HYDROGRAPHIC SURVEY BY MEANS OF ELECTRONIC TELEMETER AND DIGITAL WATER DEPTH FINDER

By

E. FARKAS and A. KRAUTER

Laboratory of the Institute of Geodesy, Technical University, Budapest

Received: January 28, 1979

In recent years the Laboratory of the Institute of Geodesy, Surveying and Photogrammetry was busy in the development of new instruments and methods for hydrographic surveys, in strict connection to the research program of KAPG Study Group 6.7. The development of a system combined of a microwave telemeter and of an ultrasonic water depth finder was primordial for the mentioned multilateral research work proposed by Poland (Institute of Telecommunication, Technical University, Warsaw). Hungary has been sharing this program since 1976.

Based on own and Polish research results, the following aim was set for the next few years:

- development of a digital water depth finder with ultrasonic echo sound. The known water depth finders [4], [5] have usually analogue (DC) output connected with a dial meter; accuracy and resolution of digital water depth finders are far better [6] and data registration is much easier. Besides digital readout, this instrument was to be combined with a cassette tape recorder for collecting and processing field data;
- combination of the digital water depth finder with the microwave telemeter *Tellurometer* CA-1000; registration of measured distances. This combination of two instruments permits to determine bed profiles;
- examination of methods and technologies available for an eventual hydrographic surveying.

The first step in our program was to develop a new water depth finder with digital readout. In 1977 this instrument was constructed according to the following specifications:

- digital readout and data output for computer data processing and automation of some kinds of hydrographic works;
- ± 2 cm accuracy (± 1 cm resolution), yielding some additional information about water condition (composition, pollution, etc.);

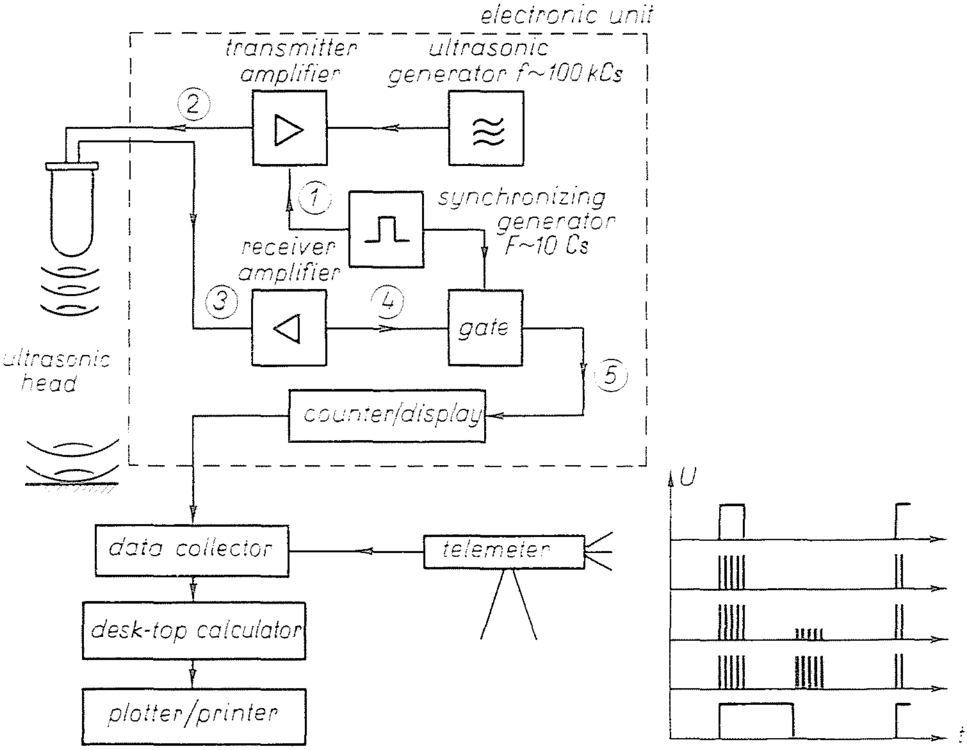

Fig. 1. Flow chart for a digital water depth finder with peripherals

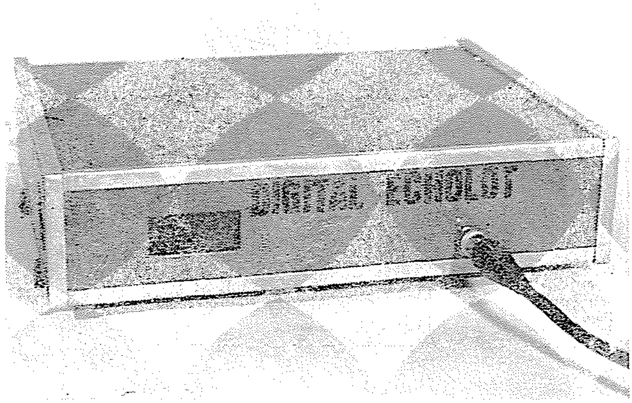

Fig. 2. Front panel of digital water depth finder (electronic unit)

- low power consumption (about 10 W): small-size battery as power source;
- range: from 0.5 m to 20 m (maximum readout 19.99 m);
- a data production and registration speed of 25 data/sec.

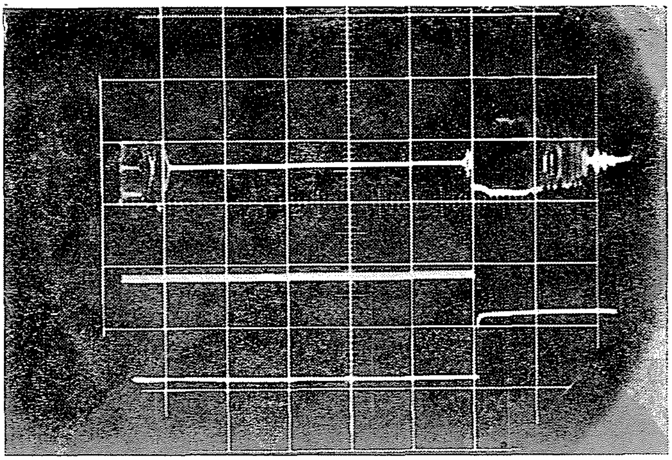

Fig. 3. Transmitted, received and gate signal on oscilloscope screen
Vertical scale: transmitted and received signal — 10 V/cm; gate signal — 2 V/cm
Horizontal scale: 0.5 ms/cm

The flow chart of operation of the instrument, completed with some peripherals is shown in Fig. 1. In the electronic unit (Fig. 2) an amplifier is controlled by pulses of synchronizing generator. The frequency of pulses corresponds to the maximum range of operation (about 20 m). During the pulses, a sinusoidal signal (frequency about 100 kCs) after amplification sets the ultrasonic head into action [1]. The transmitted ultrasonic signals reflected on the bed surface get to the receiver part of the ultrasonic head, which transforms ultrasonic signals into electric ones. Received and transformed signals get into gate circuitry. This circuitry generates a gate signal which begins at the moment of rise of synchronizing pulse and ends at the moment of rise of received pulse (Fig. 3). Hence, the length of the gate signal is proportional to the time interval between transmission and reception as a depth. The length (duration) of the signal is measured by means of frequency counting; the counter frequency may be chosen so that the result will give the water depth in meters. The counter frequency generator is slightly adjustable: it permits to take the actual propagation velocity (depending on water composition and density) into consideration [2].

The counter/readout unit displays the result which gets into the data collector (cassette tape recorder). If also a distance information is needed, a signal from a telemeter gets into another channel of the data collector. The collected information can be processed by a desk-top calculator; the final result (e.g. a bed profile or a list of co-ordinates) can be illustrated by a plotter or a printer.

The water depth finder was investigated under laboratory conditions. A 2.5 m high plastic tube with 0.4 m diameter was filled with water. The sounding head was fitted to a special floating buoy. A metal plate at the bottom of the tube represented the reflecting surface. The position of this metal plate could be changed along the tube and the momentary position could be determined by a scale. Laboratory investigations were successful, the next task will be to test the instrument in field conditions.

In the near future an automatic surveying system has to be developed, permitting complete determination of bed profile including data collection and evaluation. Determination of bed profile is one of the main operations in hydrographic surveying and corresponds to levelling in land surveying. Besides of measuring water depth, it is required to determine the momentary position of sounding vessel along the section. There are various methods (direct and indirect) to get information about the position of sounding boat, among them, the most up-to-date indirect method is based on the use of electronic (first of all, microwave) telemeters.

The arrangement of such a surveying system is as follows. One of the microwave telemeter stations *(Remote)* is positioned on the shore in the line of section. The other station *(Master)* is on board. If the distance between two stations is changing, the phase difference between transmitted and received signals in *Master* station is changing accordingly. A period of the changing phase difference from 0 to 2π corresponds to a distance difference equal to half a modulation wavelength. Marking these periods (e.g. by making pulses at the moments of positive zero-transit of transmitted and received signals and by making an output marker if these pulses coincide) results in the necessary distance information.

The use of microwave telemeters raises some problems:

— *Master* and *Remote* stations have to be in permanent connection during the measurement. Interruption of this connection leads to the loss of results. With a view on the rather sharp antenna diagram and to the sometimes storm-tossed sounding vessel, it is not so easy to keep connection between stations, therefore a special mounting is required for the *Master* station;
— microwave telemeters have a minimum range of 50 to 100 m. Measurement of shorter distances (which are, generally, necessary in hydrographic surveying) damages mixer diodes.

Both these disadvantages can be avoided by the reconstruction of the antenna system. A special wide-diagram antenna requires less skill from the *Master* station operator, and such a system (since it distributes radiation energy in a wide angle) permits to measure short distances (from 20 m) without any damage. This new antenna system is ready and laboratory investigations were successful.

Tellurometer CA 1000 microwave telemeter has many advantages for special purposes of hydrographic surveying:

- light weight (3.6 kg including rechargeable battery tray);
- small size (30 × 15 × 10 cm);
- low power consumption (4.5 W) and built-in battery;
- long range (10 km with standard antenna, 30 km with long-range antenna);
- good resolution (half a modulation wavelength: 3 m);
- permanent speech connection between two stations during measurement (it makes easier to keep the sounding vessel in the line of section).

It is worth to mention that it was decided to combine a water depth finder and the microwave telemeter type Tellurometer CA-1000 in 1976. Our decision was justified by the events: in December 1978 we were informed that "Tellurometer" Ltd. has started to install his CA 1000 model with so-called "dynamic tray" developed exactly for the task of hydrographic surveying [3].

The aim of our further investigations is to prepare some up-to-date methods and technologies for purposes of hydrographic surveying, from the point of view of automation.

— The simplest possibility is the modernization of a traditional hydrographic surveying technology: method of sounding tacheography. The instrument of this kind of surveying works can be an optical tacheometer type *Zeiss* BRT-006 after some modifications (change of parallactic angle, installation with plotter). In this case the main problem is the synchronization of two instruments: the tacheograph working on the shore, and echo sounder working on board. This problem could be solved if a tacheograph would be installed with electro-magnetic plotter connected with a two-way radio set (common "talkie-walkie"). At the moment of plotting, a radio signal is transmitted from the tacheograph to another two-way radio set, working on board and connected with the data collector.

Electro-optical telemeters can also be applied with good results. The possible technologies are: distance-distance intersection (using two electro-optical telemeters) or polar method (using one electro-optical telemeter combined with a theodolite). Regarding the moving target (sounding boat), continuous telemetry (tracking mode) is necessary in both cases. The main problem is the synchronization of telemeter(s) working on the shore and echo sounder on board. A possible solution of this problem was quoted above.

Generally, new possibilities are offered by using electronic tacheometers (e.g. *Hewlett—Packard* 3820 A, *Kern* ET-2, *Wild Tachymat* Tac-1). These instruments record distance as well as readings on circles of an electronic digital theodolite so that the momentary position of the sounding boat can be determined by the polar method. The synchronization of instruments can be achieved by the above-mentioned method or by using synchronized electronic clock signals recorded at both stations.

Summary

Up-to-date hydrographic surveying requires new instruments and methods. The paper deals with the possibilities of modernization of hydrographic surveying technologies. A flow chart for a new digital ultrasonic water depth finder with peripherals is presented. This instrument combined with Tellurometer CA-1000 microwave telemeter permits determination of bed profile at a high degree of automation; necessary modifications and some details are discussed. From the view-point of automation in the field of hydrographic surveying, some other possible technologies are recommended: use of one or two electro-optical telemeters and electronic tacheometers; problems of synchronization are also discussed.

References

1. GREGUSS, P.: Ultra-acoustics in Instruments.* Műszaki Könyvkiadó, Budapest, 1966.
2. TUCKER, J. W., RAMPTON, V. W.: Microwave ultrasonics in solid state physics. North Holland Publishing Company, Amsterdam, 1972.
3. Tellurometer Ltd.: CA 1000 Dynamic (short description).
4. Brookes & Gatehouse Ltd.: Hecta Depthmeter. Owners handbook.
5. Unitra (Zaklady Radiowe): Navigationsecholot Type SP 405/2. Technische Beschreibung.
6. Румянцев, Д. П., Колмогоров, И. П.: Автоматизированная регистрация глубин с использованием эхолота ПЭЛ-3 Геодезия и картография, № 8, 1978.

Dr. András KRAUTER, Associate Prof.
Ervin FARKAS, Eng.
H-1521 Budapest

* In Hungarian.