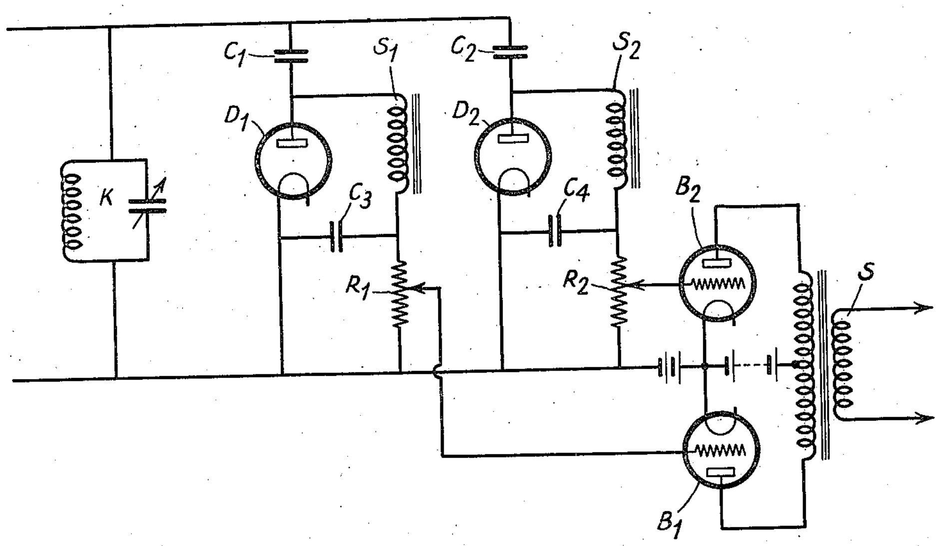
Dec. 27, 1938. C. J. VAN LOON 2,141,730

RADIO RECEIVING SYSTEM

Filed Sept. 26, 1936



INVENTOR
CAREL JAN VAN LOON
BY H. G. Grover
ATTORNEY

Patented Dec. 27, 1938

2,141,730

UNITED STATES PATENT OFFICE

2,141,730

RADIO RECEIVING SYSTEM

Carel Jan van Loon, Eindhoven, Netherlands, assignor to N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands, a corporation of the Netherlands

Application September 26, 1936, Serial No. 102,685
In Germany October 26, 1935

2 Claims. (Cl. 250—20)

The invention relates to radio receiving systems wherein an increased selectivity is obtained owing to the use of two detectors.

It is known that if two modulated oscillations of different intensity and only slightly different frequency are simultaneously supplied to a linear detector, the modulation of the weaker signal is suppressed by the stronger signal. This phenomenon may be explained as follows:

Suppose that a weak modulated signal

$$X \cos \omega t(1+m \cos pt)$$

is received simultaneously with a strong unmodulated signal $Y \cos (\omega+q)t$, ω being the angular frequency of the carrier wave of the weak signal, p the angular frequency of the low-frequency oscillation with which said signal is modulated and $(\omega+q)$ the angular frequency of the strong signal.

The voltage supplied to the detector amounts in this case to:

$$V=X \cos \omega t(1+m \cos pt)+Y \cos (\omega+q)t= [X(1+m \cos pt)+Y \cos qt].\cos \omega t-Y \sin qt.\sin \omega t$$

Instead thereof may be written:

$$V=R \cos (\omega t+\phi)$$

and

$$R=\sqrt{X^2(1+m \cos pt)^2+Y^2+2XY(1+m \cos pt) \cos qt}$$

and

$$\phi=\text{arc tan}\,\frac{Y \sin qt}{X(1+m \cos pt)+Y \cos qt}$$

R represents the enveloping curve of the voltage supplied to the detector; in the case of linear detection the curve of the output low-frequency voltage of the detector has the same course as the enveloping curve. The above expression for R may be rewritten:

$$R=Y\sqrt{1+\frac{X^2}{Y^2}(1+m \cos pt)^2+2\frac{X}{Y}(1+m \cos pt) \cos qt}$$

Since $X<<Y$, on developing the radical expression into a series and on neglecting the terms comprising

$$\frac{X^3}{Y^3}$$

and higher powers of

$$\frac{X}{Y}$$

we find:

$$R=Y\left[1+\tfrac{1}{2}\frac{X^2}{Y^2}(1+m \cos pt)^2+\frac{X}{Y}(1+m \cos pt) \cos qt-\tfrac{1}{2}\frac{X^2}{Y^2}(1+m \cos pt)^2 \cos^2 qt\right]$$

$$=Y\left[1+\tfrac{1}{4}\frac{X^2}{Y^2}(1+m \cos pt)^2+\frac{X}{Y}(1+m \cos pt) \cos qt-\tfrac{1}{4}\frac{X^2}{Y^2}(1+m \cos pt)^2 \cos 2qt\right]$$

Assuming that the oscillations having an angular frequency equal to $q\pm p$, and $2q$ are suppressed, as is customary, by means of a tone filter, the current supplied to the loudspeaker is directly proportional to

$$Y\left[1+\tfrac{1}{4}\frac{X^2}{Y^2}\left(1+\frac{m^2}{2}+2m \cos pt+\frac{m^2}{2} \cos 2pt\right)\right]$$

or approximately to

$$Y\left[1+\tfrac{1}{2}\frac{X}{Y}m \cos pt\right]$$

whereas it was to be expected that said current would be proportional to

$$Y\left[1+\frac{X}{Y}m \cos pt\right]$$

i. e., Y, the chief carrier $+Xm \cos pt$, the variation supplied by the signal.

The modulation of the weak signal is consequently suppressed in the proportion

$$\tfrac{1}{2}\frac{X}{Y}$$

which is called the modulation suppression factor, or from another point of view, the amplitude of variation is reduced from $(Xm \cos pt)$ to

$$\tfrac{1}{2}\frac{X}{Y}\,(Xm \cos pt).$$

The effect described only occurs if the detector has a sufficiently slight inertia to follow the frequency difference q so that in fact the enveloping curve is reproduced. The time constant of the detector should consequently be small. If said time constant is made larger the modulation suppression factor becomes smaller.

It is consequently evident that if two modulated signals of different intensity are simultaneously received and are supplied to two detectors having different time constants, the ratio between the amplitudes of the two signals in the output low-frequency voltage of the detectors will be different, as will be explained hereinafter.

According to the invention, an increased selectivity in a radio receiving system is obtained by supplying the modulated oscillations received to two detectors having different modulation suppression factors and by oppositely connecting the low-frequency output voltages of the two detectors in such manner that in the case of simultaneous reception of two signals of different intensity one of the signals is completely or almost completely suppressed.

The invention will be explained more fully with reference to the accompanying drawing which represents one embodiment thereof.

The high-frequency oscillations set up across an oscillatory circuit K are supplied via condensers C_1 and C_2, high-frequency choke coils S_1 and S_2 and condensers C_3 and C_4 to two diode detectors D_1 and D_2, which results in the production of a low-frequency voltage drop in resistances R_1 and R_2. The condensers C_1 and C_2 and the resistances R_1 and R_2 are so chosen that the two detectors have different time constants and therefore different modulation suppression factors. The low-frequency voltage drop across part of the resistances R_1 and R_2 is supplied to the control grids of push-pull connected amplifying tubes B_1 and B_2. The tapping points on the resistances R_1 and R_2 are so chosen that the amplitude of the undesired signal on the control grids of the two amplifying tubes is the same. Only the desired signal is present in this case in the secondary winding S of the balancing transformer.

The adequate choice of resistances and condensers permits to make the ratio between the amplitudes of the desired and the undesired signal in the output voltage of one of the detectors four times as large as in the output voltage of the other detector. In this case 75% of the amplitude of the desired signal is consequently maintained.

In order to further explain how increased selectivity is obtained, by the suppression of the effect due to an interfering signal being simultaneously received with the desired signal, it will be assumed that two modulated signals

$$A_1 \cos \omega_1 t(1+m_1 \cos p_1 t)$$

and $A_2 \cos \omega_2 t(1+m_2 \cos p_2 t)$ of different frequency and intensity are received simultaneously. In the formulae $A_1(A_2)$ represents the carrier wave amplitude, $m_1(m_2)$ the percentage of modulation, $\omega_1(\omega_2)$ the carrier frequency and $p_1(p_2)$ the audio frequency modulated on the carrier wave.

There will then be supplied to the control grid of the valve B_1 an audio frequency voltage.

$$V_1=\alpha_1(m_1A_1 \cos p_1t+\mu_1 m_2A_2 \cos p_2t)$$

In this equation α_1 represents a constant, which is dependent upon the efficiency of the detector D_1 and of the setting of the voltage divider R_1, whereas μ_1 represents the demodulation factor.

To the control grid of the valve B_2 is supplied an audio frequency voltage:

$$V_2=\alpha_2(m_1A_1 \cos p_1t+\mu_2 m_2A_2 \cos p_2t)$$

The current flowing through the primary of the output transformer of the valves B_1 and B_2 may therefore be represented by

$$I=S_1\alpha_1(m_1A_1 \cos p_1t+\mu_1 m_2A_1 \cos p_2t)-S_2\alpha_2(m_1A_1 \cos p_1t+\mu_2 m_2A_2 \cos p_2t)$$

where S_1 and S_2 are the mutual conductances of the valves B_1 and B_2.

From this equation it may be seen that the signal A_2 will be completely suppressed if

$$S_1\alpha_1\mu_1=S_2\alpha_2\mu_2$$

In this case we find

$$I=m_1A_1 \cos p_1t(S_1\alpha_1-S_2\alpha_2).$$

In the same manner the signal A_1 may be completely suppressed by making $S_1\alpha_1=S_2\mu_2\alpha_2$. In this case we find:

$$I=m_2A_2 \cos p_2t(S_1\alpha_1\mu_1-S_2\mu_2\alpha_2).$$

It will be clear from the above consideration, that the invention enables a complete suppression of one of two interfering signals.

A numerical example of the operation of the circuit is as follows.

Let the intensity ratio of the two signals be 1/5. This ratio may be decreased to 1/20 by the detector D_1 and to 1/50 by the detector D_2. Thus the voltage in the output circuit of the detector D_1 due to the stronger signal may be 1 volt and the voltage due to the weaker signal 0.05 volt, whereas in the output circuit of the detector D_2 the voltage due to the stronger signal may again be 1 volt, and the voltage due to the weaker signal 0.02 volt. Taking off 40% of the output voltage of the detector D_1 by means of the voltage divider R_1 and opposing this voltage to the output voltage of the detector D_2 we find that the weaker signal is completely suppressed, whereas a voltage of 0.6 volt due to the stronger signal is maintained.

The following component values may be used to obtain the desired effect.

$$C_1=20\mu\mu F;\ C_2=10\mu\mu F;\ C_3=200\mu\mu F;\ C_4=10\mu\mu F;\ R_1=R_2=0.3 \text{ megohm}.$$

What I claim is:

1. A radio receiving circuit for the reception of signal-modulated oscillations, comprising a tunable circuit, a pair of detectors having different modulation suppression factors connected across said tunable circuit in parallel relation, both said detectors being arranged to simultaneously demodulate the received signal voltage developed exclusively in said tunable circuit, a pair of low frequency amplifiers, a connection from each of the detector output circuits to its respective low frequency amplifier, the output circuits of said amplifiers being connected in opposition.

2. A circuit arrangement comprising a tuned input circuit, a pair of diode rectifiers, the anode and cathode of each rectifier being connected across the tuned circuit through a condenser, a load resistor in the output circuit of each rectifier, the coupling condensers and the load resistors being so proportioned that the rectifiers have different time constants, an output amplifier stage having two tubes which have their output circuits connected in push-pull, and a variable tap connection from each load resistor to one of the grids of the push-pull tubes.

CAREL JAN VAN LOON.