practice and couple a series of valves by means of untuned broadband transformers. This method had some success, but with the valves available at the time, very limited stage gains were possible.

One example was the radio frequency amplifier made by Marconi's Wireless Telegraph Company, which had needed no fewer than six stages of amplification using the baseless high frequency type V24 valve. The only selectivity was provided by an aerial tuner. Although it worked, this method of reception was clearly very cumbersome and expensive, and quite unsuitable for home use.

The alternative method, and of course the ultimate solution to many difficulties was the *superheterodyne*, attributed by Americans to work done in 1918 by Major Edwin Armstrong of the US Army. While much credit is due to Armstrong, it is now clear that the original concept of the superhet was an international effort, with much of the early work being done in France. First though, there were many technical and commercial obstacles to be overcome and it was a good 10 years before these problems, and RCA's licensing restrictions, were overcome sufficiently for the superhet to be anything like widely used.

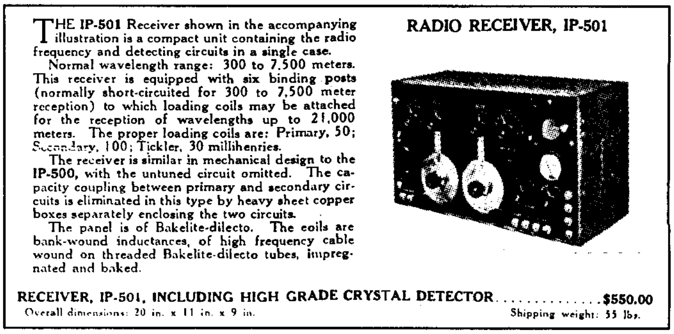
Naval problems

Meanwhile, also in 1918, the US Navy had commissioned their consultant Professor L.A. Hazeltine to design a new receiver, the SE1420. This celebrated receiver, much prized today by collectors, was required to tune from 40kHz to 1.2MHz. The SE1420 (SE stood for Steam Engineering!) provided the choice



Basic circuit of SE-1420C

(does not show shielding, binding posts, switches, etc.)



THE IP-501 Receiver shown in the accompanying illustration is a compact unit containing the radio frequency and detecting circuits in a single case.

Normal wavelength range: 300 to 7,500 meters. This receiver is equipped with six binding posts (normally short-circuited for 300 to 7,500 meter reception) to which loading coils may be attached for the reception of wavelengths up to 21,000 meters. The proper loading coils are: Primary, 50; Secondary, 100; Tickler, 30 millihenries.

The receiver is similar in mechanical design to the IP-500, with the untuned circuit omitted. The capacity coupling between primary and secondary circuits is eliminated in this type by heavy sheet copper boxes separately enclosing the two circuits.

The panel is of Bakelite-dilecto. The coils are bank-wound inductances, of high frequency cable wound on threaded Bakelite-dilecto tubes, impregnated and baked.

RADIO RECEIVER, IP-501

RECEIVER, IP-501, INCLUDING HIGH GRADE CRYSTAL DETECTOR..............$550.00

Overall dimensions: 20 in. x 11 in. x 9 in. Shipping weight: 55 lbs.

Fig.2 (above): Copied from a 1922 RCA catalog, this shows the IP-501 which was the civilian version of the SE1420. Some of these receivers were in merchant marine service well into the 1930's. Note the weight and price — both huge for a single valve receiver.

Fig.1 (left): The circuit for the US Navy's SE1420. The 'coup shield' was developed into neutralising by Prof. Hazeltine.

of a crystal or a regenerative valve detector, and provided variable coupling between the aerial tuning and detector tuning circuits.

It was essential that there be no capacitive coupling between antenna and detector circuits as, during reception of weak lower frequency signals, this had been found to experience serious interference from nearby 500kHz transmissions.

To eliminate this capacitive coupling, the antenna tuning coil was first isolated from the secondary circuit by enclosing each in a separate compartment of heavy copper sheet. But a coupling coil, in series with the secondary, was needed in the compartment containing the antenna coil to provide the required degree of inductive coupling, and the residual capacitance between these coils left a certain amount of undesired capacitive coupling which tuning could not eliminate.

To cancel this capacitance, Professor Hazeltine placed near the aerial coil an open-ended winding, shown in the diagram of Fig.1 and called a 'coupling shield', so proportioned that the unwanted coupling to the aerial coil was cancelled. As we shall see, this simple solution was later to have an important influence on broadcast receiver design.

Meanwhile, broadcasting had emerged — and with it the demand for easy to use receivers. Early American broadcast receivers usually consisted of a grid-leak detector and one or two audio stages. Regeneration was frequently used to increase detector sensitivity, but many domestic users were insufficiently skilled in its use, causing re-radiation and creating havoc for other listeners.

With the superhet still underdeveloped and tightly licensed by RCA, and the untuned amplifier an impractical complication, a method of stable RF amplification was needed. Professor Hazeltine realised that his method of eliminating capacitive coupling used in the SE1420 receiver could be adapted to neutralise the grid-to-anode capacitance of a tuned triode amplifier. Late in 1922, he designed a successful and stable radio frequency amplifier, incorporating this *neutralisation*.

Hazeltine named his new receiver the 'Neutrodyne' TRF. Incorporating two, and sometimes three neutralised RF stages, a grid-leak detector and two transformer coupled audio stages, it was to become the classic standard American receiver format of the mid-1920's.

With the degree of amplification possible with the multi-stage Neutrodyne, a regenerative detector was not essential — a definite advantage to non-technical users.

Do not install!

Another advantage of the TRF was that RCA held the regeneration patents, and demanded royalties for its use. Some manufacturers had found a way round this difficulty by not actually installing regeneration, but providing terminals with connecting instructions for a feedback winding — but with a warning for the owner NOT to do it!

Receivers using the Neutrodyne principle were still liable for royalties, payable to the Hazeltine Corporation —

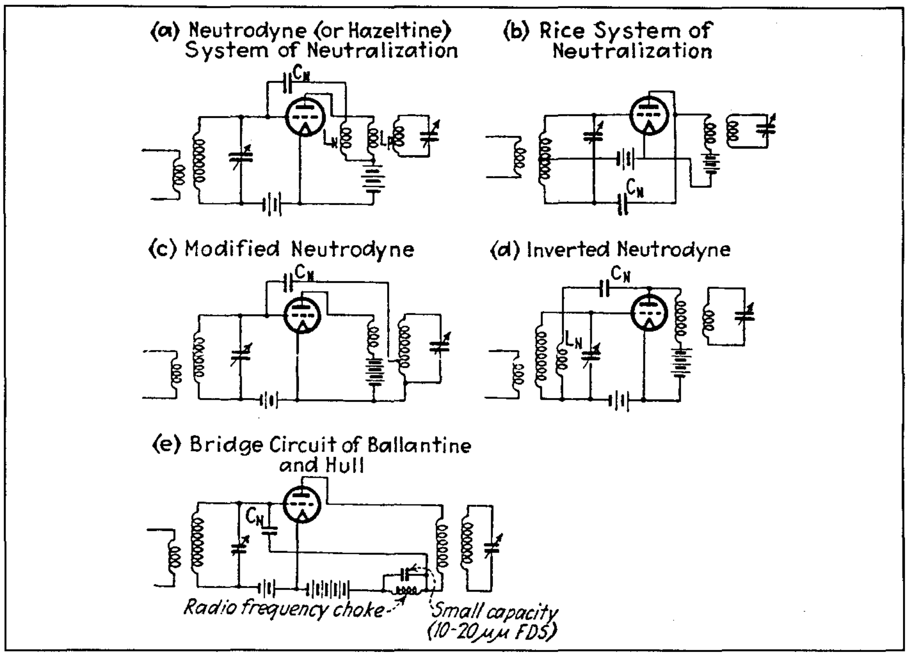


Fig.3: A group of neutralising circuits copied from Terman's 'Radio Engineering'. Each system couples a signal in phase opposition back to the grid. The method shown in (c) was used for the Browning-Drake receiver.

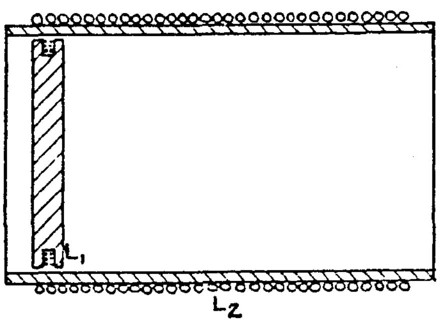


Fig.4: A diagram from a 1924 'Radio Engineering' article, which shows a sectional view of the primary (L1) and secondary (L2) windings of the Regenaformer. Note the position of the compact primary inside the main coil former.

Home built Browning-Drake receivers were to be found in all manner of cabinets. This table top chest with lift-up lid was a popular pattern.

which, incidentally, became very wealthy. Many receiver makers, including major organisations like Atwater Kent, resented this and circumvented the problem by introducing resistive losses in the RF amplifier grid leads, or by loading down the grids of the RF stages by applying positive grid bias. One receiver that used this rather cheap and nasty method was the Stewart Warner model 300, featured on the cover of my book *Discovering Vintage Radio*. However, there was little question that a well-designed neutralised tuned RF amplifier gave the best results.

Simple idea

The basic idea of neutralisation is simple enough. It can be regarded as a form of negative feedback. The capacitive coupling from anode to grid inside the valve is cancelled by externally feeding back to the grid an equal amount of signal — but in the opposite phase.

Hazeltine's phase reversal was obtained by the orientation of the primary winding of the following coupling coil. Several other similar methods of neutralisation, including systems attributed to Ballantyne, Hull, Scott-Taggart and Hartley were also used, and all used a small variable or semi-variable capacitor to adjust the coupling. Neutralisation in receivers became unnecessary with the advent about 1928 of the screen grid valve, but continued to be used with transmitting triodes.

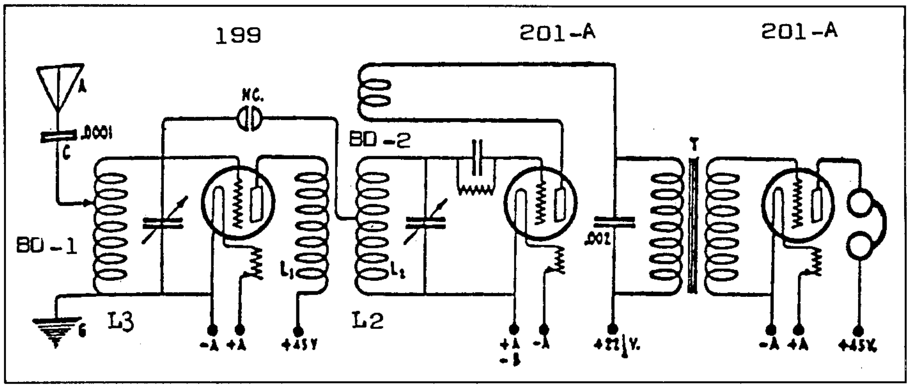


Fig.5: An early circuit intended to demonstrate the effectiveness of the Regenaformer. Glen Browning favoured the small 199 valve for the RF stage, because of its low inter-electrode capacitance.

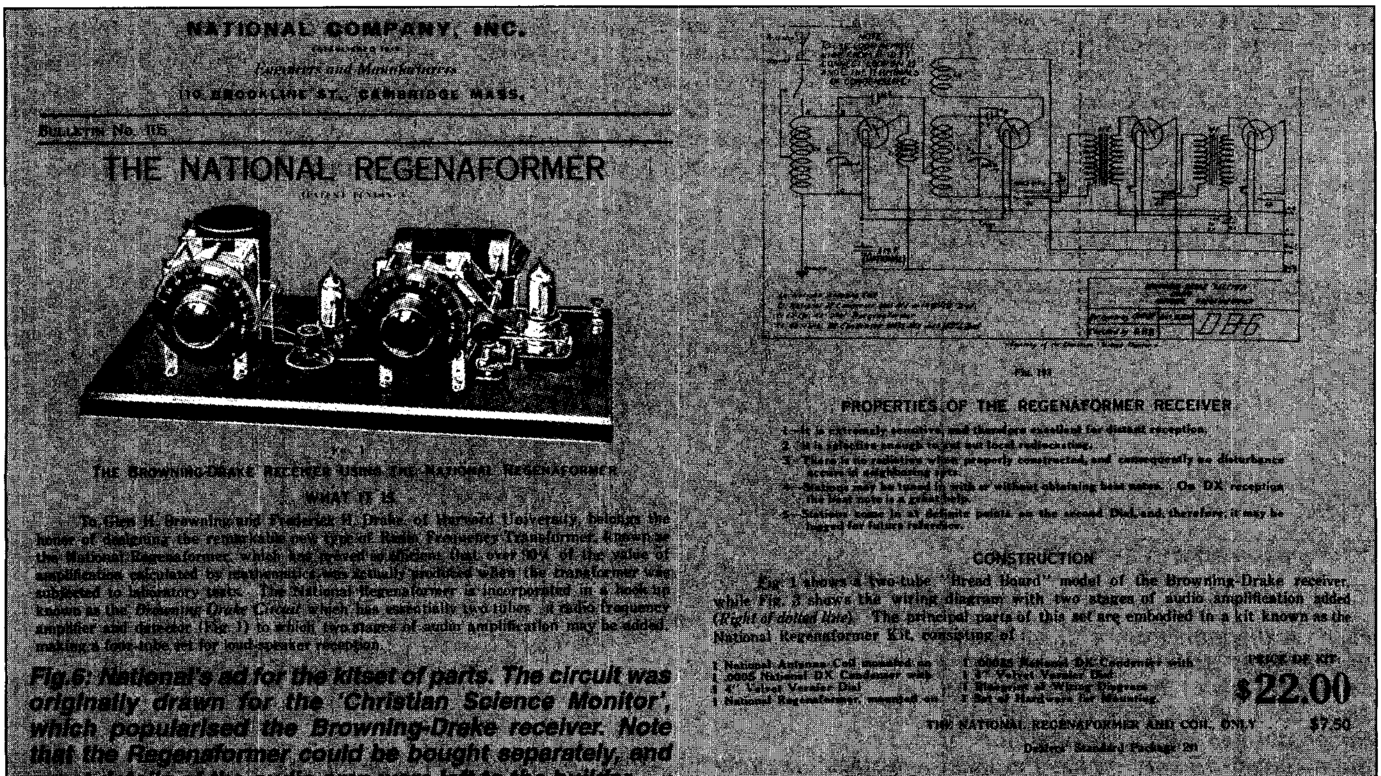
Harvard researchers

In practice, neutralised RF amplifier stages did not deliver the amount of gain theoretically possible. During 1923, at the suggestion of the radio editor of the *Christian Science Monitor*, two men at Harvard University collaborated to study the problem.

One was Frederick H. Drake, a senior student, who had made a mathematical study of the neutralised TRF; the other was Glen H. Browning, a noted Research Fellow, whom Drake persuaded to help him in confirming his theories. Their work verified that the loss of gain was due to unavoidable residual capacitive couplings, between the primary and secondary windings of the RF coils. In the conventional pattern of coil, the primary was wound over the lower end of the tuned winding.

In their research work, Browning and Drake found that there was a considerable reduction in capacitance between the two if the primary was made physically as small as possible.

They settled on the method shown in Fig.4, using a compact coil wound randomly with a relatively small number of turns of fine wire, on a grooved ring mounted inside the main coil former. It was claimed that this method achieved 90% of the maximum theoretical gain.


NATIONAL COMPANY, INC.

Engineers and Manufacturers

110 BROOKLINE ST., CAMBRIDGE MASS.

BULLETIN No. 115

THE NATIONAL REGENAFORMER

THE BROWNING-DRAKE RECEIVER USING THE NATIONAL REGENAFORMER

WHAT IT IS

To Glen H. Browning and Frederick H. Drake of Harvard University, belongs the honor of designing the remarkable new type of Radio Frequency Transformer, known as the National Regenaformer, which has proved so efficient that over 90% of the value of amplification calculated by mathematics was actually produced when the transformer was subjected to laboratory tests. The National Regenaformer is incorporated in a hook-up known as the *Browning-Drake Circuit* which has essentially two tubes, a radio frequency amplifier and detector (Fig. 1) to which two stages of audio amplification may be added, making a four-tube set for loud-speaker reception.

DB6

PROPERTIES OF THE REGENAFORMER RECEIVER

1—It is extremely sensitive, and therefore excellent for distant reception.
2—It is selective enough to cut out local radiocasting.
3—There is no radiation when properly constructed, and consequently no disturbance occurs in neighbouring sets.
4—Stations may be tuned in with or without obtaining beat notes. On DX reception the beat note is a great help.
5—Stations come in at definite points on the second Dial, and therefore, it may be logged for future reference.

CONSTRUCTION

Fig. 1 shows a two-tube "Bread Board" model of the Browning-Drake receiver, while *Fig. 3* shows the wiring diagram with two stages of audio amplification added (*Right of dotted line*). The principal parts of this set are embodied in a kit known as the National Regenaformer Kit, consisting of:

1 National Antenna Coil mounted on
1 .0005 National DX Condenser with
1 4" Velvet Vernier Dial
1 National Regenaformer, mounted on
1 .00035 National DX Condenser with
1 4" Velvet Vernier Dial
1 Blueprint of Wiring Diagram
1 Set of Hardware for Mounting.

PRICE OF KIT
$22.00

THE NATIONAL REGENAFORMER AND COIL, ONLY $7.50

Dealers' Standard Package 20

Fig.6: National's ad for the kitset of parts. The circuit was originally drawn for the 'Christian Science Monitor', which popularised the Browning-Drake receiver. Note that the Regenaformer could be bought seperately, and exact details of the audio amp were left to the builder.

Link to National

To confirm their theories, late in 1924 Browning demonstrated a 'breadboard' receiver tuner using a single neutralised tuned RF amplifier and a regenerative detector. The radio press were enthusiastic, giving the Browning-Drake tuner plenty of favourable publicity, for it really did perform as promised.

Smaller and cheaper than the conventional Neutrodyne, and with the improved gain of the RF amplifier plus the regenerative detector, this was a exactly what the home construction fraternity were looking for. The isolation provided by the RF amplifier prevented radiation of any interference from the regeneration. The performance of the Browning-Drake could match the Neutrodyne and if sold as a kitset, no royalties were payable to either Hazeltine or RCA.

By what turned out to be a fortunate coincidence, Harvard is located in Cambridge, Massachusetts — where there was also an enterprising firm, the National Company, making such diverse products as power plant equipment, household products and 'high tech' toys.

National had recently commenced making variable capacitors to cater for the new fad of radio, and were very receptive when Messrs Browning and Drake made approaches about supplying components for their tuner. These were put out as an attractively boxed kit which, as shown in the advertisement reproduced in Fig.6, included two tuning capacitors, two dials, an aerial coil, and the 'Regenaformer'.

The price of $22 was a bit high, but National's products were of first class quality. National went on to make distinguished equipment for amateur and professional use, including eventually the legendary HRO, probably the best known of all communication receivers.

Not a specific circuit

It must be emphasised that the distinguishing feature of the Browning-Drake receiver was not a specific circuit, but the Regenaformer with its special primary winding. This unit, mounted at the rear of the detector tuning capacitor, was an assembly comprising the detector tuning coil, the compact RF coupling coil and the rotatable tickler regeneration control. The Regenaformer could be purchased separately for $7.50.

The prototype was constructed without a panel, on a 'breadboard'. National's kitset diagram left precise details of the audio amplifier to the builder, but recommended two transformer-coupled stages, at that time a practically universal feature for receivers intended for loudspeaker operation.

Late in 1925, Glen Browning formed the Browning-Drake Corporation, to manufacture complete receivers as well as marketing kitsets. Whereas for most receiver makers the somewhat low-fidelity two stage audio amplifier was standard, Browning-Drake built receivers used a three stage resistance and impedance coupled amplifier, with an attendant improvement in audio quality.

Continued popularity

Unlike most contemporary receivers, which were in fashion for a year or two at the most, the Browning-Drake continued to be popular with enthusiasts for the remainder of the decade. 'Official' kitsets using National components were available from B-D until at least 1928. As late as 1930, full constructional instructions were still being published in hobby magazines and annuals — by which time, mains powered versions were being offered.

There were even instructions for building a 'screen grid' Browning-Drake, in which the triode RF amplifier was replaced by a screen grid valve. This development completely missed the point that the definitive feature of the Browning-Drake was the Regenaformer — which, with its special low capacitance primary winding, was unnecessary with a screen grid valve because it needed no neutralisation.

The Browning-Drake was the forerunner of receivers using a single tetrode or pentode RF stage, regenerative detector and audio amplifier — a format which proved to be remarkably durable, especially for amateurs and shortwave listeners. Featured in our January 1990 column, the 1929 Pilot Super Wasp popularised this configuration for shortwave receivers and it was not until the mid 1930's that the communications superhet became available.

The regenerative TRF with a single RF stage actually saw service during World War II as the R1082 receiver, which, with coverage from 111kHz to 15MHz, was part of the T9 RAF aircraft equipment.

Next month, we have some ideas and suggestions for building a Browning-Drake receiver.

Component supplier

I am often asked for addresses of suppliers of components and materials suitable for valve radio repairs.

Brian Smith's Wireless Workshop, of 12 Mansfield Street, Rockhampton Qld 4700 now issues on request a small catalog, which should be of considerable interest to vintage enthusiasts involved in restoration. ❖