History of Negative Feedback

5 Nov 1960

Tickler Feedback

1. Tuska Superdyne, 101 radio circuits about 1921
2. Freeman Counter EMF, Wireless Age Sept 1923, p 66

Network Feedback

1. Modified Hammarlund Roberts, Radio August 1927
2. "New System of R.F. amplification", F.A. Sewell, Radio News Sept 1927
3. ~~Infradyne Amplifier, Radio August 1926~~

Cathode Impedance

1. Coil in one filament lead, Radio about July 1927
2. Resistance in filament lead, Radio News Sept 1927, p 242
   Wireless World (London) 1927 or 1926

Oscillators

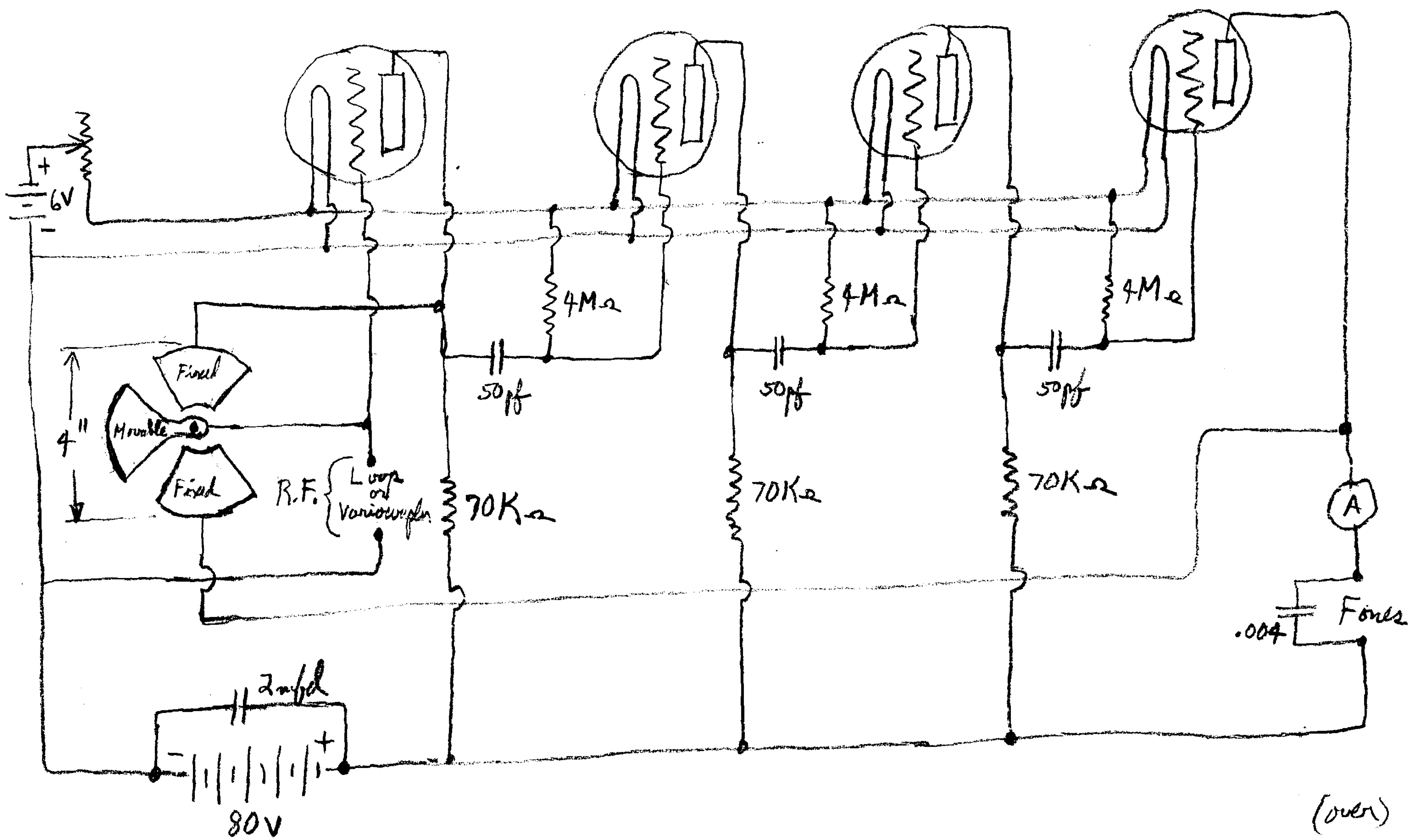
1. Patents by van B. Roberts about 1928
2. amplifier with resonant loop. Radio News, Oct 1921, p 291

Capacity Feedback

1. Resistance coupled amplifier of French design, Radio News, March 1921 p 596 + June 1920, p 680
2. Infradyne Amplifyer, Radio, August 1926

Resistance coupled amplifier of French design.

Radio News March 1921
p 596, 648, 650



(over)

Another circuit shows six stage of R.F. quite similar. Reaction condenser has movable plate still connected to first grid, one fixed plate ~~to~~ 3rd stage tube plate and other fixed plate to last stage tube plate. 1st & 2nd interstage condensers 500 pf, 3rd & 4th interstage condensers 150 pf, 5th is 100 pf. First four grid resistors 5 meg., last one 1 meg.

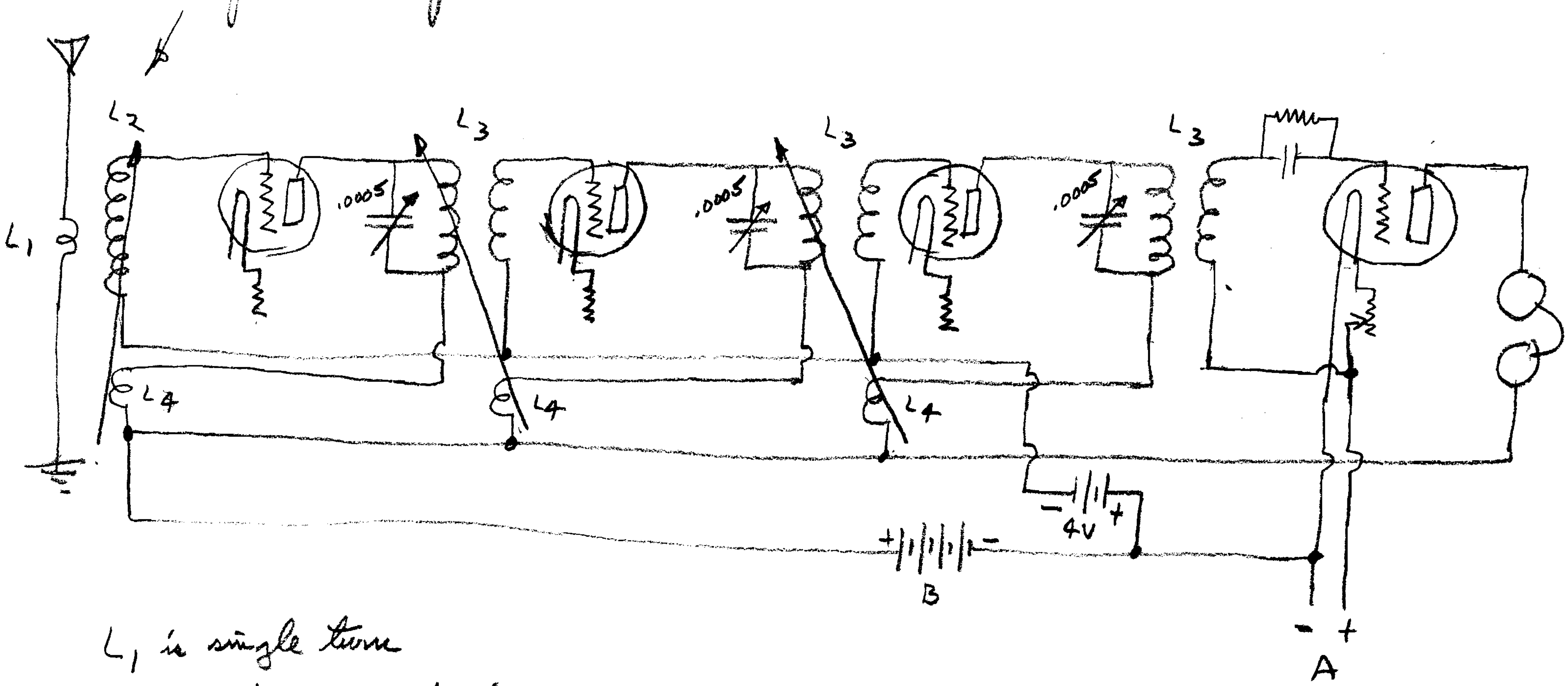
See also Radio News Jan 1922, p 594, 620, 2, 4

Stage gains given in curve are:

Meters	Gain	KC	DB
200	2	1500	6.0
400	3.3	750	10.4
600	4.1	500	12.3
1000	5.1	300	14.1
1800	5.4	167	14.7

The reaction condenser provides controlled feedback which may cause the amplifier to oscillate at a frequency determined by resonance of first grid circuit. Thus a beat note is secured for reading CW transmissions.

Aperiodic input coil.



L_1 is single turn

L_2 = 80 turns on 2" dia form

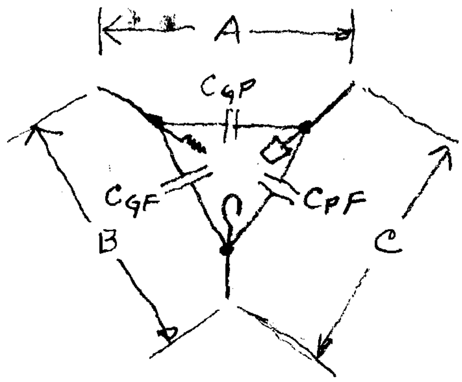
L_3 = 80 turns same but bifilar wound

L_4 small rotor of few turns inside main winding
Adjust until howling ceases.

Probably works fairly well if adjusted at 200 m, giving low gain at 500 m.
If adjusted at 500 m the set probably oscillates at 200 m.
Make a setup and try the scheme. No other details given.

"Freeman Counter EMF Receiver", A. E. Banks, Wireless Age, Sept 1923, p 66 & 82.

5 Nov 60



$$C_{GP} + \frac{1}{C_{GF}} + \frac{1}{C_{PF}} = C_A \qquad (1)$$

$$C_{GF} + \frac{1}{C_{GP}} + \frac{1}{C_{PF}} = C_B \qquad (2)$$

$$C_{PF} + \frac{1}{C_{GP}} + \frac{1}{C_{GF}} = C_C \qquad (3)$$

Solve for $\frac{1}{C_{GF}}$ from (2) and insert in (1) + (3)

$$C_{GF} = C_B - \frac{1}{C_{GP}} - \frac{1}{C_{PF}} \quad \text{or} \quad \frac{1}{C_{GF}} = \frac{1}{C_B - \frac{1}{C_{GP}} - \frac{1}{C_{PF}}} \qquad (4)$$

so from (4) + (1) we have

$$C_{GP} + \frac{1}{C_{PF}} + \frac{1}{C_B - \frac{1}{C_{GP}} - \frac{1}{C_{PF}}} = C_a \qquad (5)$$

and from (4) + (3) we have

$$C_{PF} + \frac{1}{C_{GP}} + \frac{1}{C_B - \frac{1}{C_{GP}} - \frac{1}{C_{PF}}} = C_c \qquad (6)$$

from (5)

$$\frac{1}{C_{PF}} + \frac{1}{C_B - \frac{1}{C_{GP}} - \frac{1}{C_{PF}}} = C_a - C_{GP}$$

$$C_{PF}\left(\frac{1}{C_B - \frac{1}{C_{GP}} - \frac{1}{C_{PF}}}\right) = \overset{X}{\left[C_{PF}(C_a - C_{GP}) - 1\right]}$$

$$C_{PF} = \left(C_B - \frac{1}{C_{GP}} - \frac{1}{C_{PF}}\right)[X] = \left(C_B - \frac{1}{C_{GP}}\right)[X] - \frac{1}{C_{PF}}[X]$$

$$C_{PF} - \left(\left(C_B - \frac{1}{C_{GP}}\right)\left[C_{PF}(C_a - C_{GP}) - 1\right] + \frac{1}{C_{PF}}\left[C_{PF}(C_a - C_{GP}) - 1\right] = 0$$

$$C_{PF} - C_{PF}(C_a - C_{GP})\left(C_B - \frac{1}{C_{GP}}\right) + C_B - \frac{1}{C_{GP}} + C_a - C_{GP} - \frac{1}{C_{PF}} = 0$$

$$-C_{PF}\left[C_A C_B - \frac{C_A}{C_{GP}} - C_{GP} C_B + 1 - 1\right] + \left[C_A + C_B - C_{GP} - \frac{1}{C_{GP}}\right] - \frac{1}{C_{PF}} = 0$$

multiply by $-C_{PF}$

$$C_{PF}^2 \underbrace{\left[C_A C_B - \frac{C_A}{C_{GP}} - C_{GP} C_B\right]}_{A} - C_{PF} \underbrace{\left[C_A + C_B - C_{GP} - \frac{1}{C_{GP}}\right]}_{B} \underbrace{+1}_{C} = 0$$

$$C_{PF} = \frac{-B \pm (B^2 - 4AC)^{\frac{1}{2}}}{2A}$$

$$C_{PF} + \frac{1}{C_{GP}} + \frac{1}{C_B - \frac{1}{C_{GP}} - \frac{1}{C_{PF}}} = C_C \qquad (6)$$

from (6)

$$C_{PF} + \frac{1}{C_B - \frac{1}{C_{GP}} - \frac{1}{C_{PF}}} = C_C - \frac{1}{C_{GP}}$$

$$C_{PF}\left(C_B - \frac{1}{C_{GP}} - \frac{1}{C_{PF}}\right) = \left(C_C + \frac{1}{C_{GP}}\right)\left(C_B - \frac{1}{C_{GP}} - \frac{1}{C_{PF}}\right)$$

$$C_{PF}\left(C_B - \frac{1}{C_{GP}}\right) - 1 = \left(C_C + \frac{1}{C_{GP}}\right)\left(C_B - \frac{1}{C_{GP}}\right) - \frac{1}{C_{PF}}\left(C_C + \frac{1}{C_{GP}}\right)$$

$$C_{PF}^2\left(C_B - \frac{1}{C_{GP}}\right) - C_{PF}\left(C_C C_B + \frac{(C_B - C_C)}{C_{GP}} - \frac{1}{C_{GP}^2} + 1\right) + \left(C_C - \frac{1}{C_{GP}}\right) = 0$$

A B C

$$C_{PF} = \frac{-B \pm (B^2 - 4AC)^{\frac{1}{2}}}{2A}$$

It is not possible to write down an explicit solution for C_{PF}, much less C_{GP} by this approach.

From circuit it may be observed that:

If $C_A = C_B = C_C$ the Δ is equal all around

and $C_{GP} = C_{GF} = C_{PF}$

and $C_{GP} = \frac{2}{3} C_A$

If $C_A = C_B > C_C$ the Δ is isosceles

and $C_{GP} = C_{GF} > C_{PF}$

$C_C = C_{PF} + \frac{1}{2}C_{GP}$ or $C_{PF} = C_C - \frac{1}{2}C_{GP}$

$$C_B = C_A = C_{GP} + \frac{1}{\frac{1}{C_{GP}} + \frac{1}{C_{PF}}}$$

$$C_A - C_{GP} = 1\Big/\left(\frac{1}{C_{GP}} + \frac{1}{C_C + \frac{1}{2}C_{GP}}\right)$$

$$(C_A - C_{GP})\left(\frac{1}{C_{GP}} + \frac{1}{C_C + \frac{1}{2}C_{GP}}\right) = 1$$

$$\frac{C_A}{C_{GP}} - 1 + \frac{C_A}{C_C - \frac{1}{2}C_{GP}} - \frac{C_{GP}}{C_C - \frac{1}{2}C_{GP}} = 1$$

$$\frac{C_A}{C_{GP}} + \frac{(C_A - C_{GP})}{C_C - \frac{1}{2}C_{GP}} - 2 = 0$$

$$C_A\left(C_C - \tfrac{1}{2}C_{GP}\right) + C_{GP}\left(C_A - C_{GP}\right) - 2C_{GP}\left(C_C - \tfrac{1}{2}C_{GP}\right) = 0$$

$$C_A C_C - \tfrac{1}{2}C_A C_{GP} + C_A C_{GP} - \cancel{C_{GP}^2} - 2C_C C_{GP} + \cancel{C_{GP}^2} = 0$$

$$C_{GP}\left(\tfrac{1}{2}C_A - 2C_C\right) + C_A C_C = 0$$

$$\boxed{C_{GP} = \frac{C_A C_C}{2C_C - \tfrac{1}{2}C_A}} \qquad \boxed{C_{PF} = C_C - \tfrac{1}{2}C_{GP}}$$

If C_A not exactly equals C_B, then find the average and compute C_{GP} from above. Again, note if $C_A > C_B$, raise C_{GP} by about 20% and lower C_{GF} an equal amount. Now recompute C_A & C_B. By successive approximations true values of C_{GP}, C_{GF}, C_{PF} will be found which will produce observed values of C_A, C_B, C_C. This all assumes the fields within tube don't overlap an appreciable extent. It will be true if grid mesh size is small compared to distance from grid to plate and filament.

By this method the C_{GP} of a UX199 in socket may be found. It may be resonated to 3.6 mc by a suitable coil with series resistance for broadening. Such tube may then be placed between two Infradyne amplifiers as coupling tube without further neutralization.

Sample: Let $C_A = C_B = 8$, $C_C = 6$

$$C_{GF} = C_{GP} = \frac{8 \cdot 6}{12 - 4} = \frac{48}{8} = \underline{6\,pf} \qquad C_{PF} = 6 - 3 = \underline{3\,pf}$$

Note: Connect small grid resistors to each tube by winding wire around grid pin and bring all returns to −1.5V. Use 100KΩ resistors. In standard Infradyne the grids float which is poor practice.