SELECTIVE AMPLIFIER

Filed Jan. 19, 1939 3 Sheets-Sheet 1

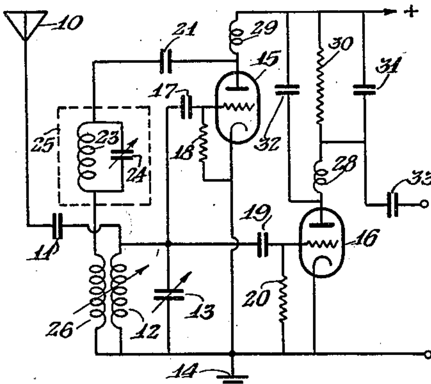

Fig:1

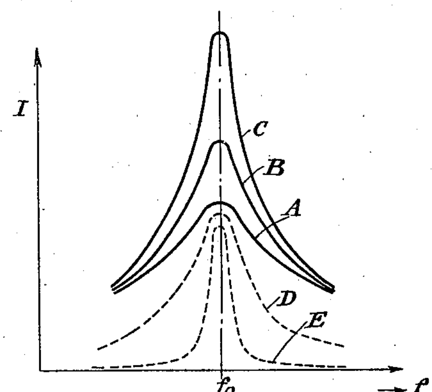

Fig:2

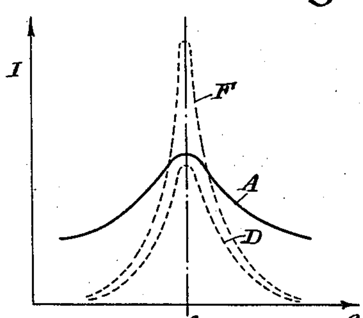

Fig:3

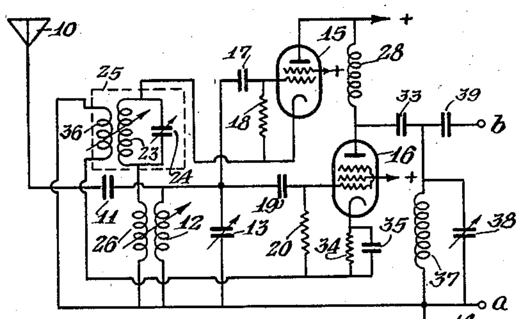

Fig:4

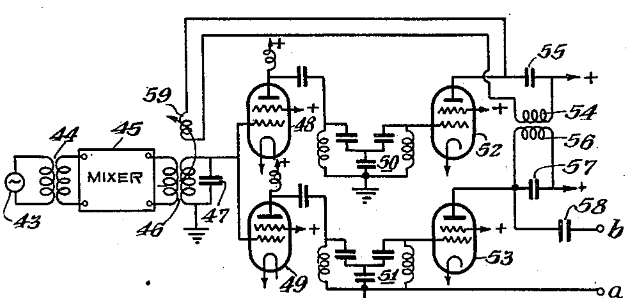

Fig:5

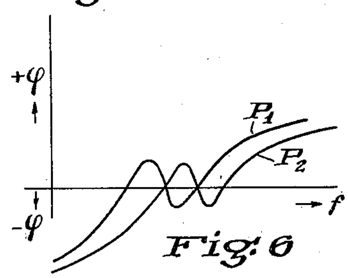

Fig:6

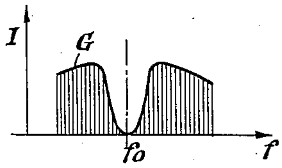

Fig:7

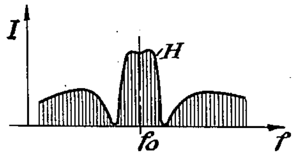

Fig:8

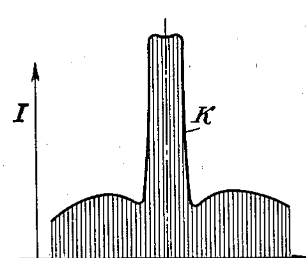

Fig:9

INVENTOR.
Jozef Plebanski
BY
Karl Mann
ATTORNEY.

SELECTIVE AMPLIFIER

Filed Jan. 19, 1939 3 Sheets-Sheet 2

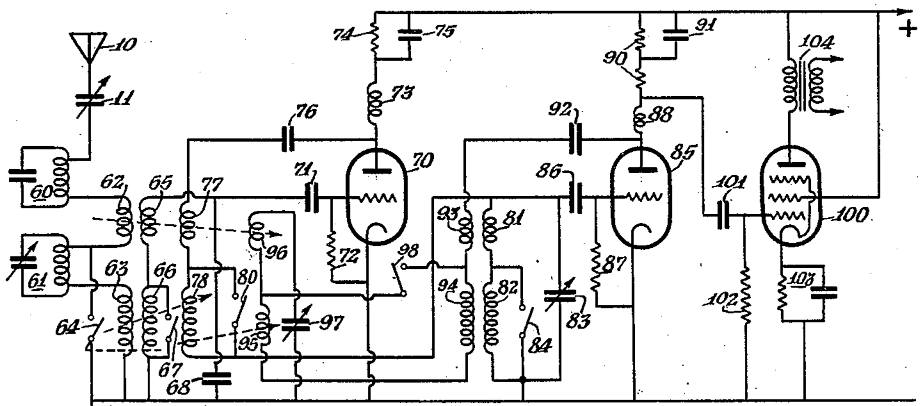

Fig. 10

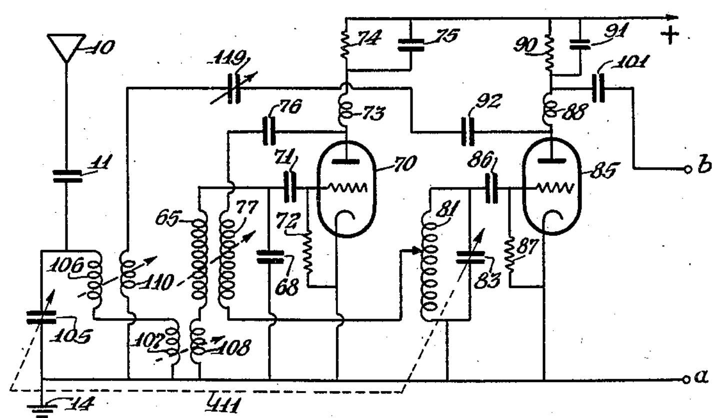

Fig. 11

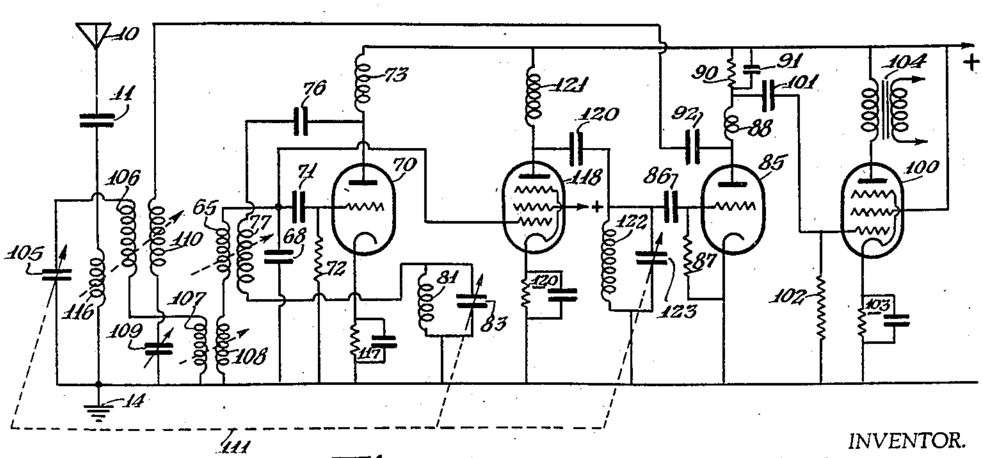

Fig. 13

INVENTOR.

Jozef Plebanski

BY Karl Rau

ATTORNEY.

SELECTIVE AMPLIFIER

Filed Jan. 19, 1939 3 Sheets-Sheet 3

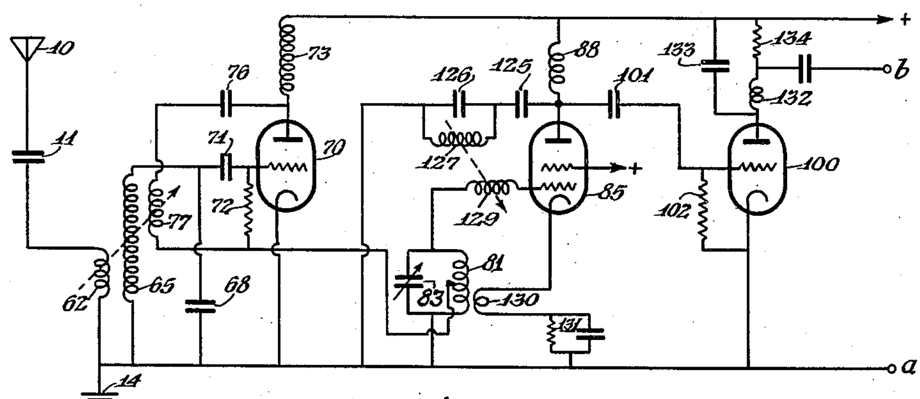

Fig. 14

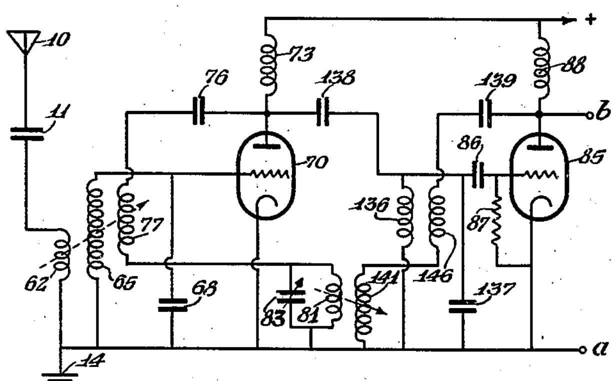

Fig. 15

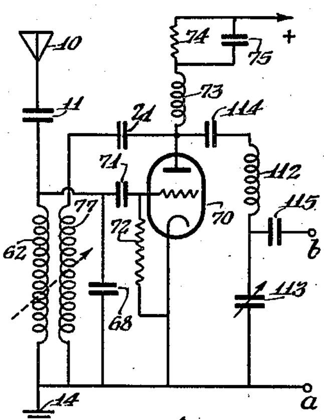

Fig. 12

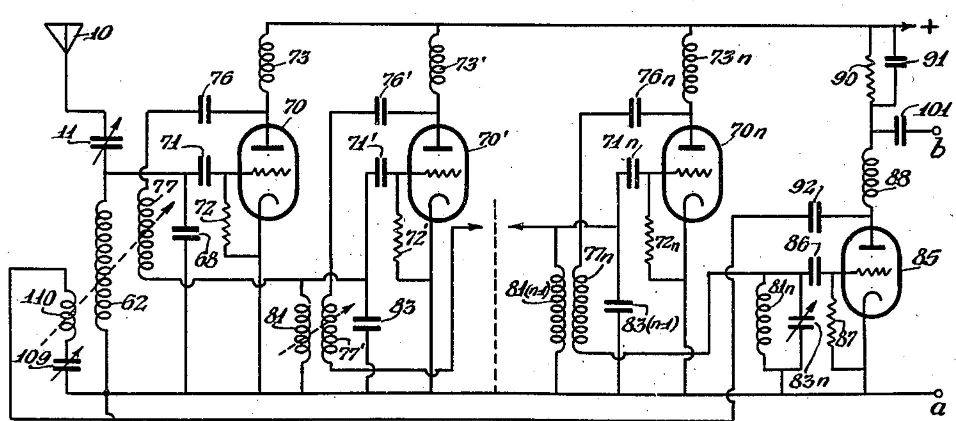

Fig. 16

INVENTOR.

BY Jozef Plebanski

Karl Rau

ATTORNEY.

Patented Jan. 6, 1942

2,268,672

UNITED STATES PATENT OFFICE

2,268,672

SELECTIVE AMPLIFIER

Jozef Plebanski, Warsaw, Poland, assignor to Radio Patents Corporation, a corporation of New York

Application January 19, 1939, Serial No. 251,682
In Poland May 24, 1938

12 Claims. (Cl. 179—171)

The present invention relates to amplifiers for alternating currents such as high frequency or medium frequency signal currents and more particularly to amplifiers of the retro-active type employing feedback of energy from a point at a higher oscillation level to a point at lower oscillation level of the amplifier.

An object of the invention is to obtain a desired selectivity with a limited number of circuit elements or amplifier stages in a receiver for high frequency or medium frequency signals compared with circuit arrangements at present known and used in the art.

Another object is to obtain an improved band-pass filter effect in a radio or other high frequency or medium frequency system serving to translate or amplify modulated signal energy.

A further object is the provision of a tuning system comprising multiple amplifying stages for receiving or translating modulated signal energy, whereby all amplifying stages may be simultaneously tuned to a desired transmitting station by a limited number including a single tunable circuit.

Still a further object is the provision of a resonant multistage amplifier capable of being tuned to a desired transmitting station by adjusting a single selective circuit or network.

A further object is to increase both the selectivity of a tuned high frequency amplifier and to improve its performance by increased stability as well as to reduce distortion, background noise and other undesirable interference.

Another object is to provide a band-pass filter for use in a radio frequency amplifier or the like characterized by an improved frequency cut-off or increased selectivity compared with filters comprising an equal number of parts or circuits known in the art.

Another object is to provide a single tunable circuit having a selectivity heretofore obtainable only with multiple circuits or sections to eliminate the necessity of ganging and aligning the circuits.

A further object of the invention is the employment of selective inverse feedback in a tuned radio frequency or medium frequency amplifier to improve both the operational stability and performance as well as the selectivity of the amplifier.

The above and further objects and advantages of the invention will become more apparent from the following detailed description taken with reference to the accompanying drawings forming part of this specification and wherein:

Figure 1 illustrates a simple selective inverse feedback amplifier constructed according to the invention,

Figure 2 shows resonance or selectivity curves illustrative of the function and operation of the circuit according to Figure 1,

Figures 3 and 4 represent, respectively, resonance curves and an improved selective feedback circuit of the type according to Figure 1,

Figure 5 shows a further modification of an inverse feedback amplifier for obtaining a band-pass characteristic with sharply defined cut-off frequencies,

Figures 6 to 9 are diagrams illustrating the function and advantages of Figure 5,

Figures 10 to 13 represent further improved modifications of a selective inverse feedback receiver of the type according to Figures 1 and 4,

Figures 14 to 16 illustrate embodiments of the invention for tuning a plurality of amplifying stages by a single resonant circuit or tuning element.

Similar reference characters identify similar parts throughout the different views of the drawings.

Referring to Figure 1, there is shown an antenna input circuit for receiving high frequency signals from a transmitting station, said circuit comprising an antenna **10** in series with a coupling or shortening condenser **11** and an input inductance **12**, the latter being connected to ground **14**. In place of an antenna, input signal energy may be supplied by any other source such as a transmission line or the like as is understood. The inductance **12** which may be shunted by a fixed or variable condenser **13**, is connected across the grid-cathode paths of a pair of triode valves **15** and **16** through grid coupling condensers **17** and **19** and grid leak resistances **18** and **20**, respectively. Valve **16** functioning in the example shown as a detector or demodulator has its anode connected to the positive terminal of a high tension source or B-supply indicated by the + sign through a high frequency choke coil **28** and a coupling resistance **30**. Items **31** and **32** are by-pass condensers for high frequency and **33** is a coupling condenser connected between the lower end of resistance **30** and the detector output terminal *b*. The demodulated signals as obtained from terminals *a*, *b* may be fed to a further amplifier or a utilization circuit such as a reproducer or other translating device.

Valve **15** which is simultaneously excited from the input coupling coil **12** serves to supply inverse feedback energy and to this end has its anode connected to the + pole of the high tension source through a high frequency coupling coil **29** on the one hand and to ground on the other hand through a feedback circuit, said feedback circuit including a blocking condenser **21** and a feedback coil **26** arranged in inductive coupling relation with the input induction coil **12** in the antenna circuit. Coils **12** and **26** are wound in such a manner that the feedback currents induced in the coil **12** are in phase opposition to the signal current received therein from the antenna thereby reducing or cancelling the output at terminals *a*, *b*. In this manner even very strong signals from a powerful local transmitter may be eliminated provided that the condenser **11** has a sufficiently small capacity, in practice below about 50 mmf., and that sufficiently strong inverse feedback or a tight coupling between the coils **12** and **26** is employed.

In order to render the inverse feedback ineffective for the desired signals, there is further provided in series with the inverse feedback path a tunable rejector circuit comprising an inductance **23** shunted by a variable condenser **24**. This rejector circuit is preferably magnetically screened or decoupled from the other circuit elements such as by enclosing it with a metallic screen indicated at **25**. As is well understood, the circuit **23, 24** allows the passage of feedback currents of all frequencies except its resonant frequency, whereby the inverse feedback effect for this particular frequency is cancelled and signals of a desired frequency may be translated and impressed upon the grid of the amplifier **16**. As pointed out, the condenser **13** may be omitted or a fixed condenser substituted therefor broadly tuning the input circuit in such a manner that the entire system may be tuned to a desired receiving signal by adjusting a single tuned circuit, i. e. the rejector circuit **23, 24** in the example illustrated.

In Figure 2 there are shown the resonance curves for a circuit according to Figure 1 in comparison, with the resonance curves for a customary positive feedback or regenerative receiver. In this figure which illustrates in a known manner the output response such as the current I plotted against frequency *f*, the solid curves A, B, C represent the characteristics of a customary positive feedback or regenerative circuit, curve A corresponding to the condition without regeneration and curves B and C corresponding, respectively, to lower and higher degrees of positive feedback or regeneration. As the degree of regeneration is increased, the signal response at the resonance frequency f_0 increases, but the response to side frequencies remains still considerable. This characteristic constitutes a great disadvantage of regenerative circuits as is well understood by those skilled besides other well known drawbacks and defects of positive feedback or regeneration. The dotted curves illustrate the conditions for inverse or negative feedback proposed by the present invention. As is seen, the response at resonance frequency remains approximately constant or is slightly decreased as the degree of negative feedback or degeneration increases, curve D showing the curve for a small degree and curve E for a high degree of inverse feedback. In the latter case, the cut-off at the ends of the frequency bands is considerably improved resulting in a more favorable, flat top type bandpass characteristic as compared with the curves obtainable with positive feedback or regeneration. This characteristic of the invention enables the attainment of high selectivity with a single or a limited number of cascaded amplifying stages compared with the conventional selective amplifiers. It has been proved by experiments that at a frequency of about 200 kc. a distant station separated from a local transmitter by about 20 kc. could be received with full volume and substantially without interference by the local signal. The attenuation of the local station due to the inverse feedback was about 40 to 60 db.

In an arrangement according to Figure 1, a certain amount of positive feedback or regeneration usually occurs in addition to the inverse or negative feedback for the desired signal or receiving frequency to which the rejector circuit **23, 24** is tuned. According to a further feature of the invention, this positive feedback or regeneration is utilized and increased by providing additional positive reaction upon either the input or rejector circuits derived from a subsequent stage such as the main amplifying valve **16** as shown. In this manner the signal response may be increased while retaining the advantages of the inverse feedback; that is, improved cut-off or selectivity in the manner described.

A circuit of this type is shown in Figure 4 which differs from Figure 1 by the provision of an additional feedback coil **36** in inductive coupling relation with the inductance **23** of the rejector circuit and inserted in the cathode lead of the valve **16** which latter in the example illustrated functions as a high frequency amplifier. For this latter purpose the anode of valve **16** is connected to cathode or ground through a blocking condenser **33** and a parallel tuned coupling circuit comprising an inductance **37** shunted by a condenser **38**. The high potential side of the circuit **37, 38** is connected to the output terminal *b* through a coupling condenser **39** and its low potential side is connected to the cathode or output terminal *a*. From terminals *a*, *b* the amplified high frequency energy may be fed to further amplifying stage or directly to a detector. According to a further modification, the positive feedback coil **36** may be coupled with the input inductance **12**; i. e. to feedback potentials applied to the grid input circuit as shown and described in connection with Figures 10, 11 and 16.

In Figure 3 there are shown the resonance curves for a receiver according to Figure 4. Curve A corresponds to the receiver without any feedback, curve D to a receiver with negative or inverse feedback alone and curve F to combined inverse and positive feedback such as shown in Figure 4. If the positive feedback currents are applied to the rejector circuit **23, 24** as shown, there will result an improved cut-off of the curve D in Figures 2 and 3, while applying the positive feedback currents to the input circuit or coil **12** will produce both improved cut-off and signal strength increase as shown by curve F in Figure 3.

Experiments carried out by applicant have shown that by employing two tuned circuits **23, 24** and **37, 38** in a system according to Figure 4 followed by a detector and a two stage audio frequency amplifier, the sensitivity and selectivity obtained was comparable to a superheterodyne receiver of known construction comprising a substantially higher number of amplifying stages and circuit elements. If condenser **13** is omitted, the inductance **12** is preferably chosen so as to be resonant, either due to its own distributed capacity or by means of a fixed shunt condenser, to a wave length just below the shortest wave length to be received or alternatively the inductance 12 may be resonant to a wave length above the longest receiving wave length. If the input circuit is untuned; that is, when omitting the condenser 13 the resonance curves obtained will not be exactly symmetrical, the attenuation being greater on one side of the resonance characteristic. This discrepancy can be minimized by increasing the degree of inverse feedback or tightening the coupling between the coils 12 and 26.

Referring to Figure 5, there is shown an embodiment for obtaining a band-pass filter having an extremely sharp cut-off by the employment of selective inverse feedback according to the invention. In this modification, item 43 represents a source of input signals which may be an antenna circuit, transmission line, etc. In the example illustrated representing a superheterodyne receiver, the input signal energy is applied to a frequency changer or mixer 45 of any known type through an input transformer 44, whereby the signal frequency is changed to an intermediate frequency. The intermediate frequency energy supplied by the mixer 45 is impressed simultaneously upon the input grids of a pair of amplifying valves 48 and 49 through a transformer 46 having its secondary tuned to the intermediate frequency by means of a condenser 47. The amplified output energies of valves 48 and 49 are transmitted through filters 50 and 51 and impressed upon a pair of further amplifying valves 52 and 53, respectively. The output of valve 53 is fed to a tuned circuit comprising an inductance 56 shunted by a condenser 57 and serving as a coupling element whereby amplified signal energy may be derived from the output terminals *a* and *b*, the latter being connected to the anode of valve 53 through a coupling or blocking condenser 58. The output of valve 52 is similarly fed to a resonant circuit comprising a condenser 55 shunted by an inductance 54 having an inverse feedback coil 59 connected in series therewith, coil 59 being arranged in inductive coupling relation with the input transformer 46. The inductances 54 and 56 of the output circuits are mutually coupled with each other and the circuits are preferably of a highly damped type.

It can be shown that in an arrangement of the afore-described type by proper design of the valve coupling filters 50 and 51 to have phase characteristics P_1 and P_2 displaced relative to each other as shown in Figure 6 (relative input-output phase φ plotted against frequency) frequency response curves may be obtained as shown at G in Figure 7 for the circuit 54, 55, 59 and at H in Figure 8 for the circuit 56, 57. As a result all frequencies will be attenuated in the input circuit by the effect of inverse feed-back except for a selected band as shown in Figure 7 in such a manner as to obtain a resultant input-output characteristic for the entire amplifier system as shown by curve K in Figure 9.

From the foregoing, it will be obvious that there is described by the present invention a selective inverse feedback amplifier comprising substantially a rejector circuit connected in the inverse feedback path. In the arrangements shown a separate valve or amplifier is provided for supplying the inverse feedback potential. Further means may be provided to produce additional positive reaction, the latter being preferably supplied from a valve different from the inverse feedback valve. The rejector circuit may be connected either in the manner shown in Figures 1 and 4, or at any other point of the inverse feedback path as is understood. The latter in the arrangement illustrated is preferably wound with thin wire directly upon the coil 12 to ensure maximum coupling between the coils. The number of turns of coil 26 is preferably somewhat less than the number of turns of the coil 12. If more than one tuned circuit is used, the circuits may be connected or ganged for unicontrol in an easy manner due to the fact that a sharp tuning is required only for the rejector circuit in the inverse feedback path, while the other circuits may tune broadly or have a flat resonance curve and serve merely to increase the amplification rather than for improving the selectivity. It is further understood that several circuits of the type shown may be connected in cascade to still further increase the selectivity.

In addition to improved selectivity as described, the inventive circuit benefits by the various advantages effects of inverse feedback such as increased operational stability, reduced distortion and low noise level, thus in turn enabling the attainment of higher amplification with a reduced number of circuit elements or amplifying stages and compensating fully or in part for the loss in gain due to inverse feedback.

In the previously described embodiments the main amplifying and the inverse feedback circuits are arranged in parallel with a common input such as an antenna circuit. According to an improvement as shown in Figures 10 to 13, the inverse feedback and main amplifying valves are connected in cascade by employing the rejector circuit in the inverse feedback path as a coupling element to supply controlling potential for the succeeding amplifier stage. Arrangements of this type have advantages over the previous embodiments as will become more apparent as the following description proceeds.

Referring to Figure 10 there are shown two rejector circuits or wave traps 60 and 61 in series with the antenna condenser 11 and a pair of input inductances 62 and 63. One of the rejector circuits such as 60 may serve for the reception of short waves and the circuit 61 may serve for receiving longer waves. As shown, the long wave rejector circuit 61 and the long wave coupling coil 63 may be short circuited by means of a wave switch 64. The coils 62 and 63 correspond to the coil 12 in Figures 1 and 4 and form the primaries of a pair of input coupling transformers having secondaries 65 and 66, respectively, connected in series and across the grid cathode path of a first amplifying valve 70 through a grid coupling condenser 71 and grid leak resistance 72. The anode of valve 70 which serves as a high frequency amplifier is connected to the + pole of a high tension source or B-supply through a high frequency coupling choke 73 and voltage drop resistance 74, the latter being shunted by by-pass condenser 75. The anode of valve 70 has further connected thereto an inverse feedback circuit comprising blocking condenser 76, feedback coils 77 and 78 in inductive coupling relation, respectively, with input coils 65 and 66, and a rejector circuit comprising inductances 81 and 82 in series shunted by a variable condenser 83 in a manner substantially similar as shown in Figures 1 and 4. The circuit 81, 82, 83 besides its function as a rejector in the negative feedback path serves as a coupling network for impressing signal potential upon the grid of the succeeding valve **85** through grid coupling condenser **86** and grid leak resistance **87**. The valve **85** in the example shown functioning as a detector has its anode connected to the + pole of the B-supply through a high frequency choke **88** and coupling resistance **90** a portion of the latter being by-passed for high frequency by condenser **91**. There is further provided a positive or regenerative feedback path traced from the anode of valve **85** through blocking condenser **92**, a pair of feedback coils **93** and **94** in inductive relation with coils **81** and **82**, respectively, of the rejector or coupling circuit, further feedback coils **95** and **96** in inductive coupling relation with the input inductances **66** and **65**, respectively, for the valve **70**, and condenser **97** to ground. Demodulated signal energy is fed from the junction between choke coil **88** and resistance **90** to the input grid of a low or audio frequency amplifier **100** through coupling condenser **101** and grid leak resistance **102**. Item **103** is a self-biasing network comprising a resistance shunted by a condenser in the cathode lead and item **104** represents a transformer in the anode circuit of valve **100** for transmitting the demodulated signals to a further amplifier or utilization circuit. Long wave coils **66**, **78**, **94**, **95** and **82** may be short circuited by means of switches **67**, **80**, **98** and **84** together with switch **64** by means of a common control element as is customary in receivers embodying multiple wave switches. The input coils **65** and **66** may be shunted by a fixed or variable condenser **68** in a manner and for the purpose similar as described in connection with the preceding embodiments.

The rejector circuits **60** and **61** and the antenna circuit have the purpose of suppressing strong local signals and were found to be advantageous in view of the fact that the selectivity of the circuit shown in Figure 10 increases substantially with a decrease in input signal strength. Under these conditions, the rejector circuits **60** and **61** were found to operate very efficiently by completely suppressing strong interfering signals to which they are tuned. It was furthermore found that a larger number of rejector circuits each tuned to a different frequency may be connected in the antenna circuit in the manner illustrated. The antenna coupling condenser **11** may serve as a volume control element or additionally as a means for tuning the antenna circuit. If the antenna circuit is tuned in addition to the circuit **81**, **82**, **83** the signal strength may be increased considerably. This receiver was furthermore found to operate more quietly and with a low noise level by reducing the input signal strength. In the latter case, the negative feedback may cause a considerable reduction or complete elimination of interference. For this reason it is advantageous to employ a tuned antenna circuit and to reduce the input coupling **62—65** or **63—66** to a minimum.

A receiver system embodying a tuned antenna circuit is shown in Figure 11. In the latter, there is arranged in series with the antenna a parallel tuned circuit comprising a pair of inductance coils **106** and **107** in series and shunted by a variable condenser **105**. The coil **107** is coupled with coil **108** in series with the inductance **65** in the grid circuit of valve **70**. The inverse feedback potential is impressed through the feedback coil **77** upon the inductance **65** in a manner similar as in Figure 10 while positive feedback is provided through a feedback path from the anode of valve **85** through condenser **92**, variable condenser **119** and inductance **110** the latter being in coupling relation with the inductance **106** of the antenna tuning circuit. The remaining part of the circuit is similar to Figure 10 with only one wave range being shown for the sake of simplicity of illustration. The tunable rejector and coupling circuit **81**, **83** is preferably connected with the antenna tuning circuit for uni-control such as by a common drive or gang control of the adjustable parts of condensers **83** and **105** as indicated by dashed lines **111**. A circuit of this type was found to be extremely selective especially when using a loose input coupling between coils **107** and **108**. The selectively obtained is equivalent to that of two tuned circuits with extremely loose coupling. It is well known that such circuits have a high selectivity, but that the response or sensitivity is decreased substantially by loosening the coupling so as to render their use impractical. When employing a coupling through a negative feedback arrangement of the type described by the invention it was found that the coupling may be reduced considerably and as a result the selectivity increased substantially without appreciable impairment of the response or decrease of signal strength. This behavior is due to the amplifying and filtering action of the feedback valve and the circuit connected therewith. The input circuit of valve **70** is aperiodic by the provision of fixed condenser **68** shunting the coils **65** and **108** as described hereinbefore. In the latter case the response characteristic of the circuit may be substantially broader than the response of the rejector circuits **81**, **83** thereby greatly simplifying the construction and aligning problems for the circuits. The systems described hereinbefore which constitute extremely efficient and selective band-pass filters may be incorporated as a translation or coupling network in any transmission or receiving system and are not limited to the use in the input circuit of a radio receiver as will be readily understood from the foregoing. Thus, a network or filter system of the type shown in Figures 10 and 11 may serve as an intervalve coupling network in the intermediate frequency section of a superheterodyne receiver in which case the adjustment of the rejector circuit or other tuned circuit to the intermediate frequency is fixed resulting in substantial simplification both as regards construction and operation.

In Figure 11, the antenna is coupled to the tuned circuit **105**, **106**, **107** capacitatively through condenser **11**, but as is understood it may be coupled in any other manner such as inductively as shown in Figure 13. The selectivity obtained with a receiver of the type according to Figure 11 using two amplifying stages approximately equals the selectivity of a standard superheterodyne receiver comprising two radio frequency stages followed by two intermediate frequency stages.

If still greater selectivity is desired, a receiving circuit may be used as shown in Figure 13 differing from Figure 11 by the employment of a further tuned high frequency amplifier stage arranged between the inverse feedback valve **70** and the detector valve **85**. Figure 13 further differs from Figure 11 by employing inductive coupling between the antenna and tuned input circuit effected through inductance coil **116** in the antenna circuit arranged in coupling relation with the inductance **106** of the tuned circuit **105**, **106**, **107**, the latter in this case constituting an intermediate circuit between the antenna and input circuit 65, 68, 108 of valve 70. The circuit 65, 68, 108 in the example shown excites a further high frequency amplifier 118 having its grid connected directly to the high potential side of the circuit 65, 68, 108. The anode of valve 118 is connected to the + pole of the B-supply through a high frequency coupling inductance 121 on the one hand and to a tuned output circuit comprised of an inductance 122 shunted by a variable condenser 123 through blocking condenser 120 on the other hand. The tuned circuit 122, 123 is in turn connected across the grid cathode path of the detector valve 85 through grid coupling condenser 86 and grid leak resistance 87 in the manner similar as shown in Figure 11. The variable condensers 83, 123, 105 are preferably ganged for uni-control by a common tuning element indicated at 111. Positive feedback or regeneration is provided from the anode of valve 85 to the tuned intermediate circuit 105, 106, 107 through coil 110 coupled with the inductance 106. There is further provided a variable condenser 109 between the lower end of the feedback coil 110 and ground for controlling the amount or degree of feedback.

In receiving arrangements with combined negative and positive feedback as shown in Figures 10, 11, 13, the positive feedback or regeneration from the detector valve to the input or antenna circuit operates very smoothly and with great stability in contrast to the known regenerative amplifiers employing positive feedback or regeneration only. Thus, the employment of combined negative and positive feedback in the manner described ensures both increased signal strength and operational stability while at the same time greatly improving the selectivity and minimizing or suppressing distortion and other undesirable defects inherent in the ordinary radio receiver at present being used.

In the arrangements according to Figures 10, 11 and 13 there is provided a fixed condenser 68 connected across the input inductance of the valve 70. As pointed out hereinabove, positive feedback and oscillations may occur in case of very tight coupling of the inverse feedback coils 77 and 78 and in order to avoid this defect it has been found advantageous to provide a shunt condenser 68 of fixed capacity of the order between 200 to 400 mmf. across the input inductance for receivers designed for the broadcast range. The negative feedback causes the circuit comprised by the coils 65, 66, in Figure 10, or 65, 108 in Figures 11 and 13, and the condenser 68 to become practically aperiodic, whereby the capacity 68 no longer has any appreciable effect on the tuning and selectivity, but acts as a stabilizing means for the receiver. In operation, the circuit 65, 66, 68 in Figure 10 or 65 and 68 in Figure 13, respectively, is actually tuned by the condenser 83 of the rejector circuit by virtue of the coupling with the latter through the inverse feedback circuit.

As pointed out previously, the employment of negative feedback in a receiver while greatly improving the selectivity in the manner described has the further advantage of lessening background noise and other interference usually very annoying during reception of radio broadcasts especially in the case of extremely sensitive receivers or when receiving weak distant stations. The reduction of the background noise is the greater, the looser the coupling of the antenna or the smaller the input energy applied to the receiver. In addition, the negative feedback provides a certain automatic selectivity control by flattening the response curve for stronger signals and by tightening it in when receiving weaker signals.

Referring to Figure 12, there is shown an alternative method of obtaining selective negative feedback for tuning a radio receiver or other high frequency circuit. According to this modification the inverse feedback path includes an induction coil 77 coupled with the input inductance 62 so as to oppose the current flow in the latter similar to the previous embodiments, while the inverse feedback effect for the desired frequency is cancelled by the provision of a series tuned circuit comprising an inductance 112 and a variable condenser 113 shunted across the anode-cathode path of the valve 70 in series with a blocking condenser 114. The output terminal *b* in the example illustrated is connected to the common junction point between the inductance and condenser of the series tuned circuit through coupling condenser 115.

In the modification according to Figure 12 the series tuned circuit 112, 113 provides a short circuit for the desired signal which is thus prevented from passing through the inverse feedback coil 77, thereby cancelling the inverse feedback effect for the desired frequency to which the circuit 112, 113 is tuned. The valve 70 may serve as an inverse feedback valve only in which case the desired signals may be derived from the inductance 62 and applied to a separate amplifier or the output signals may be derived from the terminal *b* either as high frequency or as demodulated signals according to the example illustrated.

As pointed out hereinbefore, the tunable rejector circuit placed in the inverse feedback path in Figures 10, 11 and 13 simultaneously serves as a coupling element for the input or grid circuit 65, 66, 68, Figure 10, or 65, 68, 108, Figures 11 and 13, and accordingly a further feature of the invention consists in the utilization of this effect to provide a multi-stage receiver embodying a plurality of circuits all being simultaneously tuned to a desired receiving station by means of a limited number including a single tuning element.

An arrangement of the last mentioned type is shown in Figure 14 wherein the input circuit, first negative feedback valve 70 and the output or detector valve 100 are similar to those shown in the preceding modifications. In accordance with the improved feature, valve 85 is utilized as a second negative feedback stage and to this end has a feedback path connected between its anode and cathode including a blocking condenser 125 and a parallel circuit consisting of a condenser 126 shunted by inductance 127 the latter being coupled with an induction coil 129 inserted in series with the grid circuit of this valve. The tunable rejector circuit for this feedback valve is common with the rejector circuit for the valve 70 comprising the inductance 81 and variable condenser 83 and is connected both in the grid circuit of the valve 85 and in the negative feedback path for the valve 70 in the manner described hereinbefore. In this manner the rejection of the desired frequency in both inverse feedback stages is effected by a single circuit 81, 83 effective in tuning both feedback circuits. In order to provide additional positive feedback there is provided in the example shown a coupling coil 130 in the cathode lead of valve 85 coupled with the coil 81 of the rejector circuit. Item 131 is a self-biasing network in the cathode lead to provide suitable grid biasing potential in a manner well known.

Referring to Figure 15 there is shown a modification of a resonant multi-stage inverse feedback amplifier comprising a single tuning circuit and differing from Figure 14 by utilizing the valve 70 both for supplying inverse feedback potential and for exciting the succeeding valve 85 through a circuit comprised of an inductance 136 shunted by condenser 137 connected across the anode cathode path of valve 70 through a blocking condenser 138. There is further shown a second inverse feedback circuit shunted across the anode-cathode path of valve 85, comprising condenser 139, inverse feedback coil 146 coupled with coil 136, and coil 141 coupled with coil 81 of the tunable rejector circuit. In this manner the rejector circuit is effective in suppressing the desired frequency in both inverse feedback circuits thereby affording a control of both amplifying stages by a single adjusting element. The coupling between coils 81 and 141 is preferably made variable for adjusting it to an optimum to prevent oscillations through a regenerative path traced from the anode of valve 85, feedback circuit 139, 146, 141, rejector circuit 81, 83, coil 77, coil 65 to the grid of valve 70.

Referring to Figure 16 there is shown a multi-stage receiver constructed according to the invention and embodying a single resonant circuit for simultaneously tuning a plurality of amplifying stages to a desired transmitting station. In the drawings, the first valve 70 is provided with an inverse feedback circuit comprising blocking condenser 76, feedback coil 77 and rejector circuit 81, 83 which latter in this case is fixedly tuned to an average frequency above or below or within the frequency range of the receiver. The rejector circuit 81, 83 excites the input grid of the next succeeding amplifier 70′ which is in turn provided with a negative feedback circuit including coupling coil 77′ coupled with the coil 81 of the preceding rejector circuit. The remaining elements are similar to the first amplifying stage and identified by corresponding primed numerals. In this manner any desired number of additional amplifying stages may be provided until obtaining a final stage 70*n* comprising a tunable rejector circuit 81*n*, 83*n* arranged in its negative feedback path and serving as an input coupling element for the detector valve 85. Positive regeneration may be provided in any of the previously described manners and from any desired amplifying stage from a higher oscillation level to a point at lower oscillation level such as from the plate of the detector valve 85 through blocking condenser 92, coupling coil 110, and regulating condenser 109 shown in the example illustrated.

In a system of the afore-described type if the circuit 81*n*, 83*n* is tuned to a desired frequency all the preceding circuits 81 $(n-1)$, 83 $(n-1)$ . . . 81, 83 will be simultaneously tuned although more broadly to the same frequency, thereby causing selective amplification and improving the selectivity of the entire system in the manner as is obvious from the above. Experiments have shown that most favorable and efficient operation of the system is obtained by tuning the rejector circuits 81, 83 . . . 81 $(n-1)$, 83 $(n-1)$ to a frequency in the center of the frequency range for which the receiver has been designed. The range above and below this frequency within which all circuits may be simultaneously tuned by the tuning of the circuit 81*n*, 83*n* is somewhat limited if extremely high selectivity is desired as the selectivity is decreased by tuning beyond these limit points. As is understood, all rejector circuits may be variable and ganged for simultaneous tuning in which case the system has the advantage over the known multi-stage amplifiers that the alignment of the several circuits does not have to be highly exacting as required in conventional receivers to ensure maximum selectivity.

In the circuits described herein, the effect of inverse or negative feedback on the selectivity or other characteristics of the receiver was found to increase directly in proportion to the amount or degree of feedback used. The negative feedback was found to be accompanied by a slight positive feedback in most cases, thereby providing a limit for the amount of negative feed-back to ensure efficient and stable operation. If a high degree of negative feedback is desirable resulting in the system being liable to become regenerative and to start to oscillate, this drawback may be avoided by the employment of known means such as neutralizing circuits, by suppressing the effects of interelectrode or other spurious couplings responsible for the undesirable regeneration or tendency to oscillate.

It will be apparent from the above that the invention is not limited to the specific circuit arrangements shown and disclosed herein, but that the underlying concept and principle of the invention are susceptible of numerous embodiments and variations coming within the broad scope and spirit of the invention as defined by the appended claims. The specification and drawings are accordingly intended to be regarded in an illustrative rather than a limiting sense.

I claim:

1. A selective signal translation system comprising a main amplifying path and an auxiliary amplifying path, each of said amplifying paths having a relatively broad frequency response, means for impressing input signal energy upon both of said amplifying paths, a feedback path for feeding back output energy from said auxiliary amplifying path in inverse phase upon the input of said main amplifying path, and adjustable selective impedance means having a relatively narrow frequency response in said feedback path to suppress the feedback for signals of predetermined frequency.

2. A tuned radio frequency amplifier comprising a main amplifying path and an auxiliary amplifying path both having substantially constant response over an extended range of operating frequencies, means for impressing input signal energy upon both said amplifying paths, a feedback path for feeding back output energy from said auxiliary amplifying path in inverse phase upon the input of said main amplifying path, and a rejector circuit tuned to a predetermined frequency within said range serially inserted in said feedback path.

3. A tuned radio frequency amplifier comprising a main amplifying path and an auxiliary amplifying path both having substantially equal response over an extended band of operating frequencies, means for impressing input signal energy upon both said amplifying paths, a feedback path for feeding back output energy from said auxiliary amplifying path in inverse phase upon the input of said main amplifying path, a rejector circuit tuned to a predetermined frequency inserted in said feedback path, and an additional feedback path for regeneratively feeding back

signal energy from a point of higher to a point of lower oscillation level of said main amplifying path.

4. A tuned radio frequency amplifier comprising a main amplifying path and an auxiliary amplifying path both having substantially equal response over an extended band of operating frequencies, means for impressing input signal energy upon both said amplifying paths, a feedback path for feeding back output energy from said auxiliary amplifying path upon the input of said main amplifying path, a rejector circuit tuned to a predetermined frequency serially inserted in said feedback path, and a further feedback path for regeneratively feeding back energy from a point of higher oscillation level of said main amplifying path upon said rejector circuit.

5. A tuned radio frequency amplifier comprising a first amplifying stage having input and output circuits operatively associated therewith and having a substantially constant response over a predetermined band of operating frequencies, a feedback path also having a substantially constant response over said frequency band for degeneratively feeding back signal energy from the output to the input of said stage, a resonant impedance element serially inserted in said feedback path and tuned to offer high impedance to signals having a frequency equal to the signal frequency to be amplified, at least one further amplifier stage, and coupling means from said resonant impedance element to the input of said further amplifier stage.

6. A tuned radio frequency amplifier comprising a first amplifier stage having input and output circuits operatively associated therewith and having a substantially constant response over a predetermined band of operating frequencies, a feedback path also having a substantially constant response over said frequency band for degeneratively feeding back signal energy from the output to the input of said stage, a parallel resonant circuit serially inserted in said feedback path and tuned to present high impedance to signals having a predetermined frequency, at least one further amplifier stage, and means for impressing potential developed by said parallel resonant circuit upon the input of said further amplifier stage.

7. A tuned radio frequency amplifier comprising a first amplifier stage having input and output circuits operatively associated therewith and having a substantially constant response over a predetermined band of operating frequencies, a feedback path also having a substantially constant response over said frequency band for degeneratively feeding back signal energy from the output to the input circuit of said stage, a tunable rejector circuit serially inserted in said feedback path, at least one further amplifier stage, and means for impressing potential developed by said rejector circuit upon the input of said further amplifier stage.

8. A tuned radio frequency amplifier comprising a first amplifier stage having input and output circuits operatively associated therewith and having a substantially constant response over a predetermined band of operating frequencies, a feedback path also having a substantially constant response over said frequency band for degeneratively feeding back signal energy from the output to the input circuit of said stage, a tunable rejector circuit serially inserted in said feedback path, at least one further amplifier stage, means for impressing potential developed by said rejector circuit upon the input of said further amplifier stage, and an additional feedback path for regeneratively feeding back signal energy from a point of higher to a point of lower oscillation level of said amplifier.

9. A tuned radio frequency amplifier comprising a first amplifier stage having input and output circuits operatively associated therewith and having a substantially constant response over a predetermined band of operating frequencies, a feedback path also having a substantially constant response over said frequency band for degeneratively feeding back signal energy from the output to the input circuit of said stage, a tunable rejector circuit serially inserted in said feedback path, at least one further amplifier stage, means for impressing potential developed by said rejector circuit upon the input of said further amplifier stage, and a further feedback path effectively serially including said rejector circuit for degeneratively feeding back signal energy from the output to the input of said further amplifier stage.

10. A tuned radio frequency amplifier comprising a first amplifier stage having input and output circuits operatively associated therewith and having a substantially constant response over a predetermined band of operating frequencies, a feedback path also having a substantially constant response over said frequency band for degeneratively feeding back signal energy from the output to the input circuit of said stage, a tunable rejector circuit serially inserted in said feedback path, at least one further amplifier stage, means for impressing potential developed by said rejector circuit upon the input of said further amplifier stage, a further feedback path effectively serially including said rejector circuit for degeneratively feeding back signal energy from the output to the input of said further amplifier stage, and a third feedback path for regeneratively feeding back signal energy from a point of higher to a point of lower oscillation level of said amplifier.

11. A tuned radio frequency amplifier comprising a plurality of electron tube amplifier stages in cascade, individual feedback paths for feeding back output energy in inverse phase upon the input of each stage, rejector circuits serially inserted in the feedback path of each stage, and coupling connections from each rejector circuit to the input of the succeeding stage, the rejector circuit of the last stage being relatively sharply tuned, and the rejector circuit of the preceding stages being relatively broadly tuned to the frequency of a radio signal being amplified.

12. A tuned radio frequency amplifier comprising a plurality of electron tube amplifier stages, individual feedback paths for feeding back energy in inverse phase from the output to the input of each stage, rejector circuits inserted serially in said feedback paths, coupling connections from each rejector circuit to the input of the succeeding amplifier stage, the rejector circuit of the last stage being relatively sharply tuned and adjustable over a predetermined band of operating frequencies and the rejector circuits of the preceding stages being relatively broadly and fixedly tuned to predetermined frequencies within said band.

JOZEF PLEBANSKI.