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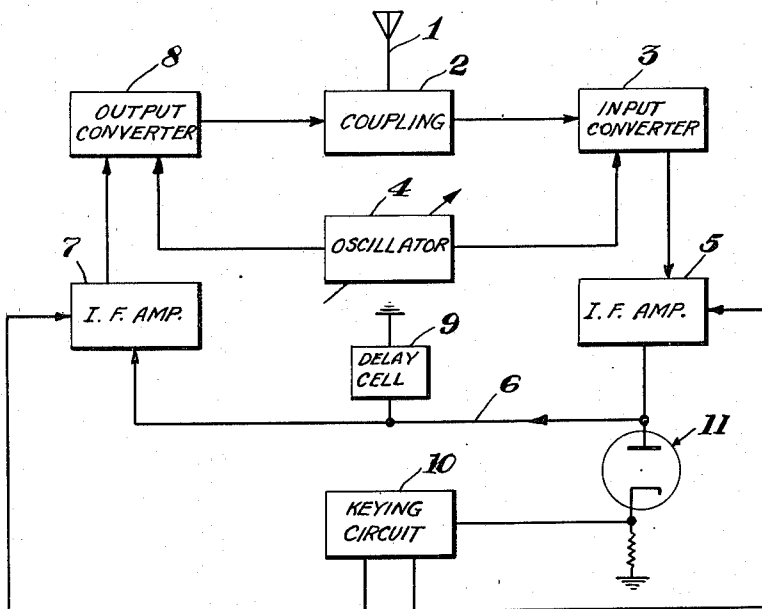
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RADIO FREQUENCY CONVERTING CIRCUITS

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3 Sheets-Sheet 1

Fig. 1.



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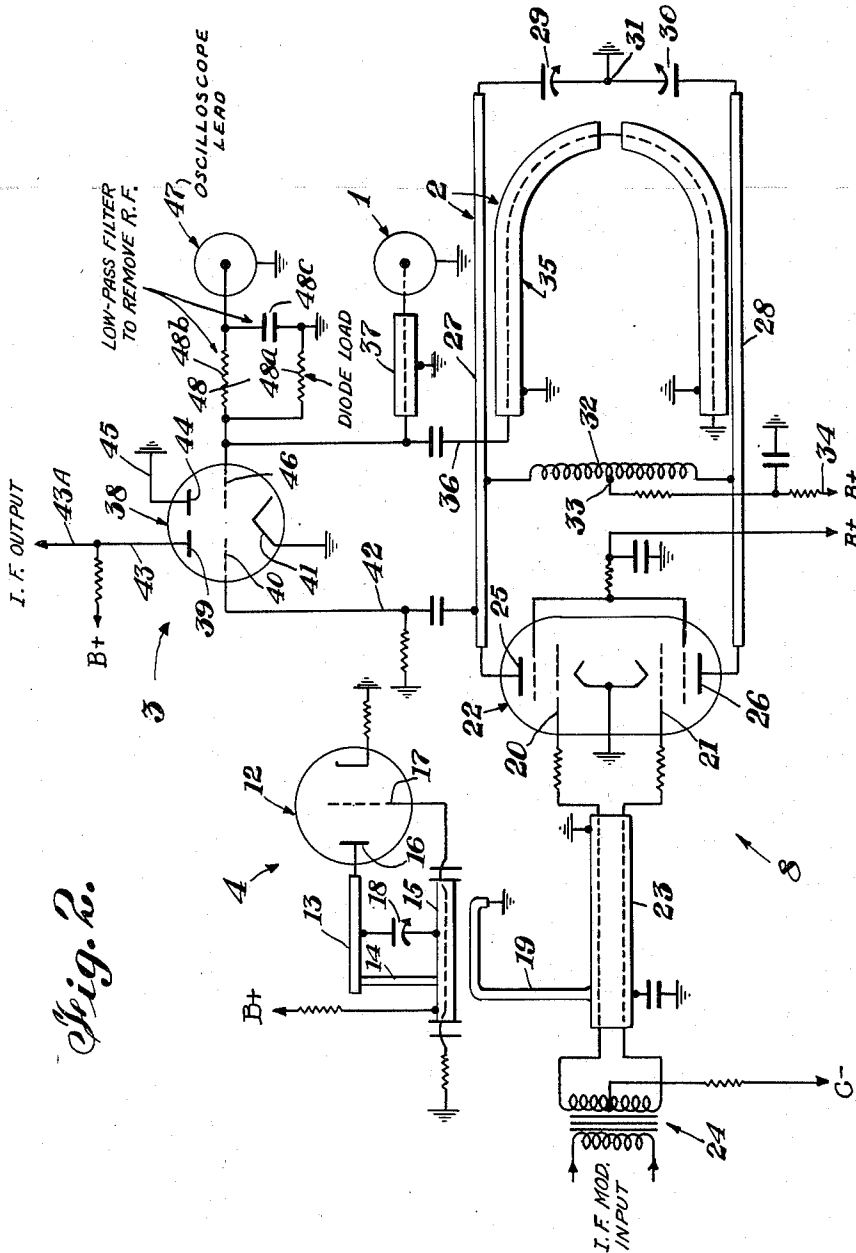


Fig. 2.

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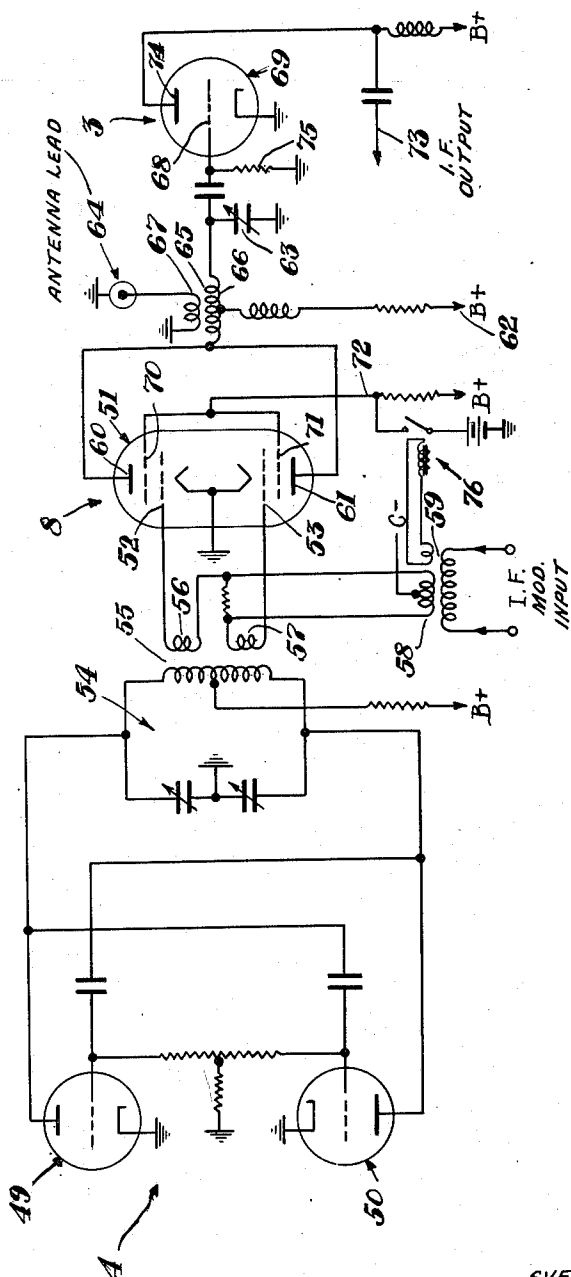
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Fig. 3.



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RADIO-FREQUENCY CONVERTING
CIRCUITS

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Application October 16, 1945, Serial No. 622,607

11 Claims. (Cl. 250—17)

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This invention relates to circuits for converting radiant energy from and back into a radio frequency and more particularly to circuits to which convert the radio frequency of incoming energy into an intermediate frequency and subsequently reconvert the signals from the intermediate frequency into the said radio frequency.

In my copending application, Ser. No. 551,470, filed August 28, 1944, I disclose a system for intercepting radio impulses transmitted by radio locating systems and for transmitting in response thereto simulated reflections as might be obtained from obstacles such as aircraft and ships.

The system includes circuits for receiving the pulses at radio frequency; circuits for converting these impulses into an intermediate frequency; and processing circuits including pulse repeating systems which upon the reception of a transmitted impulse, produces a series of significant pulses which are reconverted to the original radio frequency and are sent out in simulation of reflected pulses that might be expected from the normal reflection characteristics of an object or group of objects.

It is an object of the present invention to provide a system for converting radio frequency impulses into an intermediate frequency and to reconvert the same pulses into the original radio frequency.

It is another object to provide a circuit unit which modifies the operating frequency of radio equipment at a given power level.

It is another object to provide a circuit which modifies the frequency of incoming radiant energy and reconverts it to the original frequency with the aid of a single oscillator.

In accordance with my present invention, I provide in a system which produces simulated reflection pulses as disclosed in the aforesaid application, an incoming energy converter which is coupled into a common antenna system for the alternate reception and transmission of radiant energy impulses at radio frequency, both the input and the output converter being heterodyned by means of an oscillator associated therewith. The oscillator circuit preferably oscillates at a frequency somewhat above the carrier frequency it is desired to receive and transmit. The oscillator is also coupled for transmission of energy to the so-called transmitting converter which is modulated from an intermediate frequency source represented by the processing circuits of the system. The output converter is connected to a half wave balanced resonant transmission line which in turn is coupled to the an-

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tenna through a conventional balance-to-unbalance loop. The receiver converter, which is a triode receives unbalanced oscillator energy from one side of the output converter circuit together with half the antenna voltage appearing across the end of the half wave line. The non-linearity of the triode produces heterodyning action between the oscillator and the incoming antenna voltages and the resulting beat frequency is passed on to the intermediate frequency unit for processing.

These and other features and objects of this invention will become more apparent upon consideration of the following detailed description of an embodiment of the invention in connection with the accompanying drawings in which:

Fig. 1 is a block diagram of a simulating pulse repeater which may incorporate a frequency converter circuit in accordance with the invention;

Fig. 2 is a schematic representation of the incoming and outgoing energy frequency converting circuit which may be used in the system shown in Fig. 1; and

Fig. 3 is a schematic representation of an alternative circuit for performing the functions of the circuit of Fig. 2.

Referring now to the drawings, the repeater system of Fig. 1 which has been fully described in my copending application, Ser. No. 551,470, referred to hereinabove, comprises a two-way antenna 1 which is connected to a transmitter-receiver comprised of a coupling unit 2 connected to an input converter 3 wherein the radio frequency or ultra-high frequency of the carrier of the incoming radio pulses is beat down to a supersonic frequency by heterodyning against the output of a local oscillator 4 for application to a wide band intermediate frequency amplifier stage 5. Connected to an output connection 6 of the intermediate frequency stage 5 is an output intermediate frequency amplifier 7 which feeds into an output converter 8. Here the intermediate frequency carrier energy to which has been added simulated repeat pulse energy from a supersonic repeat pulse generating device or cell 9, coupled to the output connection 6, is reconverted to the original incoming impulse carrier frequency by heterodyning against the output of the oscillator 4. The output converter 8 is connected to supply the coupling unit 2 feeding into the antenna 1 now functioning in its transmission capacity. A keying circuit 10 receiving a controlling impulse from a demodulator 11 of the output of the amplifier 5 supplies a suitable keying potential both to the output

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amplifier 7 and to the input amplifier 5 for the blocking and unblocking of the operation of the two amplifiers respectively. This has the purpose of providing the proper sequence of reception and transmission for the system as a whole. It is to be understood, of course, that the demodulator 11 may be of any suitable form capable of performing the keying function as outlined. The keying pulses themselves may be obtained from circuits such as a multivibrator circuit which is triggered by the incoming impulse as disclosed in my copending application, Ser. No. 480,603; filed March 26, 1943.

Referring to Fig. 2 the converting circuits are there shown to comprise an oscillator 4 which preferably consists of a "lighthouse" tube 12 provided with a tuned circuit including transmission line portions 13, 14, and 15 which form a loop from plate 16 to grid 17 of the tube 12. The resonance of the loop is controlled by an adjustable condenser 18. A high frequency coupling loop 19 conveys energy from the oscillator 4 to grids 20 and 21 of a twin tetrode 22 which acts as a transmitting converter 3. The excitation of the grids 20 and 21 is obtained by way of a coupling transformer 23. The two grids 20 and 21 are also modulated in push-pull by energy at an intermediate frequency which is derived from a transformer 24 connected to the intermediate frequency amplifier 7 (Fig. 1). Plates 25 and 26 of the converter tube 22 are connected to a half wave balanced transmission line comprising line portions 27 and 28 which are tuned to resonance by capacities 29 and 30 grounded at their midpoint 31, said balanced line including an inductance 32 connected between the two line portions 27 and 28 and serving at its midpoint 33 to receive a plate potential from a source of B+ voltage over a connection 34 for the plates 25 and 26. A balance-to-unbalance loop 35 is provided which is disposed adjacent the balanced lines 27 and 28 to serve as a coupling between the converter and the antenna 1, shown here as a terminal over a connection 36 and a high frequency line 37.

The receiving or incoming energy converter 3 is a double triode 38. Half of the tube 38 is connected as a triode including a plate 39, a grid 40 and a cathode 41. The grid 40 is connected to the line portion 27 over a connection 42, the plate 39 being energized from a source of B+ potential over a connection 43. A branch 43A serves as the output circuit of the tube 38. The other half of the tube 38 is connected as a diode, a second plate 44 being grounded at 45 and a second grid 46 serving to supply rectified energy to an oscilloscope represented by the terminal 47 over a decoupling circuit 48. The resistor 48a comprises a load resistance while resistor 48b and condenser 48c comprise a low pass filter to remove radio frequency energy.

The operation of the circuit of Fig. 2 is substantially as follows: The lighthouse tube 12 oscillates preferably at a frequency which is substantially 15 megacycles above the carrier frequency it is desired to receive and to transmit. Energy oscillating at this frequency is applied to the grids 20 and 21 of the twin tetrode 22 over the coupling loop 19 and the coupling transformer 23 with approximately equal phase and amplitude for both grids. Modulating energy at intermediate frequencies obtained from the output amplifier 7 and available in the secondary of the transformer 24 is also applied to the grids 20 and 21 in push-pull. The resultant modulated

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energy appears in the transmission line portions 27 and 28 connected to plates 25 and 26. Basically, only the two side bands will appear in this circuit and the selection of the desired lower side band may be made by proper adjustment of the condensers 29 and 30. Radio frequency energy is then coupled to the antenna 1 over the balance-to-unbalance loop 35, being applied to the antenna 1 over connections 36 and 37 (Fig. 2) wherein the antenna 1 is depicted in the form of a terminal rather than of an antenna symbol. As for the function of the incoming or receiver converter 3, the half of the tube 38 connected as a triode is being supplied during the period of reception, as determined by the keying circuit 10 in Fig. 1, with unbalanced oscillator energy from the plate 25 of the twin tetrode 22 available in line 27 together with half the antenna voltage appearing across the end of the half wave line. The non-linearity of the tube produces a heterodyning action between the oscillator and the incoming antenna voltages to result in a beat frequency which is passed on to the intermediate frequency amplifier 5 via the branch connection 43A in the plate circuit of the tube 38. This circuit makes available oscillator voltage in the plate circuits of the twin tetrode 22 during the reception phase due to inevitable unbalance and capacity effects allowing the circuit to act as an incoming signal converter.

The circuit shown schematically in Fig. 3 is another form for converting incoming energy and to reconvert the same to the original radio frequency. It includes an oscillator 4 which is of the push-pull type comprising triodes 49 and 50. The triodes 49 and 50 are connected to form a source of high frequency energy arranged to supply a balanced modulator or converter 3 comprised of a twin tetrode 51 having grids 52 and 53. Grids 52 and 53 are coupled to a tank circuit 54 of the oscillator circuit 4 by means of an inductive coupling 55 including individual secondary coils 56 and 57 for the two grids 52 and 53 respectively. The coils 56 and 57 are also connected to a secondary 58 of a coupling transformer 59 which supplies energy at an intermediate frequency to the grids 52 and 53 from the intermediate frequency output amplifier 7 (Fig. 1). The plates 60 and 61 of the twin tetrode 51 are connected in parallel to be energized from a B+ potential at 62 their circuits being tuned by means of a condenser 63. Voltages available from the plates 60 and 61 are coupled to a terminal 64 leading to antenna 1 over a coupling unit 65 comprised of a primary 66 and a secondary 67. The plates 60 and 61 are also coupled over the couplind 65 to grid 68 of a receiver converter 3 comprised of a triode 69. The twin tetrode 51 is provided with screen grids 70 and 71 which are connected in parallel and supplied with a biasing potential over a connection 72 between signals and receive an additional pulse-type biasing voltage during the period of transmission over the same connection. The intermediate frequency output of the input converter 3 may be obtained over a connection 73 from plate 74 of the triode 69. It will be noted in Fig. 3 that the oscillator 4 is of the push-pull type which, for example, oscillates at about 85 megacycles, the exact desired frequency being determined by the tunable tank circuit 54. Energy is transferred from the oscillator 4 over the coupling unit 55 including a primary and the two secondaries 56 and 57 which serve to inject in push-pull both the oscillator as well as the intermediate fre-

quency energy voltage available from the intermediate frequency amplifier 7 at the coupling transformer 59 on to the grids 52 and 53. The plates 60 and 61 of the converter tube 51 are connected in parallel having the effect of canceling the fundamentals of the oscillator and intermediate frequency voltages. In the given example, if the intermediate frequency is 15 megacycles, side bands at 100 and 70 megacycles are available in the plates of the converter 8. The plate circuit of this converter 8 is tuned by means of the condenser 63 to a frequency of 100 megacycles which is the frequency radiated in this instance by the antenna connected to the terminal 64. To reduce the energy dissipation in the converter 8, its screens 70 and 71 are normally held to a given bias such as 125 volts and are given an additional positive pulse type boost to, say 200 volts during the period of transmission only as for example by the circuit arrangement 76. During reception, signals from the antenna also appear on the grid 68 of the incoming converter 3. Due to electrode capacity in the converter 8 and due to a condition of unbalance therein, sufficient oscillator voltage leaks through the twin tetrode 51 to cause an adequate heterodyning effect permitting the triode 69 to act as an input or receiving converter, the resultant required intermediate frequency becoming available in the connection 73 from the plate 74 thereof. The transmitted signal, as received and converted by the receiver-converter 3 is kept from being attenuated to any extent by the use of a high grid leak 75.

It will be seen from the above that an efficient method and system has been provided for converting the radio frequency of an incoming signal and to reconvert the said intermediate frequency to the original value. It will be also seen that while the system has been described as being used in connection with a simulated radio obstacle detection system that a frequency converting system of the type disclosed is equally useful in other applications.

While the above is a description of the principles of this invention in connection with specific apparatus and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of this invention as set forth in the objects.

I claim:

1. An electrical system for processing radio frequency signals comprising means for receiving said radio frequency signals, a source of adjustable frequency waves, means for mixing said received radio frequency waves and said adjustable frequency waves to obtain intermediate frequency waves, means for delaying said intermediate frequency waves, means for mixing said delayed waves and said adjustable frequency waves to obtain radio frequency waves therefrom, means for transmitting said radio frequency waves, and means responsive to said intermediate frequency waves for controlling said intermediate frequency waves before and after delaying thereof.

2. An arrangement according to claim 1, wherein said means for controlling comprises a keying circuit for controlling the application of said intermediate frequency waves to said delay means and the application of said delayed waves to said second means for mixing said delayed waves.

3. An electrical system for processing radio frequency waves comprising means for receiving said radio frequency waves, a source of adjust-

able frequency waves, means for combining said received and said adjustable frequency waves to provide intermediate frequency waves, means for amplifying said intermediate frequency waves, means for delaying said amplified intermediate frequency waves for a given time interval, means for amplifying said delayed waves, means responsive to said amplified delayed waves and said adjustable frequency waves for converting said delayed amplified waves to a radio frequency, means for transmitting said last named radio frequency waves, and control means responsive to said amplified intermediate frequency waves for blocking and unblocking of said means for amplifying.

4. An arrangement according to claim 3, wherein said control means comprises means for rectifying a portion of said intermediate frequency waves, and a keying circuit responsive to said rectified waves for alternately and simultaneously blocking and unblocking said means for amplifying.

5. An electrical system for converting radio frequency waves from a given circuit to intermediate frequency waves and for reconvert intermediate frequency waves into radio frequency waves for application to said given circuit comprising a source of adjustable frequency waves, a balanced modulator arrangement comprising an electron discharge device having two input electrodes and two output electrodes, means for applying said intermediate frequency waves in push-pull through a coaxial transmission line to said input electrodes, means for electromagnetically coupling waves of said adjustable frequency to said coaxial transmission line for application cophasially to said input electrodes, said modulator comprising an output circuit tuned to said radio frequency and coupled to said output electrodes, said output circuit comprising a two-conductor transmission line in a capacitive tuning network, circuit means for applying radio frequency waves from said output circuit to said given circuit comprising a coaxial loop transmission line coupled at one end to a point on said tuning network and coupled at the other end to said given circuit, said coupling loop transmission line also coupling radio frequency waves from said given circuit to said output circuit, means coupled to a point on said two conductor transmission line for removing radio frequency waves and adjustable frequency waves from said output circuit, and means for mixing said last named waves to obtain intermediate frequency waves thereof.

6. An arrangement according to claim 5, wherein said coaxial transmission line comprises a twin conductor coaxial line, said electro-magnetic coupling means comprises a loop conductor coupled inductively to said source of adjustable frequency waves and conductively connected to the outer conductor of said twin conductor coaxial line.

7. An arrangement according to claim 6, wherein said coaxial loop transmission line comprises two separate outer conductors electromagnetically coupled respectively to separate ones of said conductors of said two conductor transmission lines, the inner conductor of said coaxial loop transmission line being grounded at one end and coupled to said given circuit at the other end, said tuning network comprises separate adjustable capacitors coupled between the remote ends of said two conductor transmission line and ground.

8. An arrangement according to claim 7, wherein said adjustable frequency source comprises an electron discharge device having plate and grid electrodes and operating as an oscillator, means for tuning said oscillator comprising a single conductor transmission line coupled to a plate electrode and through a coaxial transmission line to said grid electrode, capacitive tuning means coupled between said single conductor line of said oscillator and said single conductor coaxial line, said means for applying adjustable frequency waves comprising said single conductor loop connected at one end to ground and magnetically coupled to said single conductor coaxial line.

9. An electrical system for converting radio frequency waves from a given circuit to intermediate frequency waves and for reconverting intermediate frequency waves into radio frequency waves for application to said given circuit comprising a source of adjustable frequency waves, a modulator arrangement comprising an electron discharge device having input electrodes and output electrodes, an output circuit tuned to said radio frequency and coupled to said output electrodes, means for applying said intermediate frequency waves and said adjustable frequency waves to said input electrodes to obtain radio frequency waves in said output circuit, means for applying radio frequency waves from said output circuit to said given circuit, means for coupling radio frequency waves from said given circuit to said output circuit, means coupled to said output circuit for removing radio frequency waves and adjustable frequency waves from said output circuit, means for mixing said last named waves to obtain intermediate frequency waves thereof.

10. An arrangement according to claim 9, wherein said source of adjustable frequency waves

comprises an electron discharge device arrangement providing simultaneously adjustable frequency waves of opposite phase, means for applying said adjustable frequency waves and said intermediate frequency waves to said modulator in push-pull, said modulator comprising two electron discharge devices having their output circuits coupled in parallel, transformer means for coupling radio frequency energy from said output circuit to said given circuit and for coupling radio frequency energy from said given circuit to said output circuit, an electron discharge device and means for applying said adjustable frequency waves and said radio frequency waves from said output circuit to said electron discharge device to obtain intermediate frequency waves thereof.

11. An arrangement according to claim 10, wherein said modulator comprises a plurality of control grid electrodes, means responsive to said intermediate frequency energy applied to said input electrodes for controlling the bias of given ones of said control grid electrodes.

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