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 SIGNAL SEEKING RECEIVER FOR
 FREQUENCY MODULATED SIGNALS
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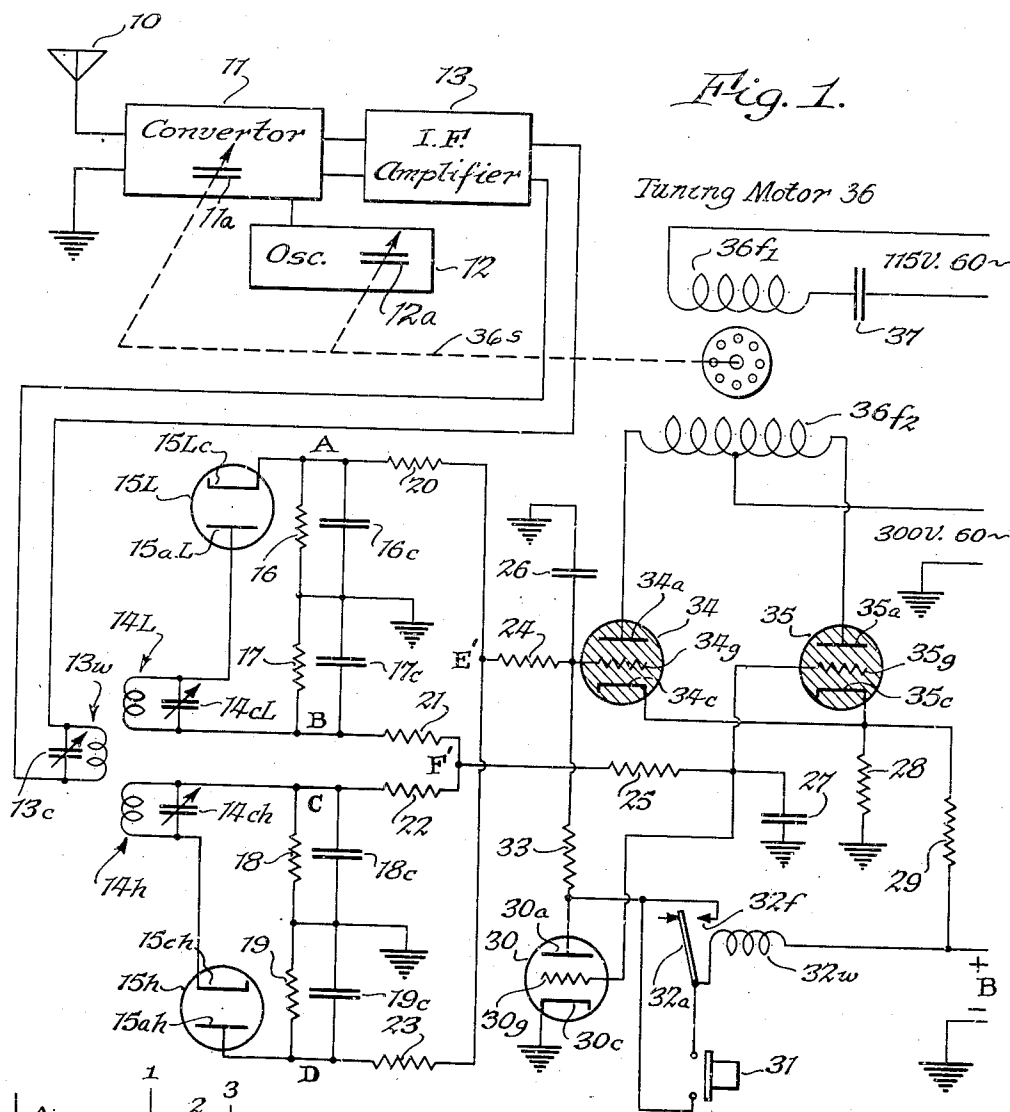


Fig. 1.

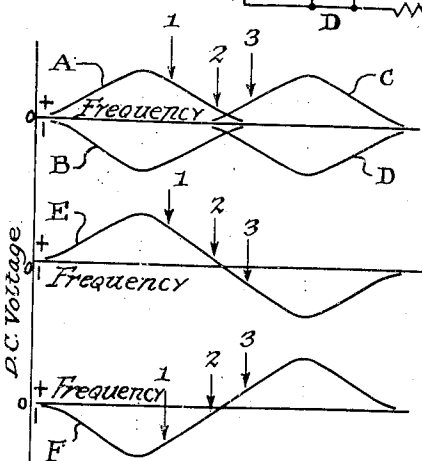


Fig. 2.

Fig. 3.

Fig. 4.

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SIGNAL SEEKING RECEIVER FOR FREQUENCY MODULATED SIGNALS

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8 Claims. (Cl. 250—40)

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This invention relates to signal seeking receivers, and more particularly to signal seeking receivers for frequency modulated signals.

A signal seeking receiver, as the term is used herein, means a receiver in which the tuning instrumentality is motor driven, in which the motor is set into operation by the momentary operation of a push button or the like and stopped by the receiver itself when a signal is tuned in, without any action by the operator.

Such receivers are not difficult to construct for operation on amplitude modulated signals, and will operate very satisfactorily in response to the same. However, if it is attempted to use such receivers for tuning in frequency modulated signals (assuming the receiver is capable of receiving them), a great difficulty immediately becomes manifest. In amplitude modulated signals the carrier frequency remains constant, and since it is the action of the carrier frequency which halts the tuning, a signal seeking receiver will always tune itself very exactly on amplitude modulated signals.

In frequency modulated signals, as is well known, the carrier is constantly changing in frequency when the signal is being modulated, shifting at a rate determined by the modulating frequency and by an amount determined by the intensity of the modulating sound. For 100% modulation in so-called wide swing frequency modulation systems the carrier may deviate or swing as much as 75 kc. on either side of the mean.

It is well known that the necessity of accurate tuning is of extreme importance. Unless the receiver is tuned very exactly to the mean carrier frequency, unbearable distortion and noise may be introduced, and it is generally true that the greater the degree of mistuning the greater the distortion and noise may be. From this it will be appreciated that the problem of providing a signal seeking receiver which will stop exactly on the mean carrier is very complex.

The use of maximum current in a resonant circuit does not lend itself to a solution, because, supposing the resonant circuit to be approaching the mean carrier frequency as its tuning changes, if the carrier happens to be swinging at the time the tuning of the resonant circuit happens to come into the range of the carrier, it is a mere matter of chance at what frequency within the deviation range the circuit will stop; and since the frequency range over which the signal is receivable is much greater than the range over which it is receivable without such

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noise and distortion, it is apparent that the chances of stopping in the correct range are comparatively small.

In accordance with my invention, I provide circuits so arranged that this effect is entirely eliminated, and the receiver will stop and remain exactly at the mean frequency within the tolerance for which the apparatus is constructed, but if it should by any chance overshoot the correct tuning position and tend to stop in an incorrect position, it will, without any attention on the part of the operator, correct itself and return to the correct position; also, if thermal drift occurs, causing mistuning, the receiver will retune itself, correcting for the drift; and this is done, not by mechanical adjustments of stops in predetermined position, but by the signal itself, according to the signal seeking principle.

From the foregoing, it will be understood that among the objects of my invention are the following:

To provide a signal seeking receiver which will operate on frequency modulated signals.

To provide a receiver for frequency modulated signals which will tune itself exactly within the limits of tolerance of the apparatus to the mean carrier frequency even though the carrier may be of the wide swing type, 100% modulated.

It is a further object of my invention to provide such a receiver which, should it for any reason accidentally overshoot and mistune the signal, will automatically set itself into operation and correct the overshooting or mistuning.

It is a further object of my invention to provide such a receiver which will automatically correct for the effects of thermal drift as and when it occurs.

It is still a further object of my invention to provide such a receiver in which the additional parts and apparatus required over and above those necessary for a signal seeking receiver for amplitude modulated signals are relatively small in number and in cost.

Still other objects and advantages of my invention will be apparent from the specification.

The features of novelty which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its fundamental principles and as to its particular embodiments, will best be understood by reference to the specification and accompanying drawing, in which

Fig. 1 is a circuit diagram of a signal seeking receiver in accordance with my invention, and

Figs. 2, 3, and 4 are curves explaining the operation of my invention.

Referring more particularly to Fig. 1, the signals may be received on any suitable form of antenna 10 and then supplied to converter 11, in which the frequency is changed by interaction with oscillations generated by oscillator 12. The frequency modulated output of the converter may then be supplied to intermediate frequency amplifier 13, all as heretofore practiced. The final output of intermediate frequency amplifier 13 may be passed into the last intermediate frequency coil 13w tuned by condenser 13c.

From this point on the construction and operation of my receiver departs from the conventional receiver. The output from coil 13w is fed to a discriminator comprising the upper portion made up of winding 14L shunted by tuning condenser 14cL, which may be tuned to a desired frequency lower than the mean frequency by the desired amount.

Connected from one side of condenser 14cL I may provide diode 15L, having cathode 15Lc and anode 15aL, and cathode 15cL may be connected through resistance 16 shunted by by-pass condenser 16c to ground. Similarly, in the other portion of the discriminator, inductance 14h may be shunted by tuning condenser 14ch, and this combination may be tuned to another frequency differing from the mean frequency by the same amount as that of 14cL and 14L, but on the high frequency side.

One side of condenser 14ch may be connected to the cathode of diode 15h, having cathode 15ch and anode 15ah. Anode 15ah may be connected to ground through resistance 19 shunted by by-pass condenser 19c. The opposite side of condenser 14cL may be connected to ground through resistance 17 shunted by by-pass condenser 17c, and the opposite side of condenser 14ch may be connected to ground through resistance 18 shunted by by-pass condenser 18c.

The high voltage side of each of resistances 17 and 18 may be connected together through resistances 21 and 22 respectively, and the high voltage side of each of resistances 16 and 19 may be connected together through resistances 20 and 23 respectively. The common point of resistances 20 and 23 may be connected through resistance 24 to the control electrode of thyatron 34, having cathode 34c, control electrode 34g, and anode 34a; and by-pass condenser 26 may be connected from control electrode 34g to ground.

The common point of resistances 21 and 22 may be connected through resistance 25 to the control electrode of another thyatron 35, having cathode 35c, control electrode 35g, and anode 35a, and also to control electrode 30g of control tube 30, which may be a triode having cathode 30c, control electrode 30g, and anode 30a; and control electrode 30g may be connected to ground through by-pass condenser 27.

The common cathode connection of the thyatrons may be grounded through resistance 28 and also connected through resistance 29 to +B.

Control tube 30 may operate a lock-in relay, having winding 32w, armature 32a, and front contacts 32f. The anode 30a of tube 30 may be connected through resistance 33 to control electrode 34g of thyatron 34.

The tuning motor in indicated as at 36, having its shaft coupled to the tuning instrumentalities controlling the receiver, diagrammatically indicated as a tuning condenser 11a in converter 11

and one 12a in oscillator 12, ganged together with drive connection 36S to motor 36.

The tuning motor may be a reversible induction motor of the capacitor type, having one winding 36/1 which may be connected through condenser 37 to an alternating current source, preferably 115 volts, 60 cycles. The action of the capacitor is to cause a substantial phase shift in the current flowing through field 36/1.

If, now, the other winding 36/2 be connected together across the same source, a current will flow through it, but this current will be displaced in phase relation to that in field 36/1 by substantially 90°. Thus the action so far obtainable is the same as that in a two-phase induction motor, with the direction of rotation being determined by which of the two possible phase connections is used, reversal of the connection of one field, of course, causing reversal of the direction of rotation of the motor.

If however, winding 36/2 is center-tapped with the tap being connected to one side of the power source, then the direction of rotation is determined by the choice of which end of the winding is connected to the other side of the power source. This connection may be established according to the present invention by connecting opposite ends of winding 36/2 to anodes 34a and 35a of thyatrons 34 and 35 and connecting the mid-point of winding 36/2 to a point on the same source having a voltage of approximately 300 volts. It will now be understood that the direction of rotation of the motor will be dependent upon which of the thyatrons is ionized.

At this point it may be noted that, while in ordinary thyatron operation, once it fires it stays fired until the plate circuit is opened, in the present case, since the plates are fed with alternating current, neither thyatron, if fired, will remain fired for a complete cycle, but each will fire for one-half cycle if the control electrode voltage permits it, and will be extinguished in any event at the end of such half cycle.

The operation of the receiver as a whole will now be described. It will be noted that the discriminator herein has two output circuits, one for each thyatron. The characteristic of each circuit is that of a typical balanced discriminator, each having the opposite polarity of the other. This is shown in Figs. 3 and 4, in which Fig. 3 represents the voltage at point E as applied to control electrode 34g of thyatron 34. While the output of each circuit is zero for exact tuning, for detuning in one direction the output of one circuit is positive while that of the other is negative and for detuning in the opposite direction the polarities of the outputs are likewise reversed.

The response of each circuit is about one-half of maximum when the signal is at center frequency. One diode rectifier is used to rectify the output of each circuit. Instead of a single diode load resistor for each diode, however, two load resistors of equal value are used, one from cathode to ground and the other from anode to ground. For diode 15L these load resistors are 16 and 17; for diode 15h they are 19 and 18.

In this way there are obtained from each diode two equal outputs, one being positive with respect to ground; the other being negative with respect to ground. This is clearly shown in Fig. 2, in which curve A represents the voltage from cathode 15Lc to ground and that of curve B the voltage from the high side of resistor 17 to ground.

Similarly, curves C and D represent respectively the voltage from the high side of resistor 18 to ground and the voltage from anode 15a $\bar{h}$ to ground. By adding outputs A and D by means of resistors 20 and 23 at point E', the curve E, Fig. 3, is obtained. Likewise by adding outputs B and C through resistors 21 and 22, the output at point F' is obtained as shown by curve F, Fig. 4. The voltages at points E' and F' are audio frequency voltages corresponding to the modulation, and either may be supplied to the amplifier and loud speaker (not shown) or since these voltages are of opposite phase, they may both be used to supply a push-pull audio amplifier.

The cathodes of the thyratrons are biased just enough so that the output of the discriminator will cause one thyatron to operate if the receiver is detuned by more than the desired tolerance. Since outputs E' and F' are opposite in polarity, only one of the two can be positive at any time; thus only one of the thyratrons will operate when the receiver is detuned.

By connecting the motor electrically and mechanically so that detuning will cause the motor to drive the tuning mechanism in a direction toward the point of proper tuning, a signal may then be tuned in by the action of the discriminator, the thyratrons, and the tuning motor. It will be seen, however, that this action will not occur unless the receiver is tuned within the zones covered by curves E and F of Figs. 3 and 4.

It is, therefore, necessary that an additional action be provided to carry the receiver into the zone where this action may occur. This is accomplished by a means which causes one of the thyratrons to operate until the tuning reaches curves E or F, which may be termed the fine tuning zone. For this purpose one of the thyratrons is caused to operate prior to receiving a signal, and this is accomplished by triode 30, push button switch 31, and lock-in relay 32.

Assuming that the receiver is tuned to a frequency far removed from that of an incoming signal, if push button 31 is momentarily depressed, plate voltage is applied to triode 30, plate current flows, and relay armature 32a swings to front contact position and locks in. Opening of push button 31 will not disturb this condition. The characteristics of triode 30 are so chosen that the relay will remain locked in as long as no negative bias is applied to the control electrode of the triode, applying a positive bias to the control electrode 34g of thyatron 34 from +B, through winding 32w and resistance 33, and the tuning motor will operate to vary the tuning of the circuit.

As soon as a signal is partially tuned in; i. e., the tuning reaches the fine tuning zone, a negative bias is applied to the triode, said bias obtained from the discriminator outputs through resistance 25, causing the plate current of triode 30 to drop sufficiently for the relay 32 to open. This removes the +B voltage which previously had been applied through resistor 33 to control electrode 34g of thyatron 34 to keep the same in operation, and control of these thyratrons is, therefore, now effected only by the output of the discriminator.

Suppose, for instance, that relay 32 opens at the frequency designated by arrow 1 in curves of Figs. 2, 3, and 4. It will be observed that the output voltage applied to thyatron 34 is positive, whereas that applied to thyatron 35 is negative. Therefore, thyatron 34 will continue to fire until

the tuning reaches a point designated by arrow 2, at which time thyatron 34 can no longer continue to fire because of insufficient positive voltage on its control electrode, no current will flow in the tuning motor field, and the motor will accordingly, come to rest.

Suppose that its inertia is such as to carry it to the frequency designated by arrow 3. Before this point is reached, the voltage impressed on thyatron 35 has changed from negative to positive, as will be observed in Fig. 4, and that on thyatron 34 has changed from positive to negative, as indicated in Fig. 3. As soon as thyatron 35 begins to fire, if the motor has not stopped rotating, the field currents passed by thyatron 35 will exert a braking action on it, and will cause it to stop and finally to rotate in the opposite direction until it passes into the tolerance zone.

It will be apparent that, should the inertia of the motor be sufficiently great, a hunting action might occur, in which the motor would continue to rotate, first in one direction and then the other, swinging the tuned frequency continuously back and forth about the center frequency. To prevent this, it is desirable that the inertia of the parts be kept small so that excessive coasting after the cutoff of motor current occurs will not take place.

It will also be clear that once the system has tuned itself to the center frequency of the discriminator as described, excessive percentages of modulation will not cause the receiver to change its tuning to follow the carrier as it swings about the mean frequency, because any currents flowing through the motor, if integrated over a period long enough to overcome the motor inertia and cause rotation, will equal or closely approximate zero.

In this connection it may be noted that the RC combinations, resistance 24 and condenser 26, and resistance 25 and condenser 27, are preferably so chosen that modulation frequencies in the output of the discriminator are by-passed to ground and do not affect the tuning.

An interesting feature of my invention is that the circuit is substantially immune to the harmful effect of thermal drift. As drift occurs, its result in the output of the discriminator is the same as mistuning. When it exceeds the tolerance limits of the circuits, one or the other of the thyratrons will begin to fire, and the motor will operate to the extent necessary to retune the receiver until the mean carrier frequency again has the desired value.

Consequently, it will be seen that the action of the circuit is that stated to be desired; i. e., by pushing button 31 the tuning variation is set into operation and will continue until the receiver tunes in a frequency modulated signal of predetermined strength, at which time the fine tuning comes into play and the receiver will tune itself to the mean carrier frequency.

In this application I have explained the principles of my invention and the best mode in which I have contemplated applying those principles, so as to distinguish my invention from other inventions; and I have particularly pointed out and distinctly claimed the part, improvement, or combination which I claim as my invention or discovery.

While I have shown and described certain preferred embodiments of my invention, it will be understood that modifications and changes may be made without departing from the spirit and

scope thereof, as will be clear to those skilled in the art.

I claim:

1. Radio receiving apparatus comprising, in combination, means for receiving frequency modulated signals, including a variable tuning instrumentality for selecting the signal to be received, electric power operated means for driving said tuning instrumentality, manual means for starting said power operated means, a frequency discriminator-rectifier network supplied by received signals, and means operated by the received signal and responsive to the degree of detuning of said received signal within the operating frequency range of the frequency discriminator-rectifier network for correcting said detuning, said last mentioned means comprising a pair of thyratrons for causing operation of said power operated means in opposite directions, and means for applying a firing control voltage of opposite polarity derived from the output of said frequency discriminator-rectifier network to each of said thyratrons respectively.

2. Radio receiving apparatus comprising, in combination, means for receiving frequency modulated signals, including a variable tuning instrumentality for selecting the signal to be received, electric power operated means for driving said tuning instrumentality, manual means for starting said power operated means, a frequency discriminator-rectifier network supplied by received signals, means operated by the received signal and responsive to the degree of detuning of said received signal within the operating frequency range of the frequency discriminator-rectifier network for correcting said detuning, a pair of thyratrons for causing operation of said power operated means in opposite directions, and means for applying a firing control voltage of opposite polarity from the output of said frequency discriminator rectifier network to each of said thyratrons respectively.

3. Radio receiving apparatus comprising, in combination, means for receiving frequency modulated signals, including a variable tuning instrumentality for selecting the signal to be received, an electric motor for driving said tuning instrumentality in opposite directions, manual means for starting said power operated means, a frequency discriminator-rectifier network supplied by received signals, means operated by the received signal and responsive to the degree of detuning of said received signal within the operating frequency range of the frequency discriminator-rectifier network for correcting said detuning, said means being responsive both in direction and magnitude to the degree of detuning of the carrier within the operating frequency range of the frequency discriminator rectifier network, and means for preventing response of said power operated means to carrier deviations caused by modulation.

4. Radio receiving apparatus comprising, in combination, means for receiving frequency modulated signals, including a variable tuning instrumentality for selecting the signal to be received, electric power operated means for driving said tuning instrumentality, manual means for starting said power operated means, and means responsive to received signals for stopping variation of said tuning instrumentality when a frequency modulated signal of predetermined strength is tuned in, said last mentioned means comprising a discriminator, a pair of thyratrons controlled by the output of said discriminator for causing oper-

ation of said power means in opposite directions, said power means comprising a pair of windings for operating said power means in opposite directions, each of said pair of windings being supplied by one of said thyratrons.

5. Radio receiving apparatus comprising, in combination, means for receiving frequency modulated signals, including a variable tuning instrumentality for selecting the signal to be received, electric power operated means for driving said tuning instrumentality, manual means for starting said power operated means, a frequency discriminator-rectifier network supplied by received signals, a first control means for providing continued operation of said variable tuning instrumentality after it has been started and until the variable tuning instrumentality reaches the operating frequency range of the frequency discriminator-rectifier network, and a second controlling instrumentality operable in the operating frequency range of the frequency discriminator-rectifier network for rendering the first control instrumentality inoperative, and for controlling tuning of the signal.

6. Radio receiving apparatus comprising, in combination, means for receiving frequency modulated signals, including a variable tuning instrumentality for selecting the signals to be received, electric power operated means for driving said tuning instrumentality, manual means for starting said power operated means, a frequency discriminator-rectifier network supplied by received signals, a first control means for providing continued operation of said variable tuning instrumentality after it has been started and until the variable tuning instrumentality reaches the operating frequency range of the frequency discriminator-rectifier network, said means comprising a lock-in relay energized by said manual means, and a second controlling instrumentality operable in the operating frequency range of the frequency discriminator-rectifier network for rendering the first control instrumentality inoperative and for subsequently controlling tuning of the signal.

7. Radio receiving apparatus comprising, in combination, means for receiving frequency modulated signals, including a variable tuning instrumentality for selecting the signals to be received, electric power operated means for driving said tuning instrumentality, manual means for starting said power operated means, a frequency discriminator-rectifier network supplied by received signals, a first control means comprising a lock-in relay for providing continued operation of said variable tuning instrumentality after it has been started and until the variable tuning instrumentality reaches the operating frequency range of the frequency discriminator-rectifier network, and a second controlling instrumentality comprising a frequency discriminator rectifier network and a pair of thermionic discharge devices for rendering the first control instrumentality inoperative and for controlling tuning of the signal within the operating frequency range of the frequency discriminator-rectifier network.

8. Radio receiving apparatus comprising, in combination, means for receiving frequency modulated signals, including a variable tuning instrumentality for selecting the signals to be received, electric power operated means for driving said tuning instrumentality, manual means for starting said power operated means, a frequency discriminator-rectifier network supplied by received signals, a pair of thyratrons for controlling the

direction of operation of said tuning instrumentality, a discriminator for applying bias voltage of opposite polarity to said thyratrons respectively to control the tuning of the signal over the operating frequency range of the frequency discriminator-rectifier network, a lock-in relay for applying firing voltage to one of said thyratrons, and a thermionic discharge tube for controlling said lock-in relay, and means for applying a bias voltage from said discriminator to said control tube to unlock said relay when the variable tuning instrumentality reaches the operating frequency range of the frequency discriminator-rectifier network.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,700,282	Burns et al.	Jan. 29, 1929

Number
1,780,669
2,011,953
2,056,200
2,113,436
2,150,265
2,152,336
2,173,154
2,174,566
2,250,532
2,251,064
2,277,581
2,279,506
2,280,019
2,282,910
2,320,996
2,349,881
2,358,454
2,369,542

Name	Date
Bruckel et al.	Nov. 4, 1930
Somers	Aug. 20, 1935
Lowell	Oct. 6, 1936
Williams, Jr.	Apr. 5, 1938
Conover	Mar. 14, 1939
Van Loon	Mar. 28, 1939
Bernard	Sept. 19, 1939
Case	Oct. 3, 1939
Hansell	July 29, 1941
Martin et al.	July 29, 1941
Duinker	Mar. 24, 1942
Reid	Apr. 14, 1942
Alexandersson	Apr. 14, 1942
Thompson	May 12, 1942
Alexandersson et al.	June 8, 1943
Peterson	May 30, 1944
Goldstine	Sept. 19, 1944
Dietrich	Feb. 13, 1945

FOREIGN PATENTS

Country	Date
Great Britain	Feb. 25, 1929