REMOTE CONTROL OF WORKING MACHINES WITH VISION SYSTEM

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Summary

Herewith it was presented as follows: the general structure of system remote controlling operations, working machines while using vision system and examples of the system results.

1. Introduction

Remote control of working machines operation is necessary when any danger to man-operator might occur. It is particularly important in cases when there is no physical possibility for a man to be in a machine or in its neighbourhood. It applies to both extreme environment conditions (high temperature, pressure or environment contamination) and the possibility of direct health and life risk occurrence (ex. removal, elimination or neutralisation of dangerous materials and mines – particularly when fire operations of an enemy in field).

In each above case of machine usage there is necessity of its operation remote control excepted the possibility of making use of impulse feedback by direct operator, which means its operation in tele-operating system.

When such way of operating is involved a man-operator is still an element though which the loop of feedback is being closed. The operator then holds a group of indicators (although only registering the results of indictors, which inform about machine parameters and the course of operation processes). He compares and regulates in a multi dimensional way but its task is to generate control signals, which are then sent to machine via transmission link. Thus the quality of controlling the course of working processes in machine depends on both the profile of a man as the element perceiving, processing gathered information and developing control signals and the parameters of transmission link as well as interference in its operations.

The role of a man in the process of such control is to use his experience and perform the tasks, which in the discipline of automatic systems corresponds with programmed – temporarily best regulator. The entries of the regulator have impulse nature, which work in situations when the environmental interference is relatively low and slowly changing.

The speed of receiving the visual information ca. 10 bodes (when registering the changes frequency ca. 10 Hz) and the speed of receiving auditory information ca. 10 bodes as well as the fact that the output signal of an operator (controlling signal) is inertia type with little power and transmission band up to ca. 10 Hz. It causes that in case of the complexity of controlling the object or the speed of output changes (controlled) it may turn out that the operator is the element, which limits the possibility of efficient performance of man-machine system. It is crucial if in the process of receiving and processing information, then taking decisions and controlling as such remote transformation of the signals occur. If there is a need to increase, ex. accuracy of a particular output regulation $y_i(t)$, the frequency of its sampling should be increased. It will make the period of its sampling shorter Δt_i – which along with the delay in man's operation and the transmission track is reduced.

A man-operator while remote control operations is not able to control the bigger amount of machine output and as a result to supervise efficiently the control process, particularly when accessible spectrum of impulse feedback is limited. It is then necessary to automatic control of the most important machine output which determines thank to support (or substitute) operator's activity while generating control signal work quality and its productivity.

It should be reminded that in the process of data generating and processing a man can use logical induction and heuristic methods while controlling the machine with incomplete information (or temporarily with no information at all). These kind of operations is basically not possible as far as automatic machines are concerned. A man-operator is than an important element in the process of controlling the machine is such system. His role as the element generating the control should be though replaced as often as possible with the tasks relating to the supervision of control system operations, transmission link and interventions in unforeseen and critical situations for machine operations (vehicle). Thus as far as the remote control is involved (with vision system usage) the division of control and supervision operations between operator and automatic systems must take into consideration human abilities, his information-control capacities as well as his creativity. Efficient usage of a man-operator in co-operation with automatic control systems allows for development of a system, which effectively remotely controls the machines operations (vehicles). According to the system a man should perform the tasks which initiate working and supervising processes with smaller range of control operations involved.

2. General structure of remote control system with usage of vision system

On the basis of researches and analysis of the course of remote control processes of vehicles and working machines it was stated that there is a need for following tracks of information flow and control signals:

1. Supervision and driving gear control and particularly vehicle drive;
2. Control, location, tools and working equipment orientation;
3. Generation and visual data transmission for operator and control and supervision of picture system performance (observing)

As far as both driving gear control and drive itself are concerned it is necessary to introduce the block supporting the operator. Its task is to perform the detailed control procedures and control parameters – only remotely initiated by an operator - and to generate the information about the performance course.

It particularly refers to start and stop the driving engine and its parameters control, the change of transmission gear in gearbox (or settings of valves and hydraulic units) as well as the control of drive shaft rotary speed in driving engine (particularly in case of significant changes of its load).

The block of drive direction and describing machine location control – connected with information delivery for an operator – must consists of the following functional modules (fig. 1):

- counting navigation (through distance measurement and the direction of vehicle movement);
- describing the machine location (vehicle) – depending on tasks – based on the following:

a) GPS system – for machines or GLOBALSTR/GSM/GPS for vehicles carrying out its task while continuous drive usage [5];
b) laser systems of location measurement – mainly for earthwork machines carrying out its tasks in relatively limited space [5];
c) object observation through stationary remote controlled cameras, equipped with the indicators describing its orientation – which allows for direct determination of object location;
d) vision system (III and IV part of tracks) – to direct observation of machine surroundings (vehicle) – equipped with remote controlled cameras coupled with the system which measures their location (the angles of camera optical axles in vertical and horizontal plane).

The choice of structure variant and the method of determining machine location depends on technological tasks which are to be performed.

The structure of the track performing the control of working tools location should consist of the following:

- block of measurement of parts of working equipment location and machine parts so as the animation of equipment location (in „on-line" mode) on the monitor and the miscalculations in location determining are possible;
- the block supporting the location control which automatically performs control functions for typical (programmed) movement sequences and introduced by an operator in "teach-in" mode;
- picture deck system based on remote controlled cameras – at least one of them should automatically change its orientation (azimuth, grade) so as in the central part of its vision field there is always a tool (bucket, blade, grab, lifting sling with a cargo, etc.).

The existence of multipath transmission paths calls for research with the aim to study the influence of transmission quality on the control system efficiency in teleoperator system and autonomous operation of remote control system in case of the lack of interference in signal transmission.

3. The examples of remote control solutions with usage of picture link

In the Institute of Machine Construction of Military University of Technology (MUT) the research prototypes of systems remotely controlling the operations of a single bucket excavator's working processes and mine clearance vehicles are elaborated. In further part of the report the general profile and exemplary research results are presented.

3.1. Remote control of single bucket excavator

The system consists of the following main functional groups (fig. 2):

- deck computer coupled with remote control transmission link;
- working block consists of well-proportioned electrohydraulic modes and electromechanical system controlling the location of engine injection pump panel;
- the group of sensors measuring basic parameters;
- deck control and supervision block;
- vision system – consists of the group of cameras, picture and monitor divider.

In order to carry out testing ground research of efficiency control of a single bucket excavator while using such system three cameras were applied. Two of them were placed directly on the machine whereas one of them – outside, in place which could allow observing its equipment in a comfortable way (fig. 3). At this stage of research it may be explicitly stated that well trained operator has no difficulty while controlling the equipment location when given the choice of cameras' pictures showing the equipment in two perpendicular planes (fig.4). However, in case of controlling machine drive operator easily loses control when has no access to a

picture from outside camera or has not possibility to observe a machine directly.

3.2. Remote control of a vehicle making passages in mine fields

Armoured vehicles (or with additional covers) with coupled equipment to minesweep tasks, called breaching vehicles are used in battlefields when doing passages in mine fields [1,3].

Nowadays, at this stage of development there is a tendency to introduce the systems of remote control coupled with picture systems allowing for controlling its operations from distant control position (within 1,5 km) (often placed on another vehicle). The research prototype of such vehicle on the basis of medium tank was elaborated in the Institute of Machine Construction MUT.

As far as the structure of remote control system of the vehicle is concerned it is simplified version of diagram from fig.1. It consists of the three following basic transmission links (fig. 5):

I – remote control of a tank power transmission system and tank drive,
II – remote control tracking set,
III – vision signals.

Signals controlling drive and vehicle power transmission system are sent by an operator from control and supervision panel. Then they are sent via sent-receive system to receive-sent system, which is placed on a minesweeping vehicle. Therefore the signals after decoding are sent to the deck block and then they are directed to each working element of drive and power transmission system control (control levers placed in the mechanic-driver). Remote control terminal was installed in a vehicle. It enables to both send control signals to electric installation of a trajectory vehicle and to supply with power remote control deck block as well as to generate information-supervision signals for an operator.

The channel of remote control tracking set is the second independent transmission link. An operator with additional panel, which reflects the panels built-up in a vehicle – via transmission link, remotely controls trajectory equipment i.e. mechanical sweep, mine cleaning line charge launchers and track axis marker.

While using the elaborated system it is assumed that a vehicle will be seen from the control position (with usage of optic observation tools). That is why picture trajectory, which enables to observe fore field and inside compartment of vehicle drive, consists of the following:

- one-way, radio transmission of picture tracks to driving position;
- two-ways remote control tracks of one outside television camera.

Television cameras are applied to general neighbourhood observation (camera K1), operation of sweep excavation (camera K2) and inside compartment of mechanic-driver and operation of working elements (camera K3).

Firing ground research proves that remote control of such vehicle is possible while using applied picture system connected to direct observation with aid of observation periscope.

It is assumed that the whole system will be also applied to remote control of medium battle tank (in its breaching version) and other support vehicles constructed on its basis [1,2].

4. Conclusions

It needs to be stressed that the usage of remote control system should be first of all determined by the care of health and life of people who are the crew of a working machine or a vehicle.

Nowadays in prevailing solutions of remote control there is a tendency to develop systems where transmission process may take place via at least two alternative communication tracks and direct impulses are replaced with vision information.

Analysis also proves that the development of remote control systems' applications should be associated with implementation of machine and vehicle automatic operation procedures in case of emergency (ex. failure of transmission link).

Presented above examples of solutions indicate that proposed structure of remote control system (connected with picture system) is fully sufficient to perform many technological tasks in conditions where a man–operator cannot work inside of a machine or nearby.

5. Literatura

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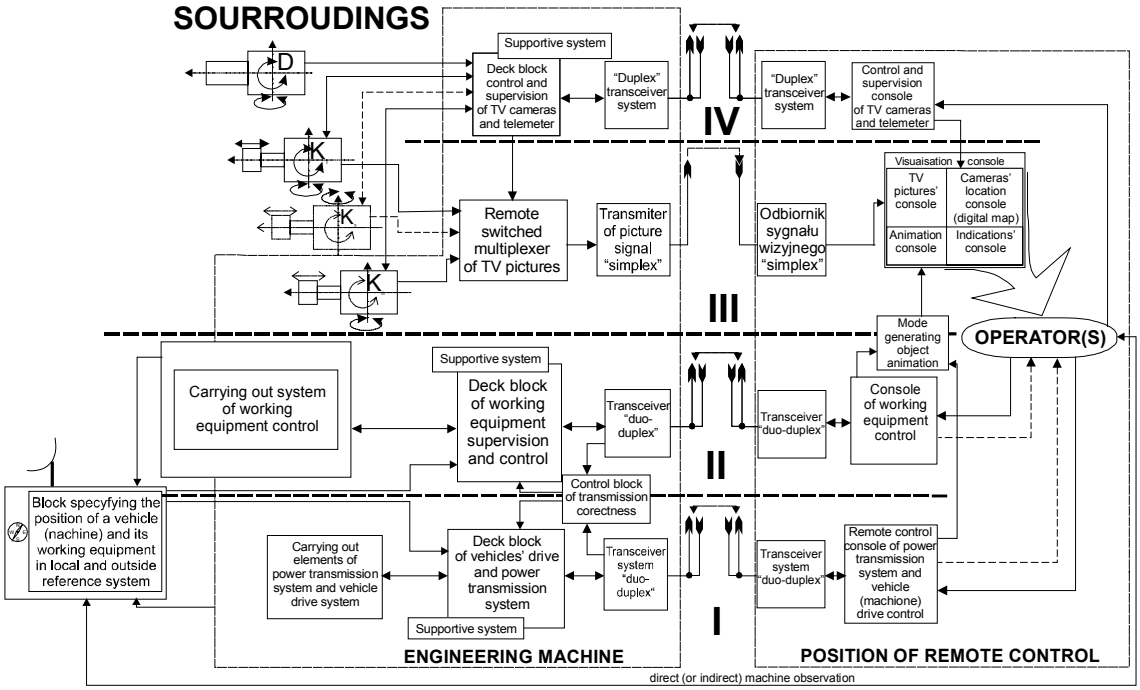


Fig. 1. General structure of vehicle remote control or mobile working machines' schemes with vision system

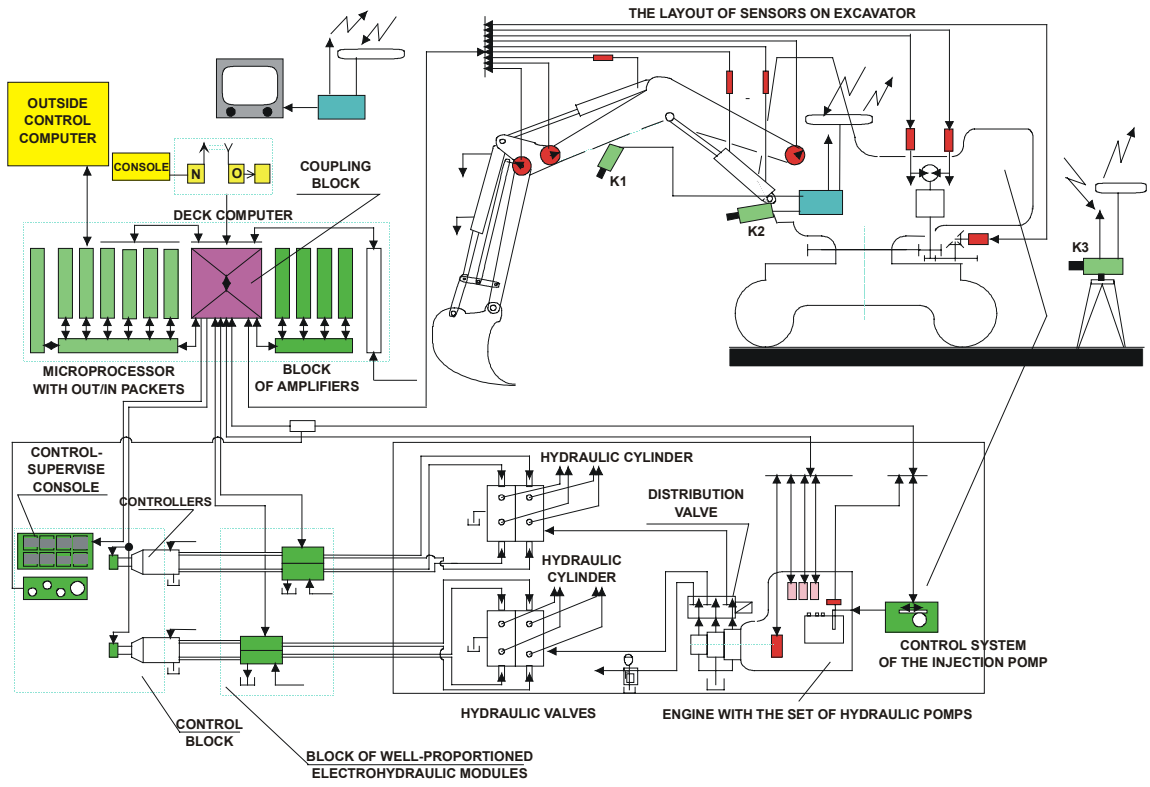


Fig. 2. Control system of a single bucket excavator schema with a vision system

a) b) c)

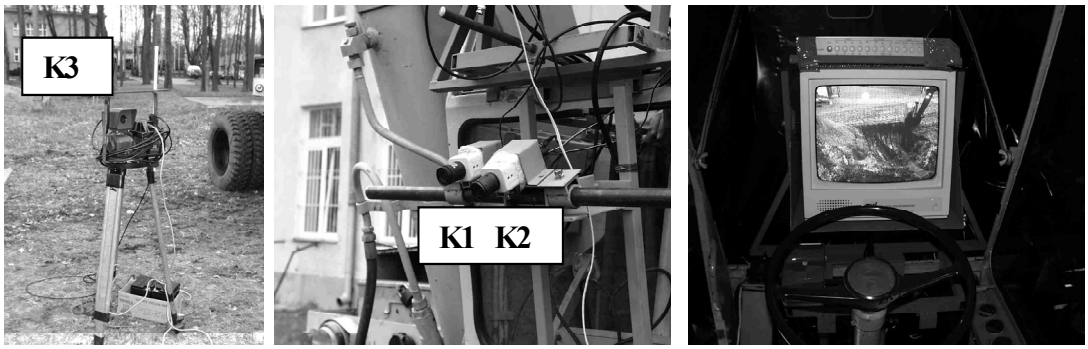


Fig. 3. A sight of picture set: a) camera (K3) placed beyond machine, b) cameras (K1 and K2) placed on a machine, c) monitor with a working equipment picture

a) b)

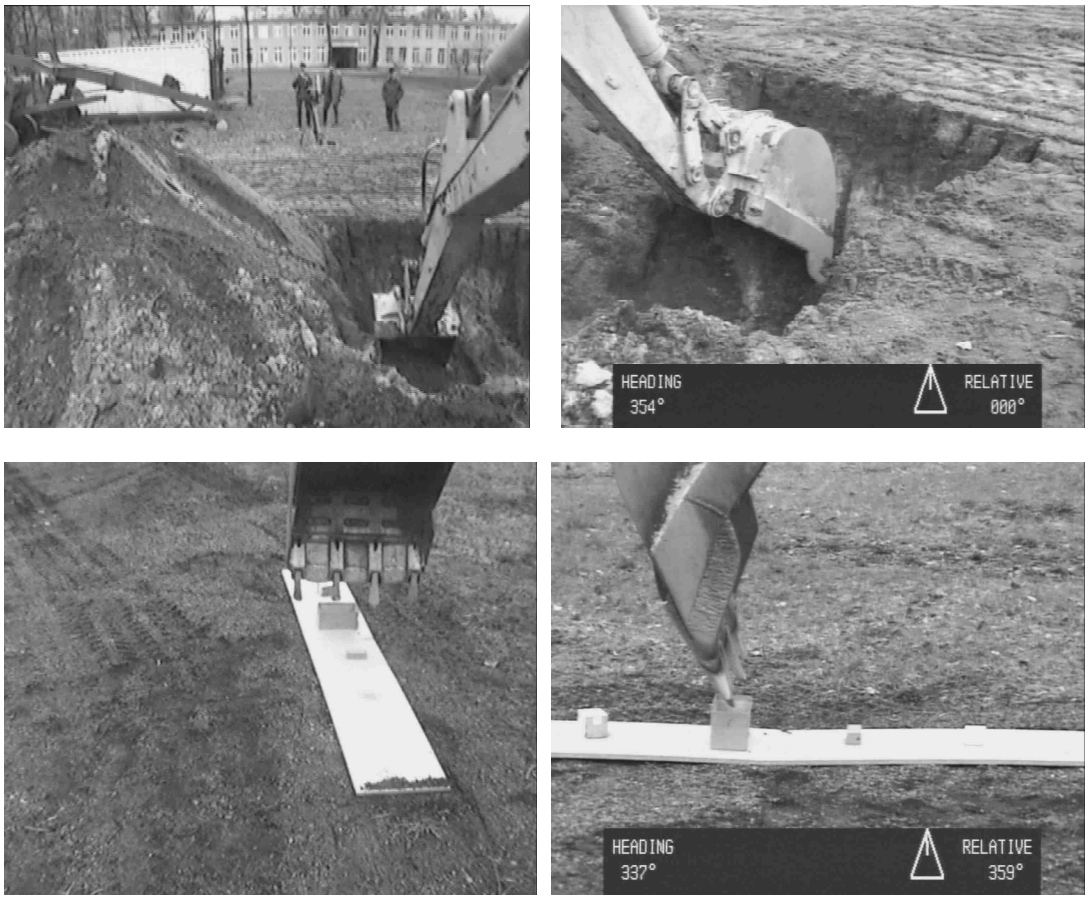
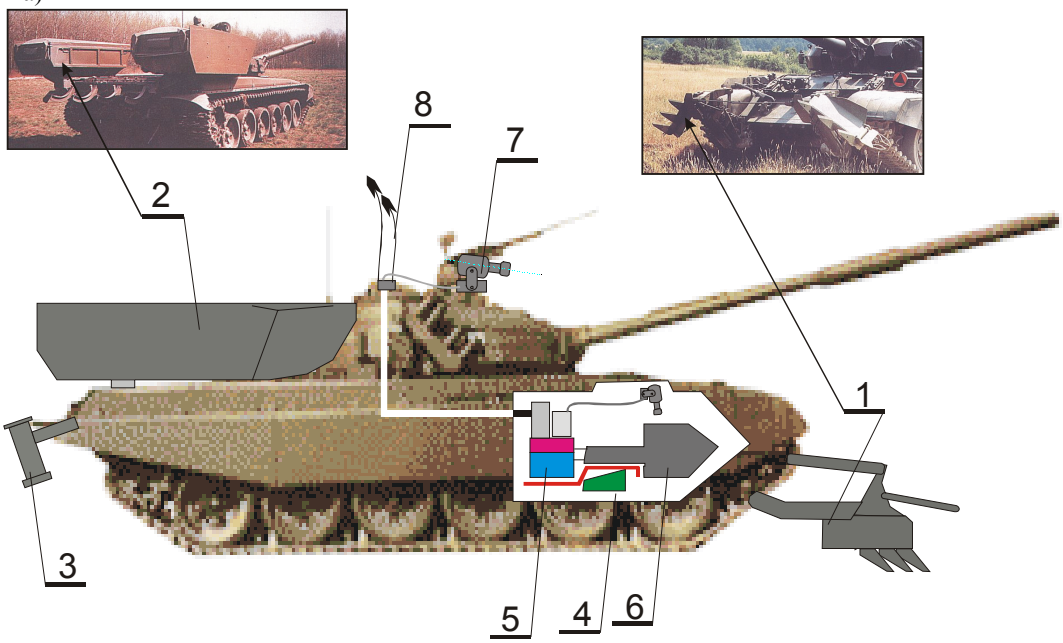


Fig. 4. A sight of working equipment from camera placed: a) in front of a cabin, b) beyond a machine

a)



b)

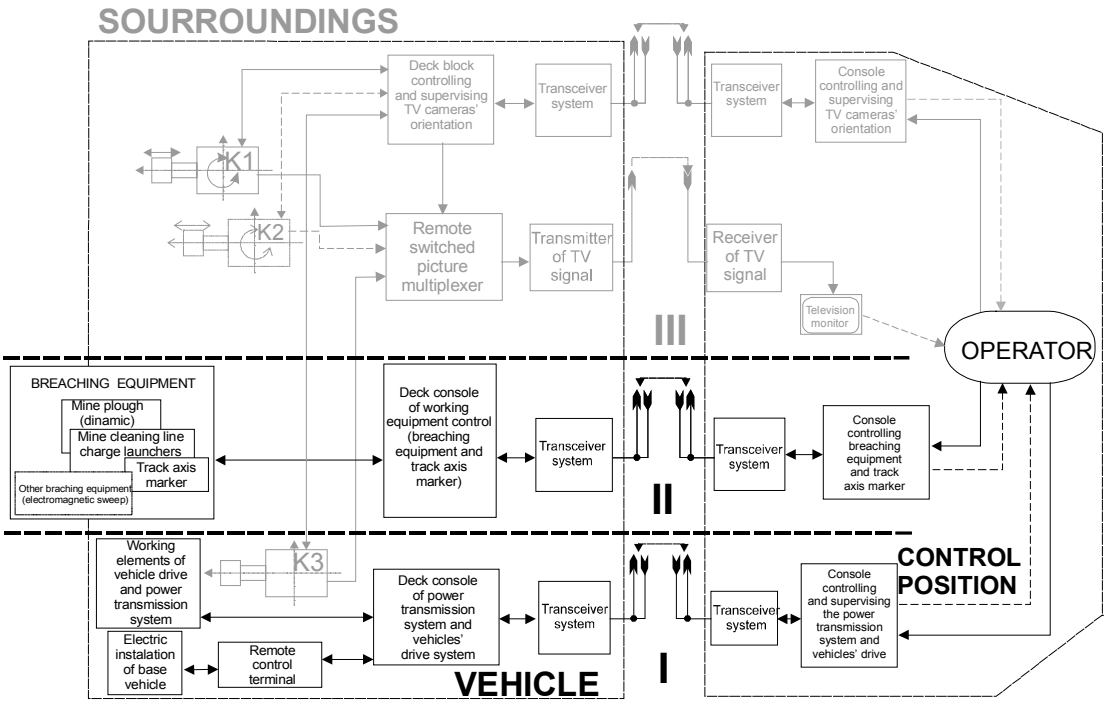


Fig.5. Remote controlled tank T-72 with breaching equipment: a) general elements layout, b) the scheme of remote control system

1 – mine plough, 2 - mine cleaning line charge launchers, 3 – track axis marker, 4 - deck fastening set of a part of remote control system, 5- electric and electronic modes, 6 – working elements, 7 – observation camera, 8 – a set of transceiving antennas