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COMPUTER-AIDED OPERATION OF THE SINGLE-BUCKET EXCAVATOR WITH THE REMOTE CONTROL AND LASER CONTROL SYSTEM OF POSITIONING

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Abstract

Essential difficulties in the operation processes of a single-bucket excavators is the fact that they are multi-functional machines. They can be fitted out with a range of various working features. Hence, elaborate automatic control system is being indispensable. It makes possible, the flexible co-operation with the operator in carrying out different technological tasks. The structure of this system ought to make possible an easy adaptation of the single-bucket excavator for carrying out specific tasks (without wasting a lot of machines' working time). This also applies to work in hazardous conditions for the operator, or completing the earth-moving operations with great precision. In this paper, a solution of such a system is discussed, backed by computer-aided controls in connection with remote control and laser control systems for fixing the position of the machine with improved precision.

1. INTRODUCTION

In classical control of working machines, the operator is an element through which the loop of feedbacks is closed (Fig.1). He addresses all of them, the indicators unit, the comparator (making a comparison between current state of working processes with tasks) and multidimensional regulator. We should bear in mind the human operators may figure out task descriptions even despite incomplete information based on logical induction or heuristic methods. Hence, optimum division of control tasks between the operator and automatic systems is required.

The efficient control system of machine's performance is created if the operator performs inspection and supervision functions and in the lesser degree the controlling functions. In this paper, the solutions concerning the automation of working machines [1,3] have been presented.

The following assumptions were made:

- automatic system should not disturb the structure of the excavator's energetic path, and the system's components can be assembled as stationary or temporarily mounted on a typical single bucket excavator,

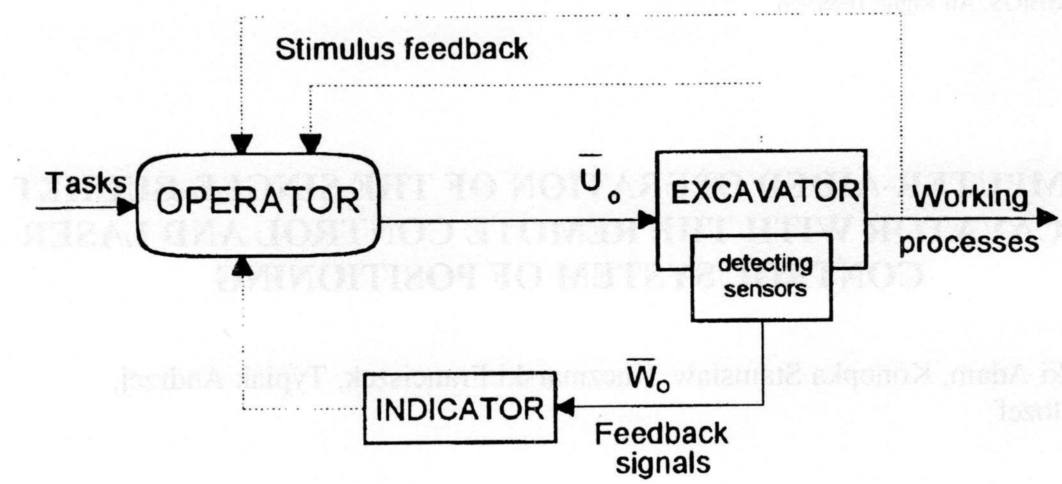

Fig. 1. General scheme of excavator control by operator

- superior control functions are carried out by the operator at the same time so the machine can work when the automatic control system is switched off,

- the control panel is simplified, except switches which set the work mode of the automatic system,

- control algorithms are designed in such a way that at any stage they can be stopped by the operator and the action suspension of the automatic system is possible,

- the development of detailed control procedures is possible, in particular co-operation with the remote control system and detectors of the laser beams which is the dead centre.

The task of the aid control system is the accomplishment of a part of control functions through generating control signals u_a based on the known operation algorithm and on the strength of measurements of machines' parameters W, W_0 and operators decisions u_{0p} (Fig.2).

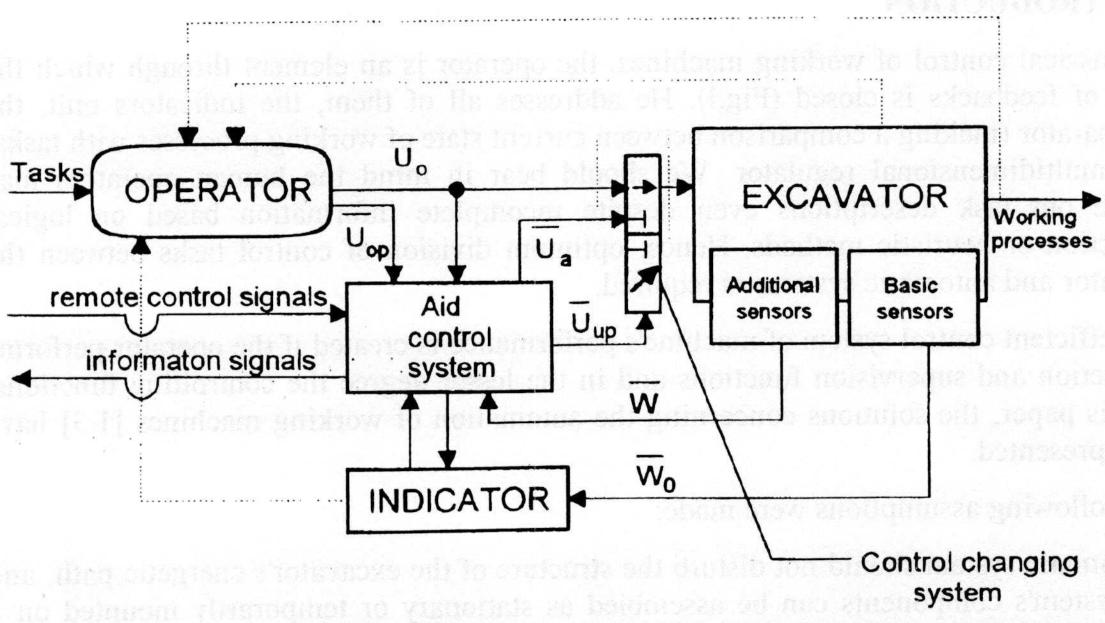

Fig.2 Scheme of aid control system

Decisions u_{0p}, which allow the aid control system to work, consist of:

- activating signals, generated by pressing the switches on the manual control levers (Fig.3),

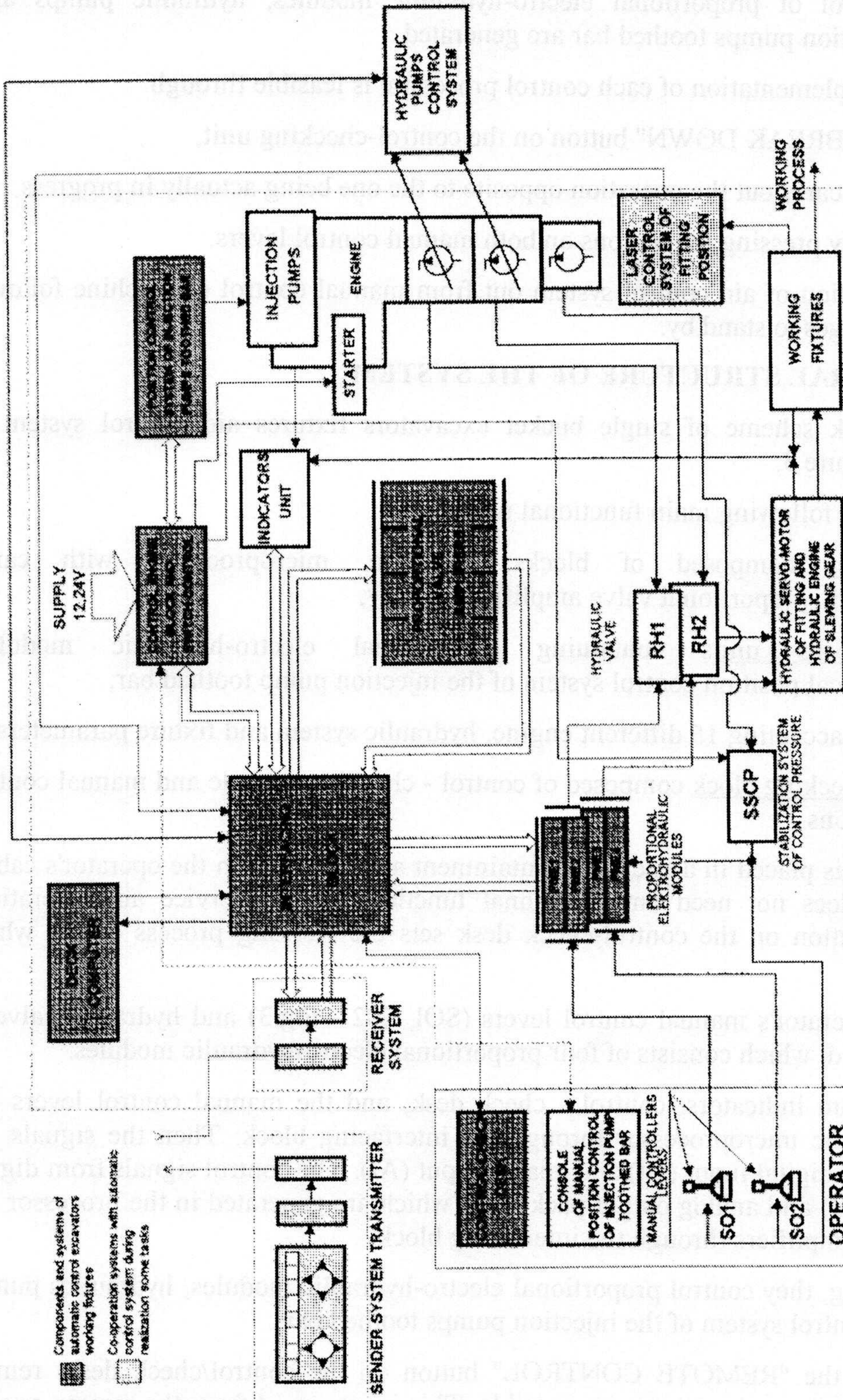

Fig.3 General scheme of automatic control system of excavator K-406

- switching over signals activated by pressing the switches on the control-check unit.

Based on these assumptions, the deck computer makes choosing a suitable control procedure possible. Next, on the strength of detailed control algorithms, the signals of automatic control of proportional electro-hydraulic modules, hydraulic pumps and position of injection pumps toothed bar are generated.

Stopping the implementation of each control procedure is feasible through:

a) pressing the "BREAK DOWN" button on the control-checking unit,

b) an attempt to carry out the operation opposite to the one being actually in progress,

c) simultaneously pressing the buttons on both manual control levers.

Then disconnection of aid control system out from manual control of machine follows, and then it changes to stand by.

2. THE GENERAL STRUCTURE OF THE SYSTEM

Expansion block scheme of single bucket excavators fixtures aid control system is presented in Figure 3.

It consists of the following main functional units:

-deck computer composed of blocks: interface, microprocessor with cards INPUT/OUTPUT, proportional valve amplifiers, supply;

-execution blocks units containing proportional electro-hydraulic modules, electro-mechanical position control system of the injection pump toothed bar;

-indicators unit accepting 15 different engine, hydraulic system and fixture parameters;

- control and checking block composed of control - checking console and manual control levers with buttons.

Deck computer is placed in a enclosed containment and mounted in the operator's cabin. The operator does not need any additional functions for its service and operation. Pressing the button on the control-check desk sets the working process of the whole system.

Between the operator's manual control levers (SOl, S02 - Fig.3) and hydraulic valve, a block is mounted, which consists of four proportional electro-hydraulic modules.

The signals from indicators, control - check desk, and the manual control levers are transmitted to the microprocessor through the interfacing block. Then the signals are sent to standard digital input (DI) and analog input (AI). The control signals from digital output pack (DO) and analog output pack (AO) which are generated in the processor are transmitted to amplifiers through the interfacing block.

After amplifying, they control proportional electro-hydraulic modules, hydraulics pumps and position control system of the injection pumps toothed bar.

After pressing the "REMOTE CONTROL" button on the control/check desk, remote control of the excavator's activities is possible. This is processed from the remote control desk set in a portable cassette (Fig.4).

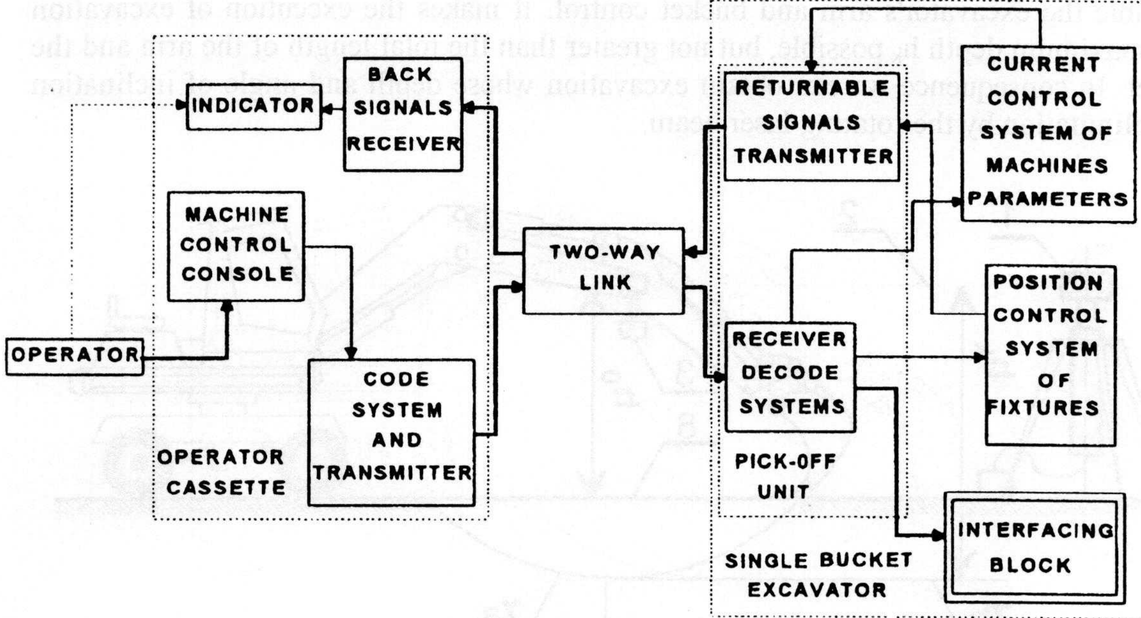

Fig. 4 Scheme of remote control system with two-way link

The control signals are changed in the coder system in binary code and transmitted on the transmitter modulator unit. In receiver, units' signals are decoded and transmitted to the interfacing block (Fig 3). As transmission link, a two way radio link, was applied combining the transceiver unit which works on frequencies 157,5 MHz with modulation type 16F3.

Such solution allows for transmission of signals with the speed 2000 bauds with reversible confirmation correctness transmission. Hence, the information signals and the most essential condition parameters are transmitted from machine to the operator.

In transceiver system in the self acting check of link transmission condition is processed even when no control commands are transferred.

In the case of any interference in transmission link, the operator is informed about breakdown (only when the remote control of the machines is still working), and the deck computer starts emergency control procedure for safe immobilizing of the machine.

For carrying out the definite depth of excavations or definite inclination, the laser system of control position of fixtures has been applied. It consists of the laser sender (1) which emits the rotating laser beam with wave length of 632 nm (2) and detection system (3) which has been mounted on outrigger (boom) - arm joint of excavators features (Fig.5a).

Laser transmitter's optical system forming laser beam and regulating adjustable components have also been provided. It allows to differentiate in terrain features using laser beam of datums plane which is parallel to the profile of the excavation bottom (4). Opto-electronic detection system installed on the excavator's body detects the laser beam, generates current signals which are transmitted to thew interfacing block as rectangular pulses (Fig.5b). The tasks of the deck computer is to generate the control signals and transmit them to the electronic current amplifiers, which control the proportional valve

(6) of the hydraulic system. The hydraulic system controls the excavator's outrigger and makes lowering of its haul below datums plate impossible. The operator has only available the excavator's arm and bucket control. It makes the execution of excavation with maximum depth h_k possible, but not greater than the total length of the arm and the bucket. In consequence we can obtain excavation whose depth and angle of inclination are delimitation by the rotating laser beam.

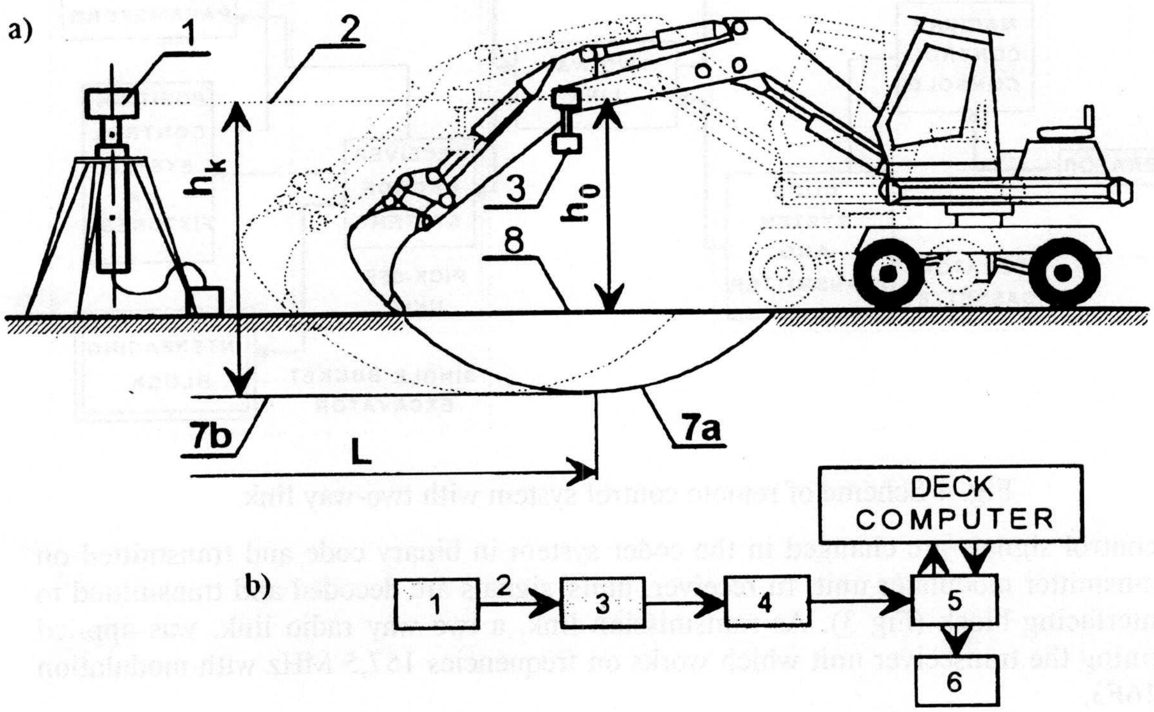

Fig.5. Laser control system of working fixtures position a) principle of operation, b) functional scheme, 1- laser transmitter, 2 - rotating laser beam, 3 - detectors of laser radiation, 4 - signals shaping block, 5 - interfacing block (look fig. 3). 6 - proportional elektrohydraulic module of outriggers control, 7a,b - real and assumed profile of excavation bottom, 8 - profile of ground surface

Exemplary profile of bottom executed excavation is presented on Fig.6a. On Fig.6b are presented deviations Δh_k between assumed and real depth of excavations.

4. CONCLUSIONS

The concept of computer-aided control, makes possible, the flexible control system of the machine's activities. It assures optimum division of control functions between the operator and the automatic system.

Due to module design, the solution presented here may be easily developed and converted. Proportional electro-hydraulic module, sensor for measuring angle of slewing gear, and the position control system of injection pumps' toothed bar can be easily used in machines used in building industry.

Remote control makes possible working in hazardous conditions and the coupling with the laser system allows for precise execution of earth - moving activities in drainage and road engineering industry.

The solution presented here is an experimental model, however, its separate components were designed for automation of mass-produced single bucket excavators.

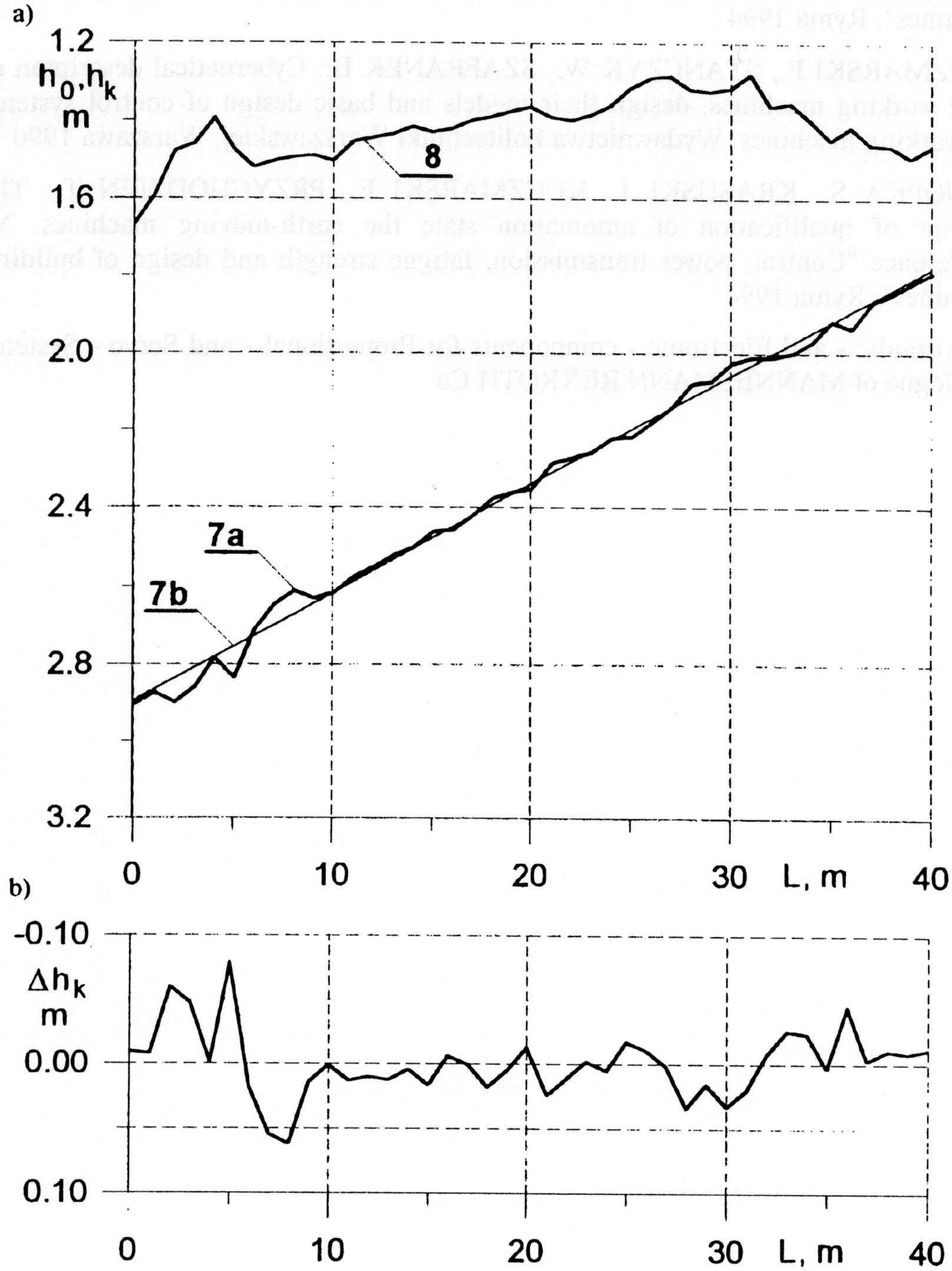

Fig. 6 Examplary profile: a) excavation bottom, b) deviations beetwen the assumed and real (Looks like on Fig.5)

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