ISSN 1068-798X, Russian Engineering Research, 2017, Vol. 37, No. 8, pp. 720–722. © Allerton Press, Inc., 2017.
Original Russian Text © I.Yu. Tyurin, A.N. Dombrachev, A.I. Korshunov, A.P. Kuznetsov, B.A. Yakimovich, R.A. Galiakhmetov, 2017, published in STIN, 2017, No. 3, pp. 8–11.

Automated Chronometric System

I. Yu. Tyurin[a, *], A. N. Dombrachev[b], A. I. Korshunov[b], A. P. Kuznetsov[b], B. A. Yakimovich[b], and R. A. Galiakhmetov[b]

[a]*AO Izhevsk Motozavod Aksion Holding, Izhevsk, Russia*
[b]*Kalashnikov Izhevsk State Technical University, Izhevsk, Russia*
**e-mail: mazak@inbox.ru*

Abstract—An automated chronometric system is developed for assessing the difficulty of machining operations in manufacturing. The system facilitates and improves labor organization and standardization in the machine-tool shop.

Keywords: chronometry, automated chronometric system, microcontrollers, seven-segment display, LCD display, TFT display

DOI: 10.3103/S1068798X17080202

Manufacturers of tools and equipment—in particular, complex molds and specialized devices—must continuously improve their performance, quality, and cost [1]. To that end, the standards for machining times must be constantly updated in relation to standards elsewhere in the world.

This often involves chronometry—that is, measurement of the times required for specific manufacturing processes. In addition to direct measurement, chronometry involves description of the production system and technology, as well as the working conditions, and quantitative determination of the influence of various factors on the production time [2–6].

Existing devices for automated measurement of operational times belong to the following international patent classes [7].

(1) G07C5/10: devices for recording or indicating the operation of machines by means of counters or digital clocks.

(2) G07C3/00: devices for monitoring and recording of machines, equipment, and testing instruments in manufacturing processes, with indicators signaling undesirable or nonstandard operation.

(3) G04F: devices for measuring predetermined time intervals, devices for formulating specific time intervals (such as metronomes), and devices for measuring unknown time intervals (such as precision measuring systems for short intervals).

(4) G07C3/04: devices for recording the operation of machines by means of counters or digital clocks.

A patent search shows a lack of adequate Russian chronometric instruments or automated methods of solving associated problems (such as calculation of the mean effort required in specific operations).

In the present work, we propose a device for the study of individual elements of a machining process by recording the time for specific manufacturing operations.

The device is intended to automate data collection regarding the duration of operations within a manufacturing process, with simultaneous drafting of operational sketches. The proposed device includes a microcontroller, control elements, graphic components, and a GSM module for the transfer of measurement data to a personal computer, for further analysis.

The device permits automation of the workstation for labor organization and standardization in the machine-tool shop [8]. In Fig. 1, we show the proposed device [8].

The device (Fig. 1a) is based on a housing *1* attached to a unit *2* indicating the time to complete a particular manufacturing operation. It also includes a photodiode *13*, text-display module *3*, graphical-display module *4*, command-input module *5* based on a 16-button keyboard (of sensor or button type), two measurement-control keys *6* and *7*, and two photodiodes *8* and *9* tracking the course of the experiment. Breakers *10* and *11* are attached to the housing and may be used for automatic initiation and shutdown of the device (for example, by supplying signals from the machine tool's control system).

All the modules are electrically connected to control module *12* within housing *1*. Their structure and attachment to the microcontroller are evident in Fig. 1b.

Seven-segment indicator *2* consists of four seven-segment indicators and the photodiode *13*, which visually separates the indicators into two groups of two. The dimensions of the seven-segment indicators are as follows: height H = 70 mm and length L = 48 mm. This ensures that the results are readily distinguishable. Text-display module *3*, based on a matrix LCD display, shows the data regarding the operation implemented.

Data-input module *5*, which takes the form of a 16-button keyboard, permits parameter modification. The two measurement-control keys *6* and *7* (the start

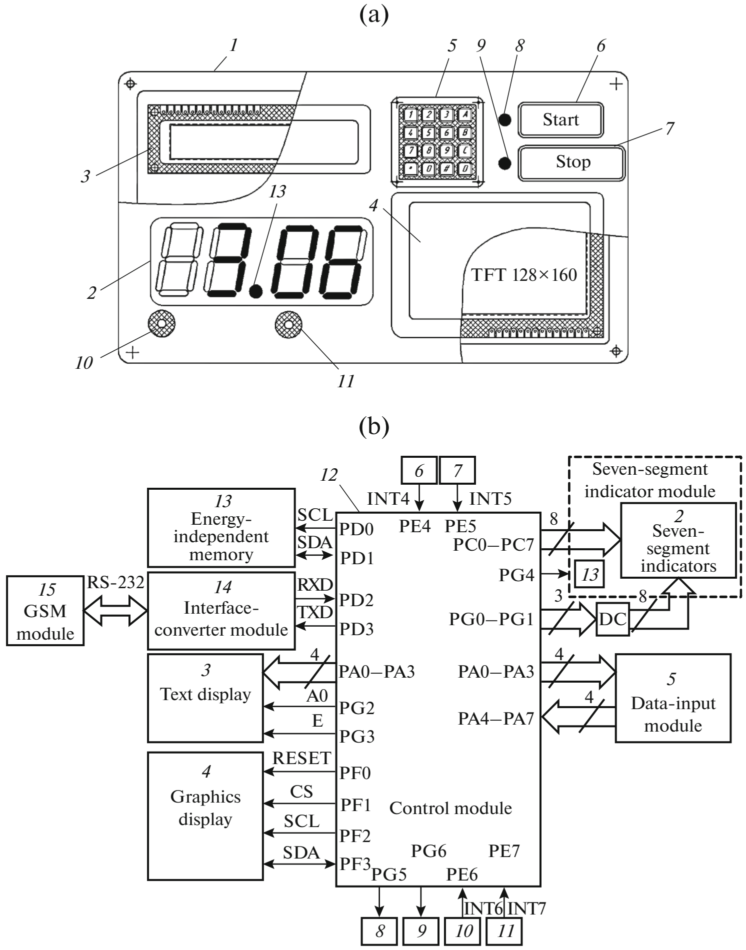

Fig. 1. Appearance (a) and structure (b) of the proposed device.

and stop keys) and the two photodiodes *8* and *9* tracking the course of the experiment switch the time count on and off and indicate the current state of the device.

Control module *12* is based on the Atmel ATMega128L eight-digit microcontroller, which is inexpensive and permits the control of various peripherals. The microcircuit includes sufficient programmable devices to permit functioning of the device: memory; timers (counters); universal eight-digit bidirectional input–output ports; and a universal synchronous–asynchronous transceiver [8].

Together with the energy-independent memory units and the interface converters, whose outputs are connected to the GSM module, components *2*–*9* are electrically connected to the input–output ports of the eight-digit microcontroller as follows.

Time indicator *2* is connected to ports *C* and *G* of the microcontroller. The eight-digit symbol codes are passed to the seven-segment indicators through lines PC0–PC7, while the specific indicator is selected by means of the eight-digit decoder DC, to whose inputs microcontroller lines PG0 and PG1 are connected. That ensures control of the four smaller characters of the decoder output. The photodiode is controlled by means of line PG4.

Text-display module *3* is connected to the four lines of port A (PA0–PA3), which are used for data transfer. This module is controlled by means of lines A0 (selection of the symbol address) and E (synchronizing strobe signal), connected to microcontroller lines PG2 and PG3, respectively.

Graphical-display module *4* is connected to the microcontroller through a three-line serial interface, by means of the lines of port F (PF0–PF3). The controller of the TFT display is selected by means of line PF1(CS); data transfer is selected by means of line PF3(SDA); and synchronization is selected by means of line PF2(SCL).

Data-input module *5*, which takes the form of a 16-button keyboard, is connected to microcontroller port A. To ensure a carry-1 algorithm, the smaller lines of the port PA0–PA3 operate as outputs (iterative sampling of columns), while the smaller lines of the port PA4–PA7 operate as inputs (scanning of rows).

The start and stop keys *6* and *7* are connected to lines PE4(INT4) and PE5(INT5). These lines of port E of the ATMega128L microcontroller have an additional function: the signal from their inputs is sent to the input of the cutout controller (not shown in Fig. 1). That permits their use as counters of the external events ensuring the reaction of the device to a key push.

Photodiodes *8* and *9*, which are used together with keys *6* and *7*, are connected to lines PG5 and PG6 of port G. They are used to track the state of the device.

Breakers *10* and *11* (like keys *6* and *7*) are connected to the inputs of external interrupters INT6 and INT7 of port E (lines PE6 and PE7, respectively) and, as noted above, may be used for automatic stop and start of the system.

Energy-independent memory *13* is based on an AT24 microcircuit and connected to the control module by means of lines PD0(SCL) and PD1(SDA), which are, respectively, the line of serial cycle-pulse transmission and the line of serial data transfer.

Interface-converter module *14* is based on a MAX232 microcircuit, which converts the signals from the RS-232 serial port to signals suitable for use in digital systems based on TTL or CMOS technology. Module *14* is connected to the control module by means of lines PD2(RXD) and PD3(TXD), which are, respectively, the input and output of the universal synchronous–asynchronous transceiver of the eight-digit microcontroller [9]. The output of module *14* is connected to the input of the GSM module through an RS-232 interface.

The chronometric device operates as follows. After it is turned on, the observer (or a worker) selects the operation code by means of 16-button keyboard *5* (Fig. 1a), in accordance with the machining process. Control module *12* loads data regarding the selected operation (including its name, the standard time for its completion, and other parameters) from energy-independent memory *13* and sends them to indicator modules *3* and *4* (Fig. 1b).

Before the operation begins, the observer switches the device to timer mode by means of the start key *6* (Fig. 1a). Then the control module switches on photodiode *8* and begins the count of the operation's duration (with simultaneous display on indicator *2*). As each second is counted, photodiode *13* is turned on and off. After the end of the operation, the observer pushes the stop key *7*. The control module then switches off photodiode *8*, switches on photodiode *9*, stops the count, and stores the result in the energy-independent memory.

Data regarding the difficulty of the operations on the machine tool may be transferred—by means of the universal synchronous–asynchronous transceiver of the microcontroller, module *14*, and the GSM module *15*—to the server that stores the measurement data, through a wireless interface (for example, by the transmission of SMS messages).

Thus, we have proposed a convenient and up-to-date multifunctional measuring instrument for specialists in labor organization and standardization in the machine-tool shop. It automates the collection and preliminary analysis of statistical data regarding the time to complete each component of the manufacturing process [10].

By further analysis of the measurement data stored in the proposed device, we may derive the principles that underlie time standards for particular machining operations, by an empirical–statistical method. In addition, the device may be used to assess standards obtained analytically and those found in the literature.

ACKNOWLEDGMENTS

The publication was prepared with the support of the Ministry of Education and Science of the Russian Federation in the framework of the project "Development and creation of high-tech production of a unified machine for technological electric transport", carried out jointly by the State Educational Technical University "Izhevsk State Technical University named after MT Kalashnikov" and JSC "Sarapul Electric Generator Plant" (Contract No. 02. G25.31.0132 of 01.12.2015).

REFERENCES

1. Božek, P. and Pokorný, P., Analysis and evaluation of differences dimensional products of production system, *Appl. Mech. Mater.*, 2014, vol. 611, no. 10, pp. 339–345.
2. Akhumov, A.V., Genkin, B.M., and Ivanov, N.Yu., *Spravochnik normirovshchika* (Handbook of Rate-Setting Engineer), Akhumov, A.V., Ed., Leningrad: Mashinostroenie, 1986.
3. Tikhomirova, T.P. and Chuchkalova, E.I., *Organizatsiya, normirovanie i oplata truda na predpriyatii. Uchebnoe posobie* (Organization, Standardization, and Salary at an Enterprise: Manual), Yekaterinburg: Ross. Gos. Prof.-Pedagog. Univ., 2008.
4. Dombrachev, A.N., Development of an automated system for determination of the complexity and the forecast of labor costs for manufacturing of parts of toolmaking production, *Cand. Sci. (Tech.) Dissertation*, Izhevsk: Izhevsk State Tech. Univ., 2005.
5. Dombrachev, A.N., Korshunov, A.I., and Yakimovich, B.A., Automated system for standardization of tool accessories based on complexity theory, *Trudy IV mezhdunarodnoi nauchno-tekhnicheskoi konferentsii "Informatsionnye tekhnologii v innovatsionnykh proektakh"* (Proc. IV Int. Sci.-Tech. Conf. "Use of Information Technologies in Innovative Projects"), Izhevsk: Izhevsk. Gos. Tekh. Univ., 2003, part 3, pp. 28–29.
6. Dombrachev, A.N., Yakimovich, B.A., and Korshunov, A.I., Automated system for standardization of products of instrumental production, *Trudy III mezhdunarodnoi nauchno-tekhnicheskoi konferentsii "Informatsionnye tekhnologii v innovatsionnykh proektakh"* (Proc. III Int. Sci.-Tech. Conf. "Use of Information Technologies in Innovative Projects"), Izhevsk: Izhevsk. Gos. Tekh. Univ., 2001, pp. 137–138.
7. Official webpage of the Federal Institute of Industrial Property, 2009. http://www1.fips.ru. Accessed July 24, 2015.
8. Tyurin, I.Yu., Yakimovich, B.A., Korshunov, A.I., Kuznetsov, A.P., and Dombrachev, A.N., RF Patent 164625, 2016.
9. Evstifeev, A.V., *Mikrokontrollery Tiny i Mega semeistva Atmel* (Microcontrollers Tiny and Mega of Atmel Family), Moscow: Dodeka-XXI, 2008.
10. Míkva, M., Prajová, V., Yakimovich, B., Korshunov, A., and Tyurin, I., Standardization—one of the tools of continuous improvement, *Proc. Eng.*, 2016, vol. 149, pp. 329–332. doi 10.1016/j.proeng.2016.06.674

Translated by Bernard Gilbert