

The present invention relates to a radar device for measuring the distance "h" which separates it from an object, which device includes transmission means for transmitting a frequency-modulated wave towards the object, receiving means comprising mixing means for receiving the wave after reflection from the object and for providing a beat wave between the transmitted wave and the received wave, high-speed digital processing means for carrying out a time/frequency transformation operation on the beat wave, output means for providing the indication of the distance "h" and management means consisting of a microprocessor executing the instructions of a program installed in a read-only memory whilst there are provided a first link for linking the management means to the output means, a second link for linking the management means to the receiving means, a third link for linking the management means to the high-speed digital processing means, and a fourth link between the management means and the transmission means, the said links preferably being two-way.

The kind of application more particularly addressed by the invention is the determination of the altitude of an aircraft, the device being stowed on board the latter whilst the object consists of the ground.

For some time, there have been efforts to use digital processing circuits for this distance determination (see for example the United States Patent No. 4,568,938).

A device of the aforesaid kind is described in another United States Patent No. 4,268,828. This known device uses management means consisting of a programmable microprocessor which acts on the receiving means so that the measurements for determining "h" may be carried out at suitable levels and thereby proper information may be supplied to the output means.

However, the disadvantage encountered with this device is that the high-speed digital processing means, especially when they exhibit a certain degree of sophistication, are the elements most subject to

deficiencies.

In order to provide information on "h" despite the deficiency in the high-speed processing means, a device of the kind mentioned in the preamble is noteworthy in that the high-speed digital processing means include a time frequency transformation unit operating on the output signals from a device for correlating the beat signals, and in that the program installed in the read-only memory of the management means contains instructions for carrying out a time/frequency transformation operation to make up for a deficiency in the high-speed digital processing means.

The present invention will be better understood with the aid of the following description, accompanied by the attached drawings. In these drawings:

Figure 1 shows a radar device according to the invention.

Figure 2 shows in more detail the high-speed processing means linked with the management means as well as the display module.

Figure 3 shows the control of level of the transmission means.

Figure 4 shows the control of frequency of the transmission means.

Figure 5 shows the control of gain of the receiving means.

Reference 1 pertaining to Figure 1 indicates the device of the invention. Reference 2 indicates the object separated by a distance "h" from the device. In the example described relating to the envisaged application to radionavigation, the object 2 is the surface of the ground whilst the device 1 is stowed on board an aircraft, not shown.

In order to measure this distance "h", use is made of a wave $E(t)$ which is linearly frequency-modulated from a carrier frequency f_0 (for example 4 GHz) over a frequency range ΔF , which may be written:

$$(1) \quad E(t) = A \cos[2\pi(f_0 + \frac{\Delta F}{T} t)t]$$

for t varying in the time span T where the sawtooth
5 occurs.

A is a constant defining the amplitude of the wave.

This wave is transmitted into space from a
transmitting antenna 5 which is connected to the output
of a transmission amplifier 7. This amplifier 7 amplifies
10 the signal provided by an oscillator 9 having a voltage-
controlled frequency. A sawtooth signal generator bearing
the reference 11 provides the control voltage for this
oscillator 9. The wave $E(t)$ is reflected by the object 2
so that the received wave can be written:

$$15 \quad (2) \quad R(t) = B \cos[2\pi(f_0 + \frac{\Delta F}{T} (t-\tau)t]$$

where B is a constant defining the received level
and τ represents the delay between the transmitted wave
20 and the reflected wave.

In order to receive this wave $R(t)$, the radar
device 1 is fitted with a receiving antenna 15, and a
high-frequency reception amplifier 17.

A mixer circuit 20 mixes the received wave
25 amplified by the amplifier 17 with the transmission wave
tapped off by means of a directional coupler 22 inserted
between the oscillator 9 and the transmission amplifier
7. This mixer 20 provides a wave $M(t)$:

$$30 \quad (3) \quad M(t) = C \cos[2\pi \frac{\Delta F}{T} \tau t]$$

where C represents a constant.

The distance " h " is deduced from the frequency
" f_b " of the signal $M(t)$:

$$f_b = \tau \frac{\Delta F}{T} \quad \text{where } \tau = \frac{2h}{c}$$

(c = speed of light)

5 whence:

$$(4) \quad h = \frac{f_b \cdot c}{2\Delta F} T$$

10 The signal M(t) is advantageously processed in digital form; to do this, there has been provided an analog/digital converter 25 for converting this signal M(t) which has previously undergone amplification effected by a beat amplifier 27.

15 The analog/digital converter 25 delivers digital samples to a high-speed digital processing assembly 30 which is provided so as to form frequency spectra thereof. These spectra are next processed by a management assembly 35 so as to provide the user with the value of the distance "h" on an indicator 55.

20 The radar device is endowed with a management assembly 50 for providing the user with, in particular, the value "h" by way of a display module 55 and for controlling, in particular, the sawtooth signal generator 11 and also the high-speed digital processing assembly. 25 Furthermore, the management assembly controls the level of the transmission wave by acting on an attenuation control incorporated with the transmission amplifier 7. In order to show the control of these elements by the management assembly, a bundle FSCX which links them to 30 the management assembly 50 has been represented in the figures. It goes without saying that, in practice, the various links between the elements and the management assembly might not follow the same route and therefore do not necessarily have the physical aspect of a bundle of 35 wires.

Represented in more detail in Figure 2 are the management assembly 50, the high-speed digital processing

assembly 30 and the display module 55.

The management assembly is built around a microprocessor module 100 comprising, as is well known, the microprocessor proper μ Pg (for example the 6809 manufactured by MOTOROLA), a random-access memory RAM and a read-only memory ROM in which the program desired by the user is recorded. This module communicates with the outside by way of a line BSDG so as to relay data and a line BADG so as to relay address codes.

The assembly 50 includes an address code decoder which decodes the codes transmitted by the line BADG; this decoder provides various signals CZF, CAFF, RG, WG, CDS, CTM, CATT which are relayed to various elements of the radar device of the invention by way of the bundle FSCX. The assembly 50 also includes a programmable interface circuit 115 (for example the proprietary circuit 6820 manufactured by MOTOROLA), the ports of which are linked to wires forming part of the bundle FSCX.

The digital processing assembly is formed also of a microprocessor module 200 containing a microprocessor proper operating at high speed (for example the TMS 320 manufactured by Texas Instruments) a read-only memory ROM and a random-access memory RAM; this module is programmed to carry out fast Fourier transformations (the article by SURENDER HAGAR et al., entitled " μ C builds FFT band spectrum analyzer" may be consulted on this subject, appearing in the compendium "Signal Processing with the TMS 320" published by Texas Instruments). The Fourier transformation is carried out on the output signals from an autocorrelation device 203 of a type described in French Patent Application No. 85 12 337 filed on 13 August 1985 in the name of the Applicant. The output signals from this device are relayed by a data transmission line BSDF connected to the module 200. The input of the device for the signals to be autocorrelated is linked to the output of the digital/analog converter 25 by way of a register 207. A second two-way register 210 links this input to the line BSDF. Thus, it is possible

to test for the proper operation of the device 203. To do this, the register 207 is disabled and preset data from the module 200 may be fed into the device and, thereby, it becomes possible to check whether these data have been correlated correctly. There is also provided an address code decoder 215 connected to the line BADF relaying the address codes leaving the module 200; this decoder 215 provides, in particular, signals WF and RF. The assembly 30 is connected to the bundle FSCX by way of two memories 218 and 220 of the first-in, first-out type (FIFO memory of the LS222 kind). The input of the memory 218 is connected by way of a two-way register 222 to the line BSDF and its output to the line BSDG by way of the bundle FSCX. The input of the memory 220 is linked to the line BSDG again by way of the bundle FSCX, whilst its output is linked to the line BSDF by way of the register 222. The signals WF and RF make it possible respectively to write to the memory 210 and to read from the memory 220, the data to be written and to be read relating to the module 200. The signals WG and RG travelling through the bundle FSCX allow respectively the writing to the memory 220 and the reading of the contents of the memory 218, the last data to be written and to be read relating to the module 100. The signal CZF travelling through the line BSCC can be used to initialize or reinitialize the module 200.

The display module 55 makes it possible to visualize the result provided by the module 100 by way of the line BSDG travelling through the bundle FSCX. The signal CAFF assigned to the module 55 is what fixes the destination of the data relayed by the line BSDG.

Represented in Figure 3 is one way in which the transmission level can be controlled by acting on the transmission amplifier 7. This amplifier is formed of an amplifier with constant gain 300 followed by an attenuator with switchable PIN diodes 302. The switching of these diodes is determined by a transcoding circuit 305 which converts into a switching code the continuous code in a register 310. The inputs of this register 310 are

linked to the line BSDG by way of the bundle FSCX. In order for the data relayed by these lines to be recorded in the register 310, the signal CATT travelling through the bundle FSCX must be active.

5 Figure 4 shows how the sawtooth signal generator is controlled by the management assembly 50. The generator is devised around a circuit 350 described in European Patent No. 0,113,975. The sawtooth duration is determined by a code contained in a register 360. The inputs of this
10 register 310 are put through to the line BSDG by way of the bundle FSCX when the signal CDS also travelling through this bundle is active. A timing circuit 370 is adjoined to the circuit 350. This timing circuit 370 (for example the proprietary circuit 6840 manufactured by
15 MOTOROLA) determines the actual duration of the sawtooth and this duration is forwarded to the management assembly by way of the line BSDG travelling in the bundle FSCX. This forwarding takes place only if the signal CTM travelling through the bundle FSCX is active.

20 Figure 5 shows the way in which the gain of the reception amplifier 27 is varied. This amplifier is formed of two fixed-gain amplifiers 400 and 402 mounted in cascade and between which is mounted an attenuator 405. This attenuator is in fact a logarithmic digital/
25 analog converter (for example of the proprietary type AD7118); this converter provides an output signal which is dependent both on the input code and on the input signal. The input code comes from the circuit 115 travelling through the bundle FSCX.

30 The structure of the device according to the invention makes it possible, by programming, to satisfy the most diverse wishes of the user. For example:

- by acting on the generator 11 it is possible to vary the duration T (and measure it later with the circuit
35 370 for more accurate calculations) so that the frequency f_b (see formula (4)) stays within limits appropriate to the processing effected by the high-speed digital processing assembly 30.
- by acting on the transmission level by means of the

attenuator 302 (Figure 3) it is possible to obtain the lowest possible transmission level compatible with proper measurement of "h", this allowing lesser disturbance of the neighbouring apparatuses.

- 5 - by acting on the gain of the amplifier 27, the amplitude of the signals to be processed by the assembly 30 is tuned to its optimal value.
- the management assembly 50 can trigger a test of the processing assembly 30 and take measures in view of the
- 10 deficiencies of the latter.

CLAIMS

1. Radar device for measuring the distance "h" which separates it from an object, which device includes transmission means (11, 9, 7, 5...) for transmitting a
5 frequency-modulated wave towards the object, receiving means (15, 17, 20, 21...) comprising mixing means (20) for receiving the wave after reflection from the object and for providing a beat wave between the transmitted wave and the received wave, high-speed digital processing
10 means (30) for carrying out a time/frequency transformation operation on the beat wave, output means (55) for providing the indication of the distance "h" and management means (50) consisting of a microprocessor executing the instructions of a program installed in a read-only
15 memory whilst there are provided a first link (FSX) for linking the management means to the output means, a second link (FSX) for linking the management means to the receiving means, a third link (FSX) for linking the management means to the high-speed digital processing
20 means, and a fourth link (FSX) between the management means and the transmission means, the said links preferably being two-way, characterized in that the high-speed digital processing means include a time frequency transformation unit operating on the output signals from
25 a device for correlating the beat signals, and in that the program contains instructions for carrying out a time/frequency transformation operation to make up for a deficiency in the high-speed digital processing means.

2. Radar device according to Claim 1, characterized
30 in that the transmission means include an oscillator (9) endowed with a control of frequency modulation characteristics which is connected to the fourth link.

3. Radar device according to one of Claims 1 or 2,
characterized in that the transmission means include a
35 network for attenuating the transmitted wave which is connected to the fourth link.

4. Radar device according to one of Claims 1 to 3,
characterized in that the transformation unit consists
of a high-speed microprocessor to which is attached a



read-only memory in which is installed in particular a program for the time/frequency transformation operation.

5. Radar device according to one of Claims 1 to 4, characterized in that there are provided two memory assemblies of the first-in, first-out type (FIFO memory) in order to form the third link.

6. Radar device according to one of Claims 1 to 5, characterized in that the receiving means include a beat signal amplifier attached to an attenuator endowed with an attenuation control connected to the second link.

