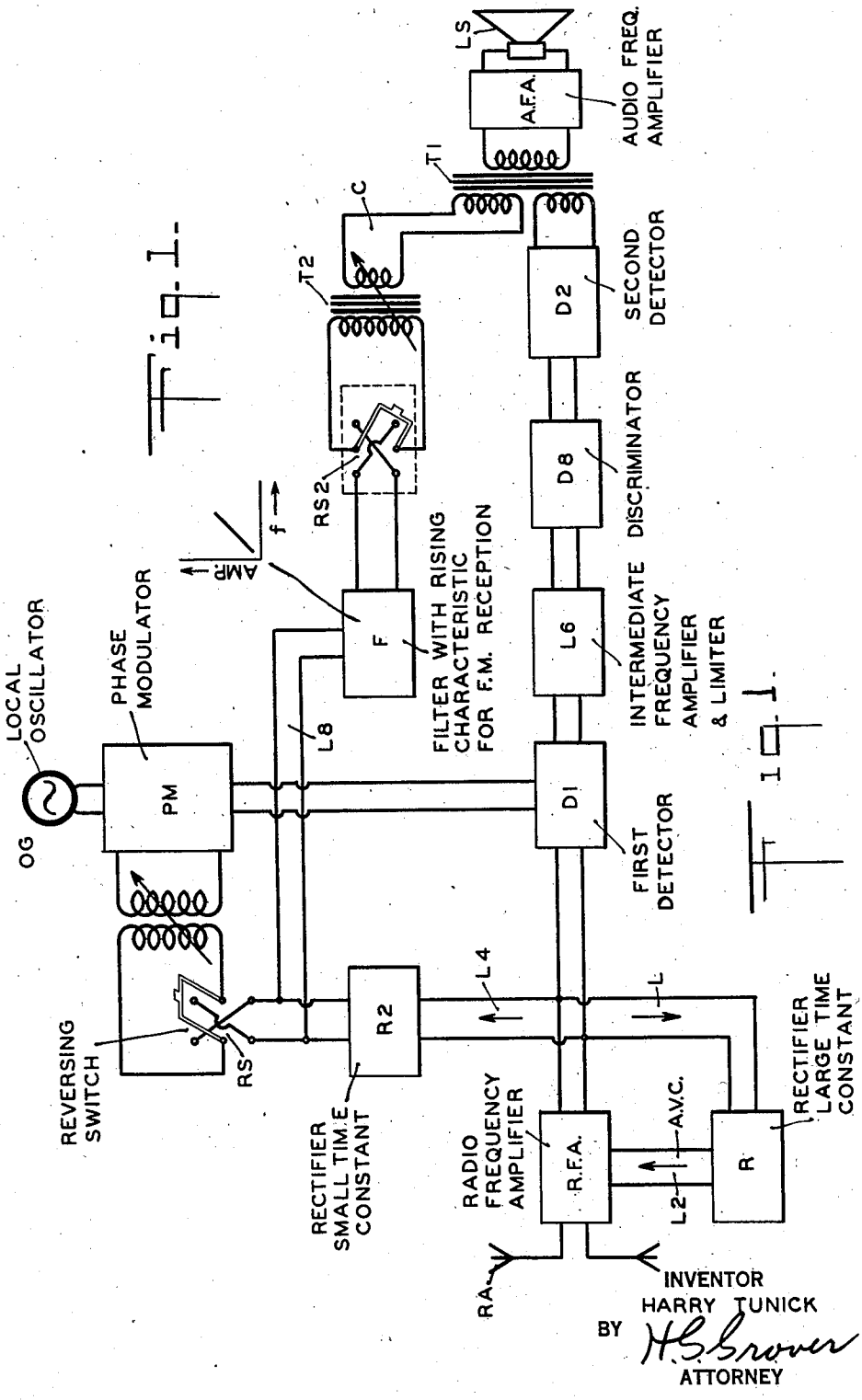
March 13, 1945. H. TUNICK 2,371,416

RECEPTION OF TIMING MODULATED WAVES

Original Filed Dec. 20, 1941 3 Sheets-Sheet 1

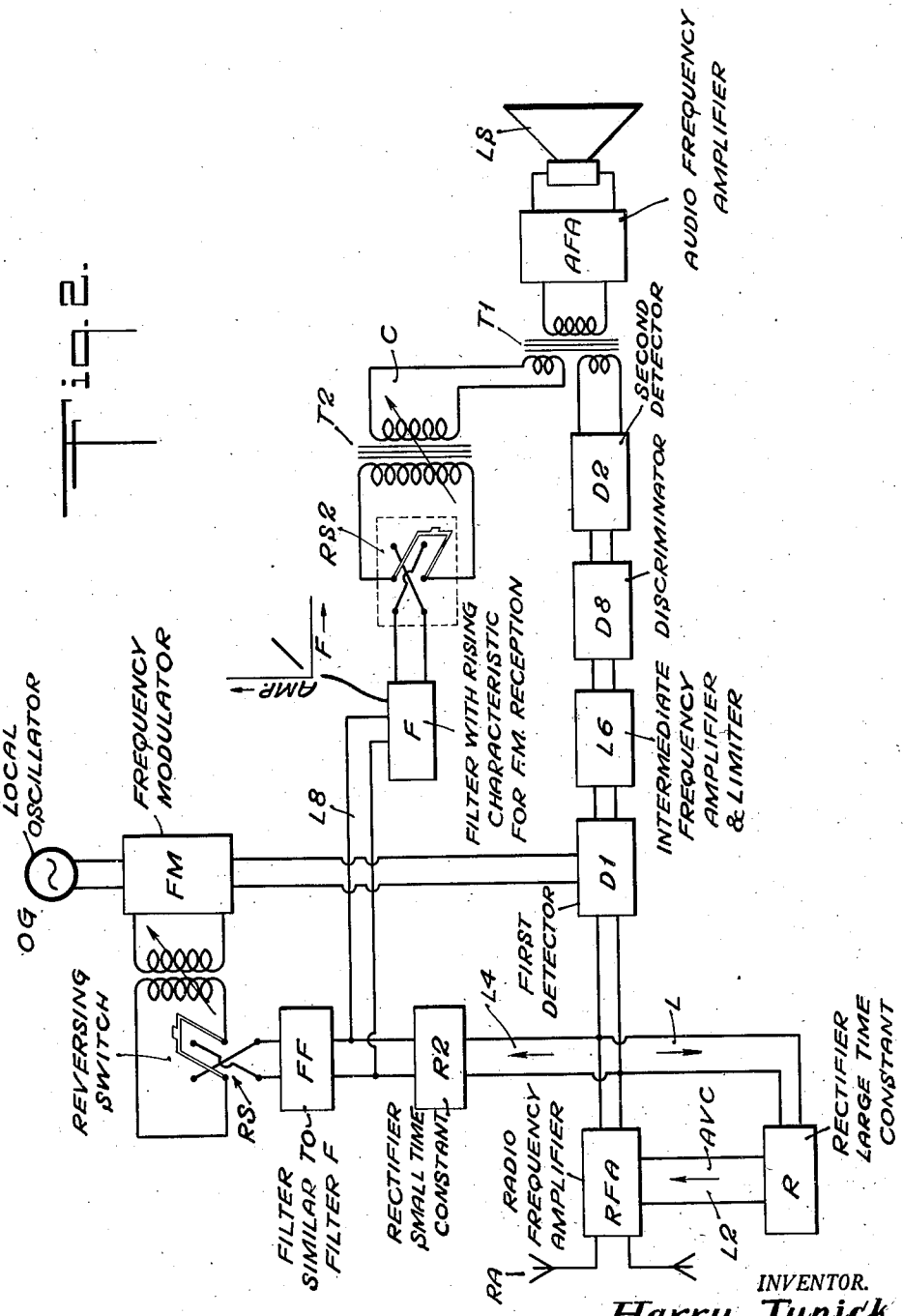


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RECEPTION OF TIMING MODULATED WAVES

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Fig. 2.



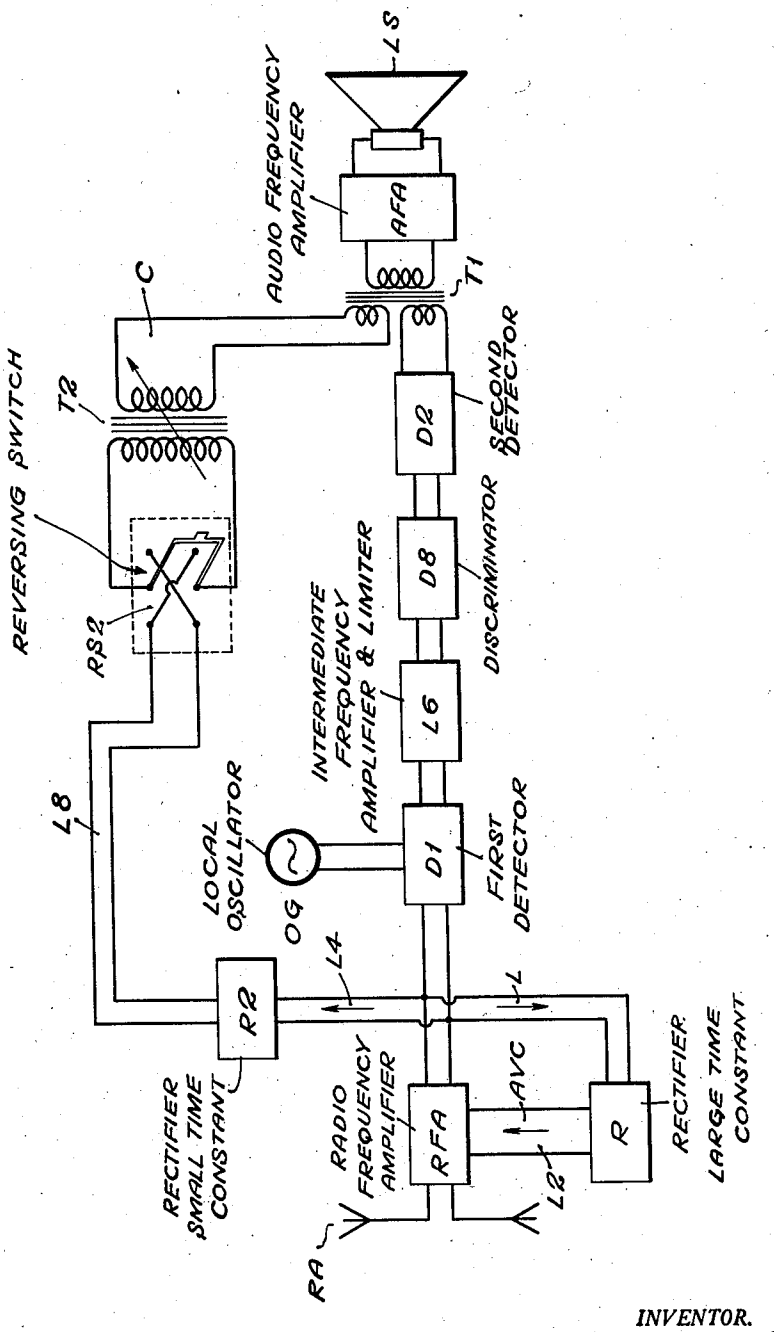
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Fig. 2.



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2,371,416

RECEPTION OF TIMING MODULATED WAVES

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Original application December 20, 1941, Serial No. 423,763. Divided and this application August 21, 1942, Serial No. 455,566

9 Claims. (Cl. 250—20)

This application is a division of my copending application Serial No. 423,763, filed December 20, 1941. My U. S. application Serial No. 423,763 is a continuation in part of my U. S. application Serial No. 361,413, filed October 16, 1940, and now U. S. Patent No. 2,282,101.

The object of my present invention is to provide improved circuits for the reception of angular velocity or timing modulated waves and particularly for frequency modulated waves.

In the accompanying drawings, Figure 1 is a diagram of a receiver, in accordance with my present invention, for receiving angular velocity modulated waves. The arrangement of circuits is such as to secure a substantial reduction in noise.

Figure 2 is a modified form of the system shown in Figure 1, and Figure 3 is a simplified arrangement of the apparatus of both Figures 1 and 2.

In the receiving system of Figure 1, frequency modulated waves received upon the antenna RA are fed to a radio frequency amplifier RFA. Most of the tube noise in the receiver is developed in the first radio frequency amplifying tube of the radio frequency amplifier RFA; that is, in the tube electrically nearest the antenna. By means of the receiver of Figure 1, this tube noise or hiss is substantially reduced. Part of the amplified output of the radio frequency amplifier RFA is fed through leads L to a rectifier R having a large time constant. The output of this rectifier R is fed through leads L2 to automatically volume control radio frequency amplifier RFA. Another portion of the output of the radio frequency amplifier RFA is fed through leads L4 to a second rectifier R2 having a very small time constant so that the output of rectifier R2 produces noise voltages as distinct from desired signal voltages.

The first detector D1 is supplied with locally generated oscillations from the local oscillation generator OG. The beat frequency or intermediate frequency output of D1 is fed to a network including an intermediate frequency amplifier and limiter L6 and then to a discriminator D8, which converts the limited frequency modulated waves into waves of varying amplitude. The latter are detected by the second detector D2 and fed through transformer T1 to an audio frequency amplifier AFA and then to loudspeaker LS. The discriminator D8 may be of a type such as described in my copending application Serial No. 423,763 or in Seeley Patent No. 2,121,103 or in Usselman Patent No. 1,794,932 or in Crosby Patent No. 2,071,113.

The limiter L6 operates to reduce the amplitude modulation component of the waves fed to it. The limiter effectively eliminates solely that portion of the noise whose voltage is in phase or exactly 180 degrees out of phase with the desired signal carrier. Since noise voltages, however, produce waves generally different in frequency than that of the signal frequency in the limiter, the noise effectively phase modulates the signal output of limiter L6 at such times when the instantaneous position of the noise vector is not exactly in alignment with the signal vector. It is this phase modulation which normally goes through the discriminator and second detector circuits to produce the undesirable noise effects in the audio frequency system and this phase modulation noise is produced despite the utilization of limiting, balanced detectors and automatic volume control.

By the arrangement shown in Figure 1 the phase modulation component of the noise may be substantially reduced or eliminated. The output of the rectifier R2 is fed through manually operated reversing switch RS to a phase modulator PM. The noise voltage output of rectifier R2 phase modulates the waves from the local generator OG and these phase modulated waves are fed to the first detector. The reversing switch RS is thrown to such a position, which will be found by trial, as to introduce in the beat frequency output of the first detector D1 and, therefore, in the intermediate frequency amplifier and limiter, a phase modulation which counteracts the phase modulation produced by the limiter when the noise components and signal voltages are combined therein.

It is preferable, although not essential, that the output of the phase modulator PM is limited before being fed into the first detector D1.

As an additional means to reduce the noise produced by phase modulation within the receiver of Figure 1, the apparatus, including leads L8, filter F, reversing switch RS2, transformer T2 and circuit C, may be employed. Since the noise output of the limiter appears as a phase modulation, de-modulation action by the frequency modulation discriminator D8 and detector D2 will produce a noise voltage in transformer T1 which rises with increase in frequency of the noise voltage. This noise voltage may be balanced out by feeding the output of rectifier R2 through reversing switch RS2, properly thrown by trial to its correct position, and circuit C to the primary side of transformer T1. The filter F is constructed to have a rising characteristic, namely, it is made so as to have an output which increases

with frequency over the noise frequency range. In this way, the emphasis produced by the frequency de-modulation of the phase modulation noise in the discriminator D8 and second detector D2 is effectively counteracted. Consequently, it follows that the overall noise is more completely compensated, bucked out or neutralized when the pre-emphasized noise voltage is fed in opposite phase through circuit C to the transformer T1, with respect to the noise voltages fed thereto by the output coil of detector system D2.

In the event that the receiver is provided with a discriminator for phase modulated waves so that the receiver is a phase modulation receiver receiving transmitted phase modulated waves, then, of course, the emphasizing circuit F for the noise voltages may be omitted.

It will be found that the arrangement shown in Figure 1 is especially useful for elimination of QRM or interfering signal which appears on one side of the carrier only under certain conditions of reception.

Moreover, as shown in Figure 2, it is to be noted that the output of rectifier R2 may be used to directly frequency modulate the local oscillation generator, thereby dispensing with the necessity for the phase modulator PM. In this event, however, a filter FF similar to filter F, should be interposed between the rectifier R2 and the frequency modulated local oscillator. Such an arrangement will effectively phase modulate the output of the local oscillator OG.

As a further alternative, as shown in Figure 3, the phase modulator PM, reversing switch RS and filter F, all of Figure 1, may be omitted and the output of R2 fed either with or without amplification directly into the reversing switch RS2. This simplified arrangement of Figure 3 will give a general averaging cancellation of that portion of the noise not eliminated by the limiter.

The frequency swing employed at the transmitter of the system may be of any desirable value, such as, for example, specified by Hansell in his U. S. Patent 2,179,182. Thus, for example, assuming a transmitter to handle a modulating frequency band of zero to 15,000 cycles, this modulating wave may be used to vary the transmitted frequency plus and minus 15,000 cycles, plus and minus 20,000 cycles, plus and minus 50,000 cycles, plus and minus 100,000 cycles, plus and minus 200,000 cycles, etc. The admittance band of the discriminator, that is to say, the separation between the resonant peaks of the discriminator circuit, should be made wider than the maximum swing of the received waves.

Having thus described my invention, what I claim is:

1. The method of receiving frequency modulated waves which includes collecting frequency modulated waves, generating local waves, beating the local waves with the received waves, deriving from the received waves a voltage representative of noise, phase modulating the locally generated waves with the derived voltage prior to said beating step, converting wave energy derived from the beating step into waves of variable amplitude, detecting the waves of variable amplitude and translating the detected waves.

2. The method of treating received angular velocity modulated waves having undesired amplitude modulation components therein, which includes deriving a voltage from said received waves representative of said amplitude modulation components, generating local waves, phase modulating the local waves with the derived voltage, heterodyning the phase modulated local waves and received angular velocity modulated waves, limiting the beat waves produced by the heterodyning process and utilizing the limited beat wave.

3. The method as claimed in claim 2 characterized by the fact that the limited beat waves are converted to waves of varying amplitude, and being further characterized by the fact that the waves of varying amplitude are rectified and utilized to produce the desired modulation of the angular velocity modulated waves.

4. The method of treating received angular velocity modulated waves having therein an undesired amplitude modulation which includes rectifying a portion of the waves to produce a voltage representative of the undesired amplitude modulation, angular velocity modulating locally generated waves with the derived voltage, and heterodyning the locally generated modulated waves with another portion of the received waves, and demodulating the resultant beat wave energy so as to produce the desired modulation represented by the angular velocity modulation in the received waves.

5. Apparatus for receiving angular velocity modulated waves having an undesired amplitude modulation component therein which includes a circuit for receiving said waves, a rectifier for rectifying a portion of said waves so as to derive a copy of the undesired amplitude modulation, a local generator for generating local heterodyning waves, angular velocity modulating the locally generated waves with the wave copy derived from the rectifier, a detector to which another portion of the received waves and the locally generated modulated waves are fed and detected, a limiter for limiting the wave energy output of said detector, and apparatus for utilizing the output of said limiter.

6. Apparatus as claimed in the preceding claim characterized by the fact that circuits are provided for feeding the output of said limiter to a discriminator wherein the limited angular velocity modulated beat energy derived from the detector is converted to waves of varying amplitude, and a second detector for rectifying the waves of varying amplitude derived from said discriminator.

7. A receiving system for angular velocity modulated waves comprising a circuit for receiving said waves, a rectifier for rectifying a portion of the received waves and for producing a voltage which is a copy of the amplitude modulation component of the received waves, a local generator, apparatus for phase modulating the wave output energy of said local generator with said voltage, a first detector to which another portion of the received waves and said phase modulated locally generated waves are fed for heterodyning, a limiter for limiting the beat output energy of said first detector, and a utilization circuit for utilizing the output of said limiter.

8. Apparatus for receiving angular velocity modulated waves having undesired variable amplitude components therein, which includes a circuit for receiving said waves, apparatus for producing from said received waves a voltage representative of the undesired variable amplitude components, a local generator for generating local heterodyning waves, means for phase modulating the locally generated waves with the representative voltage, a detector to which the received waves and the locally generated phase modulated waves are fed for mixing, a limiter

for limiting the beat wave energy output of said detector, and apparatus for utilizing the output of said limiter.

9. The method of treating received angular velocity modulated waves having undesired amplitude variations therein which includes producing from said received waves a voltage corresponding to the amplitude variations in said angular velocity modulated waves, generating local waves, phase modulating the local waves with said voltage, heterodyning the phase modulated locally generated waves and said angular velocity modulated waves, limiting beat frequency wave energy produced by the heterodyning process, and utilizing the limited beat frequency wave energy.

HARRY TUNICK.