1. Introduction
Modern equipment for the extraction and processing of minerals, as well as transport and construction equipment, is saturated with electronic devices and mechatronic instruments. Their repair and maintenance in extreme climatic conditions of the Arctic is complicated by the deterioration of human micromotor capabilities due to warm clothing or hypothermia, so the creation of technical means to facilitate these works is an urgent task.

Typically, electronic and instrumentation units are replaced as necessary with serviceable ones. However, there are situations when the replacing process is inconvenient or irrational. For example, temporarily removing for a complex system as a whole and adding a new one requires additional settings of the latter, which causes additional losses from the downtime of expensive equipment. Sometimes it’s enough to replace only individual small electronic components or parts. From the point of view of material and time costs, such a small and short-term repair is preferable in comparison with the delivery and replacement of larger blocks. This is especially true for the repair of expensive equipment in hard-to-reach places, since after identifying the causes of failures, an unacceptably long wait is required for serviceable units to arrive [1].

Replacing small electronic components, for example, microcircuits or instrument parts, requires positioning of instruments with an error (sensitivity) of the order of 0.1 - 0.4 mm. In conditions of low temperatures, wind and high humidity, the specialist performing these works is forced to be in warm clothes, including thick and coarse gloves. Such clothing intervenes and makes it difficult to tactile control of the instrument, in addition, cooling enhances the natural tremor of a person [2]. The delicate operation of mounting small electronic components and parts of devices is difficult or even impossible.

Conventional industrial robots [3] and micromanipulators [4] here also cannot be used due to the large weight, dimensions, unjustified laborious transportation and installation at the place of work.
displacement of the instrument is carried out by deformation of this structure under the action of the redistribution of tension between various groups of muscles of the hand. The tool is moved mainly by swinging relative to a certain point and by shifting along the longitudinal axis.

Similar to human hand, the base of the proposed micromanipulator is fixed on the table or other static objects by the adaptive support mechanism (Figure 1).

![Micromanipulator for extreme climatic conditions. General arrangement](image)

The tool holding gripper is connected to this support mechanism by a three-stage coordinate movement device.

By the handle on the housing, the micromanipulator is transferred to the place of work. Under the control of the operator, the coordinate displacement device moves the gripper with the tool relative to the adaptive support and accordingly to the workpiece. In this way, precise machining or mounting operations are performed by screwing or soldering.

Program control of such a micromanipulator [5] is unacceptable due to the uncertainty of the target position and the origin of movement coordinates of the working body. It requires manual control, preferably in the copy version [6]. However, such anthropomorphic manipulation systems are not sensitive enough. The greater sensitivity, maneuverability and compactness are distinguished by manipulators based on parallelogram mechanisms [7], [8]. More simple and cheap is manual speed control to tool movement with the buttons under three different fingers on the handle of the micromanipulator.

In the process of performing technological operations, the micromanipulator operates in several different modes. Before starting the operation, you need a tool, for example, a screwdriver or a soldering iron, to fix in the gripper.

First the device is moved to the place, where execution of micromovements work is needed. After the tool approaches the place of interaction with the processed object, the adaptive support rests on nearby static objects and fixed.

Then the mechanism of micromovements is turned on. The main part of the operation is performed, for example, a screw is fixed or conductors are welded. After that, the adaptive support is released and transferred to its original position. The micromanipulator is ready for the next operation.
In general, the operator controls the micromanipulator through voice commands. This is how working modes can be regulated, for example, the speed of a screwdriver or drill or the heating of a soldering iron. At the required moment, the fixing and releasing of certain mechanisms is ensured. The micromovements can also be controlled by voice. But it is more convenient to set the speeds and positions of the micromovements mechanism with keys under the operator fingers directly on the device housing or from an additional control panel.

Many technological processes require control of efforts and moments. Due to the use of self-braking gears, it is inevitable to use torque sensors on the output links of the kinematic circuits [9].

A specific problem is the transfer of load information to a human operator. In many areas of robotics and prosthetics, vibrating zones adjacent to the human body are used for these purposes [10].

Due to warm clothing, this method is at least inconvenient. Sound alarm remains. But it does not show the direction of the acting forces. To compensate for the latter drawback, it seems appropriate to supplement visual alarm with visual indicators or screens with a spatial diagram of the measured loads.

When servicing and repairing electronic circuit boards and flat instrument blocks, most operations are performed on a horizontal surface with a vertical tool. In this case, the micromanipulator takes the form of a certain apparatus covered by a human hand (Figure 2).

![Figure 2. Portable manipulator for a vertical tool](image)

Operator turns some active padding between the palm and the tool. Tool (Figure 2) (for example, a screwdriver or a soldering iron) is inserted in a unifying adapter into the micromanipulator housing with
adaptive supports and is moved by electric drives under the control of five keys. More sophisticated controls can be inserted.

On the top cover of the apparatus are placed a line of LEDs, showing the direction and intensity of tool interaction with the workpiece. Additionally, there is a sound alarm (speaker or headphones) providing information about forces intensity.

As necessary, an illuminated optical magnifying system is installed on the top cover with an appropriate adjustable stand. It can additionally raise the achievable positioning accuracy (sensitivity) to a few hundredths of a millimeter.

Such micromanipulators are quite light and compact. When leaving for a repaired object, a specialist can take with him a set of such devices for various tools. This speeds up and facilitates the repair, since during the transition between operations, there is no need to change and fix various tools in the manipulator.

3. Conclusion

The proposed concept of portable micromanipulators makes it possible to compensate for the partial loss of human micromotor capabilities in conditions of low temperatures characteristic of the Arctic region. Similar devices are also promising in other cases of loss or difficulty in micromotor functions, for example, after amputation of the upper limbs or various lesions of the nervous system, up to strokes.

Portable micromanipulators can find application in the repair of industrial equipment and household appliances. It is of interest to use them for machining (grinding, milling and drilling) of small-sized objects in experimental production or the jewelry industry. Such tools are indispensable when performing accurate work on setting up and repairing apparatuses for various purposes under shaking conditions, for example, on land, air or sea transport.

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