Foregoing Audio Transformers since the Wireless Era…

Research by Bart Lee, K6VK, CHRS Archivist

Philip Monego asked me about an uncommon 1920s radio without any audio transformers:

No interstage or audio transformers
Strange
But lots of resistors and one mica cap
No information on the company

Philip Monego Photos

I did find another image of this radio from an auction site:

What does the “Rectifier” knob control?

What does the “Selector” do? Is it a band-spread? Does it narrow the bandwidth?

Is this circuit a detector followed by a multi-stage audio amplifier?

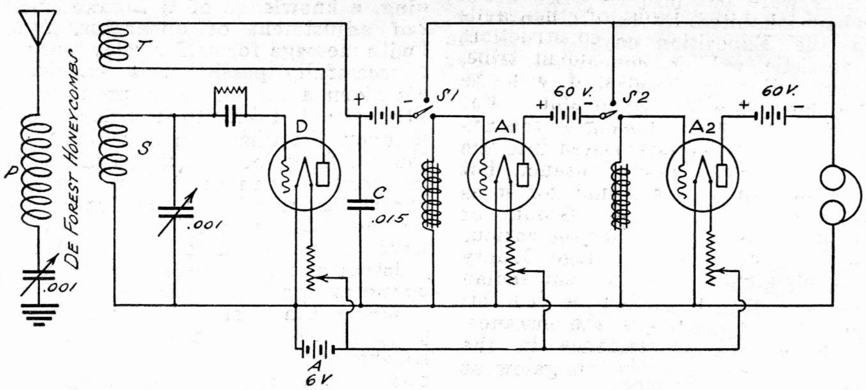
In the wireless era, before broadcasting, transformers cost a lot of money, relatively speaking. Clever radiomen created work-arounds, but still got amplification. *QST* magazine published a vacuum tube receiver circuit that seemed to work well using chokes but not transformers. Thus inductive coupling could save some money, and still get the era’s spark signals through to the headphones.

As *QST* points out, transformers had the virtue of impedance matching the inputs and outputs of the tubes. As the writer points out, transformers are expensive. So why use them when Ford spark coils are ubiquitous? (Or at least they were in 1920 – now they’re hens’ teeth).

Amplification with Choke Coils

By Robert Muns

WHY are all the wireless concerns in the country trying to sell the poor amateurs expensive amplifying transformers? When I entered the Air Service Radio School and advanced as far as amplification, I was handed a diagram of a two-step amplifier using transformers but the instructor said, "We have discarded these sets as they are very inefficient, but you better look this over in case you should run into one some time." With this information we passed on to the use of choke coils for amplifying.



Since the war I have done considerable experimenting with various chokes and find them 1¼ to 1½ times as efficient as amplifying transformers when using the hook-up shown. The best choke is a section of a 2" spark coil filled with core wire but the secondary of a Ford spark coil works very well. In this case the primary is not used at all. (How could we run a wireless if it were not for the Ford?)

The only disadvantage of this circuit is that a separate "B" battery is necessary for each tube but the increased results are worth it. Besides, the current used from each battery is less, so that the cost in the long run is about the same for batteries but reduced by the cost of the coils. A Ford coil costs about $2.50 while an amplifying transformer is anywhere from $4.50 to $7.50.

I have used up to four tubes with this circuit with no trouble from howling, and think that many more can be added without trouble.

(Editor's Note: The main advantage of a two-winding transformer is that it makes possible the obtaining of impedances in both input and output circuits which are best fitted for the tube used. These values should equal the internal input and output impedance, respectively, of the tube. Another advantage of great importance is the step-up in voltage secured by a proper turns-ratio, so that a transformer-coupled amplifier will reach the possible maximum of amplification with less tubes than one impedance-coupled. There is no question, however, that very satisfactory results may be obtained by the use of chokes, but it must be remembered that the turns-ratio is only 1 to 1.)

Transformerless Wireless? So how actually does this circuit work? Resurrected from the mists of time, it challenges at least me. Are the chokes sending some but not all of the tube's output on to the next grid? Are they in effect an audio slot filter facilitating amplification of some audio frequencies? Would it matter for a spark signal?
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The Oracles of the Internet shed some light on this circuit:

Impedance-Coupled Amplifiers Author: J.B. Hoag

The principle of the impedance-coupled amplifier was discussed previously. The addition of the power supplies, with their attendant filtering and decoupling circuits, follows the same lines of reasoning as for the R-C coupled amplifiers.

The inductance of the coupling impedance is made as large as possible; by winding its turns on an iron core when amplifying audio frequencies. The iron core is of the closed-shell type in order that the magnetic field will be confined as much as possible to that particular coil; so that it will not spread out to cut the wires and coils in other parts of the circuit, with the attendant induction of e.m.f.'s in undesired parts of the circuit. The higher the inductance L of the coupling impedance, the greater will be the reactance ($2\pi fL$) of the coil, and the greater will be the a.c. voltages across it, i.e., the higher the amplification. The need for a large L is particularly great at the low frequencies, where $2\pi fL$ is small because f is small. Values of L range from 10 to 800 henries in audio amplifiers. The inductance of an iron core coil decreases as the d.c. current through its windings is increased above a certain small value. This is due to a decrease in the magnetic property (called the permeability) of the iron with increase in magnetizing force of the larger currents. In order to keep L large and independent of the d.c. plate current, the plate circuit is sometimes split into two parallel branches, one for the d.c, the other (containing the coil) for the a.c, as in Fig. 25 F.

Fig. 25 F. Coupling unit for an impedance-coupled a.f. amplifier using parallel plate feed

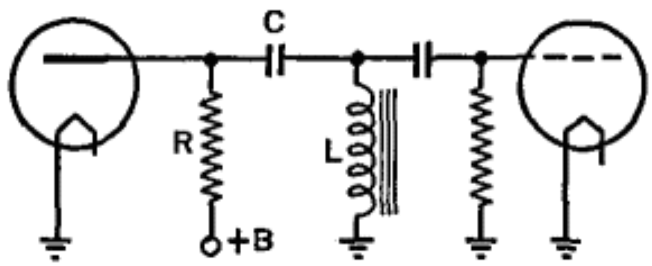

Fig. 25 F. Coupling unit for an impedance-coupled a.f. amplifier using parallel plate feed

The blocking condenser C can be chosen so that its reactance is numerically equal to that of the coil L for a given frequency. Parallel resonance then occurs in the circuit RCL. The voltages which develop across L at the resonant frequency are comparatively large. If L = 125 h. and C = 0.05 μfd., then fr = 60 cycles. Then the gain of the amplifier at the low frequency end will be greatly augmented. In fact, the frequency whereat the resonant character of the RCL circuit is developed can be chosen at will, thus increasing the gain at low, at intermediate, or at high frequencies. If R is kept to a low value, the resonant peak will be sharp, and vice versa. Thus the frequency-response curve of this type of amplifier can be made to have a wide variety of shapes. In conclusion, we may say that impedance-coupled amplifiers give somewhat greater gain per stage than do R-C coupled amplifiers, they do not require as high a voltage for the B supply, and they do not (in general) have as constant an amplification at different frequencies. (Emphasis added).

http://www.vias.org/basicradio/basic_radio_26_07.h
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Resistance coupling

As an alterative to inductive (and transformer coupling), resistance coupling came to the fore in the 1920s and 1930s.

Resistors and capacitors are cheaper than transformers, and appropriate inductors maybe hard to find.

1930s Catalog Advertisement
See Also https://www.earlytelevision.org/daven_receiver.html

An IEEE article abstract helps:

VACUUM-TUBE amplifiers for audio-and low-frequency applications are commonly resistance-coupled, and their-design is an everyday problem for engineers in many different fields of application. The published information on the resistance-coupled amplifier is not only widely scattered and confusing but also inadequate. No convenient method is available for predicting the required electrode voltages and the correspondingly changed dynamic constants of a vacuum tube having a resistor in its plate circuit. Furthermore, no really practical method is available for designing a coupling network or for determining the phase and amplitude characteristics of both the tuned and wide-band resistance-coupled amplifier.

https://ieeexplore.ieee.org/document/6441078

(See also: Resistance coupling

https://www.angelfire.com/electronic/funwithtubes/Amp-RC.html)

So, the Air-Way radio, with no transformers, likely features a resistance coupled audio section, but maybe some inductors underneath. Engineering it in the 1920s, or shortly thereafter, faced challenges. Maybe that's why there are so few of them around. Or maybe the Great Depression ate the company…

(20 VII '22 v2.1 de K6VK) ##