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SCANNING TELEVISION OPTICAL MICROSCOPE FOR BIOLOGICAL MICROOBJECTS RESEARCH

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Abstract: Ways of developing a scanning television microscope, which can be used for the investigation of biological microobjects, have been analyzed. The capabilities of the microscope are extended due to a raster formation in the television mode and little-frame mode. Ways of changing the raster size while maintaining the microobject image resolution have been proposed.

Key words: Scanning microscope, electron beam tube, microobject.

1. Introduction

The scanning television optical microscope (STOM), developed by the authors, allows to investigate microobjects with the dimensions more than 0,1 – 0,2 mcm. In this microscope an electron beam tube (EBT) with the high resolution is used as a light source. Very short time of its afterglow allows using a running beam mode. Comparing with a video television microscope, this microscope has such advantage as the microobject (MO) image formation using 5000 picture dots on each axis. By comparison with the electronic microscope, the STOM provides an opportunity to investigate living MO in real-time mode. The advantage of the STOM in comparison with a Laser microscope is that it illuminates far less latter, and so does not influence living MOs. The change in the sizes of the scanning raster provides the change in the scale of the MO image formation without any losses of the image resolution.

In the article the ways of developing the microscope with wide functionalities have been considered. The full structural scheme of such microscope and the structural schemes of its separate units have been described.

2. Scanning microscope

The structural scheme of the STOM has been introduced in Fig. 1 [1]. It consists of the block of scanning raster forming (BFSR), the scanning EBT control block (BMOM), the block of the EBT with high resolution and the ultra-violet luminescence screen (BEBT), the block of an optical channel (BOC), the photoelectronic multiplier block (BPEM), the block of video signal processing (BPVS), the block of video signal forming (BFVS), the block of connecting to a personal computer (BIPC).

It also includes the personal computer PC and a monitor M, where the image of a microobject is formed. The structure of particular units of the STOM is determined by its possible application: a) research laboratories at small medical institutions (the cheapest and simplest STOM); b) research laboratories at larger medical institutions (rather cheap but with wider range of capabilities); c) branch research laboratories which need the STOM with the widest functionalities.

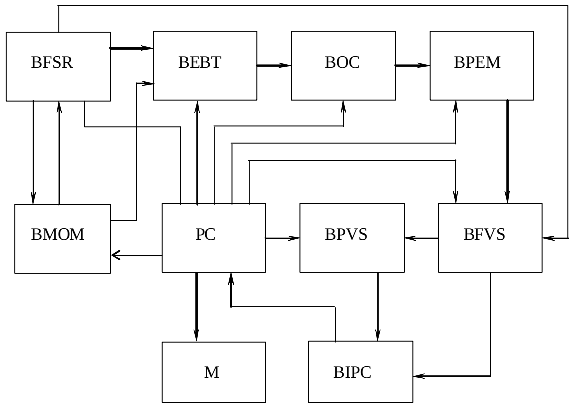

Fig. 1. The structural scheme of the STOM for the investigation of biological microobjects

In the first case the scanning microscope with the minimal functionalities working in the standard television mode is the most suitable one. If PC is used as input device for the images of investigated MO, cheap standard image input systems, and cheap standard software for image processing and storage are utilized. It is possible to use a cheap EBT in such a microscope, because in this case it is not necessary to provide the possibility of wide range change in the sizes of the scanning raster for scaling of MO images. The change of the sizes of the scanning raster and its shift can be realized by simple resistor circuits.

In the second case the use of an electron-beam tube of high resolution is necessary for obtaining the high-quality image. To form a sweep for the image decomposition consisting of approximately 1000x1000 picture dots, it is possible to use analog circuits (with the very small value of a sweep nonlinearity factor), as well as digital ones. The input image should be preliminary digitized, therefore standard video blasters for the image input to personal computers cannot be used. Besides, for image processing images involving large data arrays it is necessary to use expensive sophisticated specialized software..

In the third case the scanning microscope should have the widest range of functionalities for carrying out complex specialized research. The sweep formation should provide the image resolution equal to 5000x5000 picture dots. In the mode of fast proximate analysis of MO investigated it is necessary to provide the television mode of scanning raster formation for the image input to the personal computer. For detailed analysis the raster scans providing the high accuracy of a scanning miniraster at any point of the EBT screen can be used. They facilitate the investigation of the separate fragments of the MO. Thus it is necessary to mention that if the input of one picture dot lasts one micro second, the input time for a full-size raster graphics image with the full resolution exceeds 25 seconds. This microscope should provide extended opportunities for changing a zoom factor, sensitivity, a contrast range and other parameters in a wide range.

To secure its broad functionalities, STOM provides:

- forming the scanning raster signals according to the television standard and low-frame-rate mode (discrete step-by-step formation of a raster);
- changing the sizes of the scanning raster in the television mode for scaling the investigated MO image by changing the sweep signal amplitude when sending it to the voltage-current converter which provides the precision conversion of the sweep signal into the current of deflecting coils;
- moving the reduced scanning raster to any point of EBT screen for investigating an image fragment being scaled-up;
- changing the formation frequency of the raster scanning by changing the duration of forming one picture dot and their quantity;
- shifting the reduced scanning raster by changing the coordinates of the beginning and the end of the scanning raster while working in the discrete mode of the raster formation;
- changing the sizes of the scanning raster by changing the sweep signal amplitude while working in the discrete mode of the raster formation;
- the independent shift of the scanning raster along any axis while working in the discrete mode of the raster formation;
- providing the input of the MO image investigated to the personal computer through the video blaster while working in the television standard;
- providing the input of the MO image to the personal computer through the USB port while working in the discrete mode of the raster formation.

3. The EBT control block

One of the STOM basic units is the scanning EBT control block.

This block provides [2, 3]:

- the regulation of EBT brightness depending on the contrast and transparency of investigated biological MO;
- the regulation of a scanning spot lighting delay in the discrete formation mode of the scanning raster for the period of setting the current in deflecting coils, with the given accuracy;
- the regulation of a scanning spot size depending on the chosen scanning raster resolution in its discrete formation mode;
- the EBT protection against its burning out at disappearance of the sweep on any coordinate;
- adjusting the scanning EBT beam in the calibration mode;
- the dynamic focus of the scanning EBT light beam for maintaining the maximal resolution on a raster workspace;
- the formation of the current in deflecting coils with high accuracy and stability;
- the power supply of all EBT electrodes.

The block diagram of the scanning EBT control block is shown in Fig. 2.

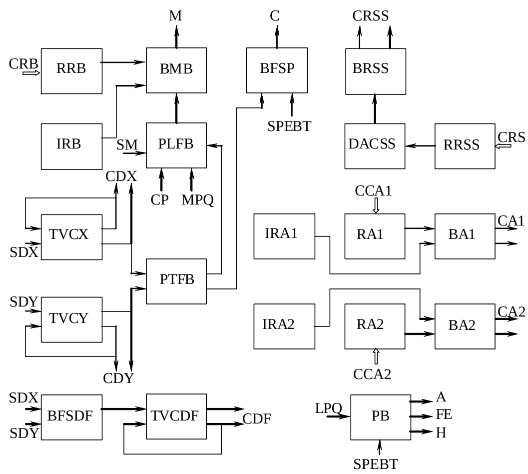

Fig. 2. The block diagram of the EBT control block

It includes the register of brightness regulation (RRB), the block of independent adjustment of EBT brightness (IRB), the block of brightness control (BMB), the block of forming the scanning spot lighting pulses (PLFB), two voltage – current converters on the axes X and Y (TVCX, TVCY), the block of forming the pulses of a transient process (PTFB), the block of forming an EBT protecting signal, which protects the screen from burning-out in emergency operation mode of the microscope (BFSP), the register of size regulation of the scanning spot (RRSS), the digital-analog converter of a signal of the size regulation of the scanning spot (DACSS), the block of size regulation of the scanning spot (BRSS), two independent blocks of EBT beam adjustment (IRA1, IRA2), two registers of adjustment code in automatic operating mode (RA1, RA2), two blocks of adjustment (BA1, BA2), the block of forming a signal of dynamic focusing (BFSDF), the voltage – current converter of a dynamic focusing signal (TVCDF), the power block for the power supply of EBT electrodes (PB).

The input signals of the EBT control block are:

- the code of the EBT brightness regulation (CRB);
- the code of the scanning spot size regulation (CRS);
- the code of the adjustment control (CCA1);
- the code of the adjustment control (CCA2);
- the signal of an operating mode of the scanning microscope (SM);
- the signal of the deflection of a scanning beam along the axis X (SDX);
- the signal of the deflection of a scanning beam along the axis Y (SDY);
- clock pulses (CP);
- the mix of quenching pulses (MPQ);
- the line quenching pulses (LPQ);
- the signal of EBT protection in emergency operation mode of the microscope (SPEBT).

The load of the scanning EBT control block consists of: the EBT modulator (M); the EBT cathode (C); the EBT anode (A); the EBT focusing electrode (FE); the EBT incandescence (I); the coil of regulation of the scanning spot size (CRSS); the coil of dynamic focusing (CDF); the adjustment coils (CA1, CA2); the coil of deflection along the axes X and Y (CDX, CDY).

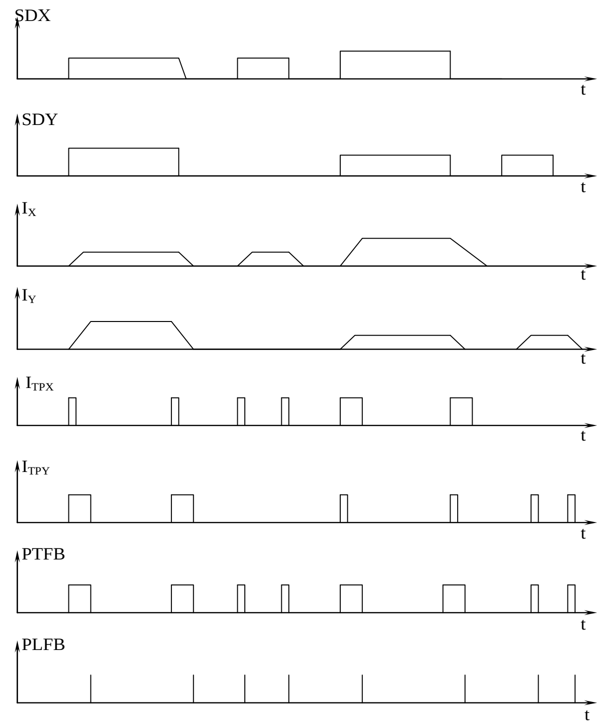

Fig. 3. Time diagrams of pulses formation

The block of brightness control (BMB) provides the amplification of lighting pulses of the scanning spot up to the size defined by the modulation characteristic of the EBT and regulation of initial shift on the EBT modulator. Its value is defined by the code of brightness regulation (CRB), recorded in the register of brightness regulation (RRB). Lighting pulses of a scanning spot are formed in the block of lighting pulses forming depending on the needed operating mode of the microscope with the help of the signal of an operating mode (SM). In the television mode the lighting pulses are formed by the mix of quenching pulses (MPQ). In the discrete mode the lighting pulses of the scanning spot are formed by clock pulses (CP) depending on the input signal from the block of forming the pulses of a transient process (PTFB). Time diagrams of forming the lighting pulses in the discrete mode of the scanning raster formation are shown in Fig. 3.

4. Block of scanning raster forming (BFSR)

BFSR must provide:

- forming of the scanning raster signals in the television standard;
- forming of the scanning raster signals in a discrete low-frame-rate mode;
- changing the scanning raster sizes in the television mode for MO image scaling by changing the sweep signal amplitude when sending it to the voltage-current converter which provides precision conversion of the sweep signal into the current of deflecting coils;
- moving the reduced scanning raster to any point of the EBT screen;
- changing the raster sizes in the discrete mode for the MO image scaling by changing the quantity of picture dots in the raster while its resolution is maintained;
- changing the formation frequency of the raster in the discrete mode by changing the duration of forming one picture dot;
- changing the formation frequency of the raster in the discrete mode by changing the quantity of picture dots in the raster;
- shifting the reduced scanning raster by changing the coordinates of the beginning and the end of the scanning raster while working in the discrete mode of the raster forming;
- changing the sizes of the scanning raster by changing the sweep signal amplitude while working in the discrete mode of the raster forming;
- the independent shift of the scanning raster along any axis while working in the discrete mode of the raster forming.

The structural scheme of the block of scanning raster forming, which illustrates all operation modes of the microscope, is shown in Fig. 4 [3, 4]. The block consists of the clock-signal generator (TG), the frequency divider (FD1), the television synchronizing generator (TSG), two generators forming sweep signal in the television mode (SGX, SGY), five switchboards (S1, S2, S3, S4, S5), the sweep frequency decoder (SFD), the sweep step decoder (SSD), two shift signal code registers (DRX, DRY), two digital-to-analog converters of the shift signal (DACDX, DACDY), two analog regulators of the shift (ADRX, ADRY), two registers for the code of the sweep beginning (SRX, SRY), two registers for the code of the sweep end (ERX, ERY), two counters for the codes of scanning spot location (CX, CY), two digital-to-analog converters of forming the digital sweep signal (DACX, DACY), the register for the code of regulating the amplitude of the deflection signal (ARR), the digital-to-analog converter of the signal of sweep amplitude regulation (DACAA), the block of analog regulation of the amplitude (ARB), two amplitude regulators (ARX, ARY), two co-ordinating amplifiers (MSX, MSY).

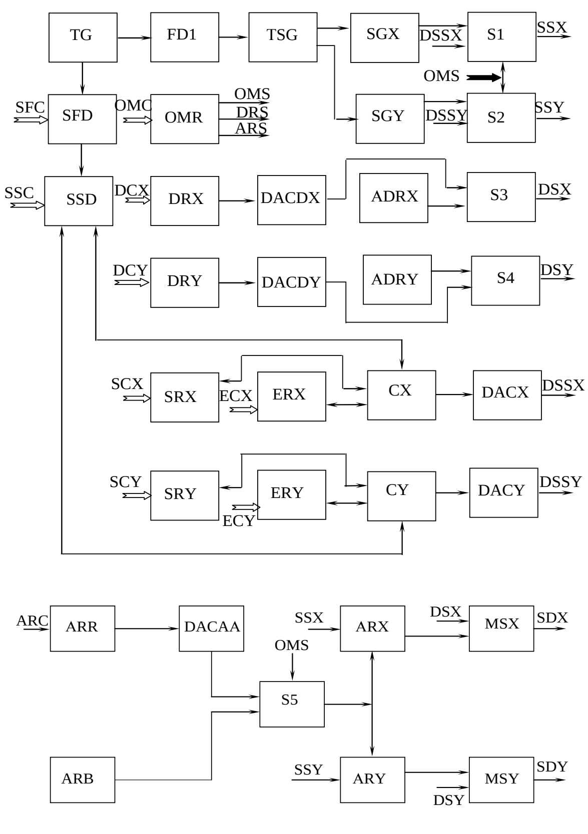

Fig. 4. Structural scheme of the block of raster forming

The input signals of the block of scanning raster forming are: the code of an operation mode (OMC); the sweep frequency code (SFC); the sweep step code (SSC); the raster shift codes (DCX, DCY); the codes of the sweep beginning (SCX, SCY), the codes of the sweep end along the axes X and Y (ECX, ECY). The block output signals are the scanning raster deflection signals (DSX, DSY). The block internal signals are: the operation mode signal (OMS); the scanning raster shift regulation signal (DRS); the scanning amplitude regulation signal (ARS); the digital sweep signals (DSSX, DSSY).

The scanning raster signals in the television standard are formed as follows. The signal from the clock-signal quartz-crystal-controlled generator (TG) passes through the frequency divider (FD1) and then to the input of the television synchronizing generator (TSG). The TSG forms the line and frame synchronization pulses, the line and frame pulses for scanning beam quenching during the flyback of sweeps and their mix. The line pulses of quenching are used for forming the saw-tooth deflection signal along the axis X by the line-sweep generator (SGX) with time parameters of the television standard and the amplitude providing the maximal shift of the scanning raster along the line. The signal from the output of the line-sweep generator (SGX) passes to the first input of the first switchboard (S1). The digital signal of the line sweep (DSSX) is conveyed to the second input of the switchboard (S1). In accordance with the operation mode signal (OMS) the line-sweep signal of the scanning raster is formed on the output of the switchboard S1. The quenching frame pulses are used for forming the saw-tooth deflection signal along the axis Y by the frame-sweep generator (SGY) with time parameters of the television standard and the amplitude providing the maximal shift of the scanning raster over the frame. The output signal from the SGY is conveyed to the first input of the second switchboard (S2)**.** The digital signal of the frame sweep DSSY passes to the second input of the switchboard (S2)**.** In accordance with the operation mode signal (OMS) the raster frame-sweep signal is formed on the output of the switchboard S2.

The code of shifting the raster along the axis X (DCX) is recorded in the shift signal code register (DRX) and then transformed into the analog signal of the shift along the axis X by the appropriate digital-to-analog converter (DACDX). This signal is conveyed to the first input of the third switchboard (S3). The analog regulator of the shift along the axis X (ADRX) forms a control potential in accordance with the position of the regulator on the front face of the microscope. This potential passes to the second input of the third switchboard (S3). The code of shifting the raster center along the axis Y (DCY) is recorded in the shift signal code register (DRY) and then transformed into the analog signal of the shift along axis Y by the appropriate digital-to-analog converter (DACDY). This signal is conveyed to the first input of the fourth switchboard (S4). The analog regulator of the shift along the axis Y (ADRY) forms a control potential in accordance with the position of the regulator on the front face of the microscope. This potential is sent to the second input of the fourth switchboard (S4). In accordance with the scanning raster shift regulation signal (DRS) the signals of the raster shifts DSX and DSY are formed on the outputs of the switchboards S3 and S4 according to the operation mode of the microscope (defining the location of the scanning raster on the EBT screen).

The axis X sweep signal (SSX) is conveyed to the input of the axis X amplitude regulator (ARX), where its amplitude changes according to the signal from the fifth switchboard (S5). The first-input signal of the fifth switchboard is received from the block of the manual regulation of the deflection signal amplitude (ARB), and the second-input signal of the fifth switchboard is received from the output of the digital-to-analog converter of the signal of sweep amplitude regulation (DACAA). The input code of the received signal is recorded in the appropriate register (ARR) on command from the personal computer. The output signal of the fifth switchboard (S5) is sent simultaneously to both amplitude regulators (along the axes X and Y) ARX and ARY. Such regulation provides for the smooth change of the image scale simultaneously along both axes and so the elimination of the scale distortions at the scale changes of the MO image.

Forming the sweep signal in the discrete mode is carried out as follows. The signal from the clock-signal generator passes to the input of the sweep frequency decoder (SFD). The decoder changes the output frequency of the generator and, respectively, the sweep frequency according to the sweep frequency code (SFC) from the personal computer. The output signal from the sweep frequency decoder (SFD) is conveyed to the input of the sweep step decoder (SSD), which is controlled by the sweep step code (SSC) from the personal computer. The change of the sweep step is carried out by using the proper bit of the counter in accordance with binary rule. The minimum sweep step corresponds to sending the clock-signal generator signal to the least significant bit of the counter. The number of the counter bit is changed simultaneously over both axes.

When the counter contains the maximal value of the sweep code along the axis X, its output signal passes through the sweep step decoder (SSD) to the proper bit of the counter along the axis Y. The output codes of the counters for the axes X and Y (CX and CY) are transformed by the digital-to-analog converters (DACX and DACY) into the digital sweep signals along the axes X and Y (DSSX and DSSY). Forming of a partial raster in the digital mode is carried out as follows. The codes of the sweep beginning and the sweep end along the axes X and Y are recorded to the proper registers (SRX, ERX, SRY, ERY). The output codes of the registers are the codes of the beginning and the end of counting in the counters CX, CY. Thus registers SRX, ERX, SRY and ERY set the sizes of the partial raster in the discrete mode.

Basic technical parameters of the block of scanning raster forming are:

- the amplitude of the sweep signal along any axis for all of the raster formation modes – 4 V;
- the period of the line sweep signal in the television mode – 64 mcs;
- the period of the frame sweep signal in the television mode – 20 ms;
- the duration of forming one picture dot in the discrete mode of raster forming – 2 mcs, 4 mcs, 8 mcs, 16 mcs;
- the period of the frame sweep in the discrete mode of raster forming – 2 s, 4 s, 8 s, 16 s;
- the quantity of picture dots at the scanning raster discrete forming – 1024x1024;
- the non-linearity of the saw-tooth sweep voltage – no more than 1 %;
- the load resistance for the sweep signals – no less than 2 kΩ;
- a ratio of maximal sweep size to minimum one – 10:1.

5. Photoelectronic multiplier block

Considering the functionalities of the scanning television optical microscope, the photoelectronic multiplier (PEM) block provides [5, 6]:

- discrete regulation of PEM source voltage;
- changing PEM gain by changing source voltage of some PEM dynodes;
- PEM overload protection in case of extraneous light emission towards the biological microobject;
- PEM sensitivity calibration.

The structural scheme of the PEM block is showed in Fig. 5. It includes the photoelectronic multiplier supply register (PEMSR), the photoelectronic multiplier supply block (PEMSB), the protection block (PB), the preamplifier (PA), the photoelectronic multiplier (PEM).

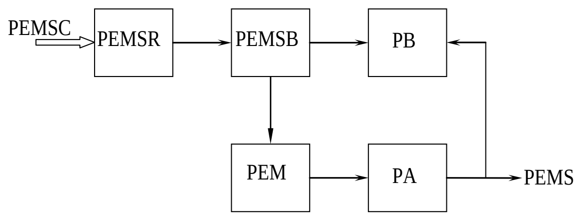

Fig. 5. Structural scheme of the PEM block

The input signals of the PEM block are the PEM supply code (PEMSC) and the light signal from the investigated microobject getting to the PEM photocathode through the microscope optical channel.

The input voltage supply code of the PEM (PEMSC) is conveyed from the personal computer. Changing PEM sensitivity is conducted by changing the supply voltage during the microscope calibration. A PEM peak signal does not exceed 0.1 mcA. With the PEM load of 1 MΩ the signal does not exceed 0,1 V. The preamplifier (PA) amplifies the signal up to 0,1 V at the load of 1 kΩ and corrects frequency distortions of the input signal appearing as a result of the PEM high load resistance and input capacitance of the input cascade of the preamplifier (PA). The protection block (PB) generates a signal that turns off the photoelectronic multiplier supply block (PEMSB) on condition that the signal at the preamplifier output exceeds significantly its peak amplitude, e. g. 1 V. The signal can occur at the PEM parasitic light-striking. The output signal of the PEM block (PEMS) is conveyed to the block of video signal forming.

6. Block of video signal forming

The structural scheme of the block of complete video signal forming is introduced in Fig. 6 [7, 8]. It includes the preamplifier gain control register (PAR), the contrast control code register (CCR), the signal polarity inversion code register (PR), the black color level lock-in code register (BLBR), the white color level lock-in code register (WLBR), the output signal polarity code control register (PCR), the input amplifier (IA), the contrast control block (CCB), the signal polarity inversion block (PIB), the black color level lock-in block (BLBB), the white color level lock-in block (WLBB), the quenching and synchronizing pulses mix block (QSPMB), the output amplifier (OA), the inverting output amplifier (IOA), the switchboard (S).

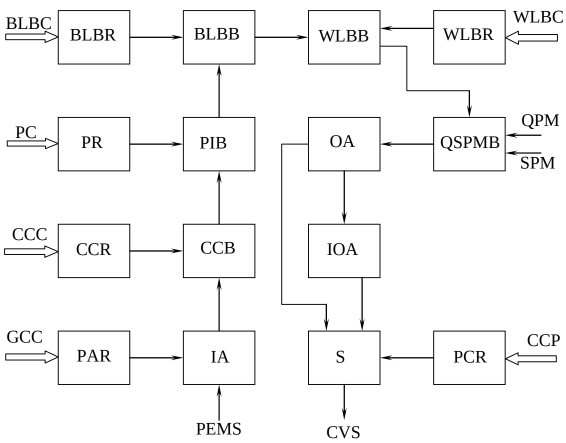

Fig. 6. The Structural Scheme of the Video Signal Forming Block

The block of complete video signal forming (VSFB) provides:

- the discrete regulation of the gain of video preamplifier input cascades;
- the discrete regulation of the image contrast of the investigated biological microobject;
- the discrete regulation of black color level lock-in during generating the complete video signal;
- the discrete regulation of white color level lock-in during generating the complete video signal;
- the discrete calibration of the necessary gain during the exploration of a test object;
- switching the output signal of the block of complete video signal forming depending on the operating mode chosen;
- the change of video signal polarity in order to increase the image information capacity by means of changing the positive image to the negative one;
- controlling the insertion of quenching and synchronizing pulses into the video signal according to the scanning raster formation mode.

The input signals of the complete video signal generator (VSG) are:

- the gain control code (GCC);
- the contrast control code (CCC);
- the signal polarity code (PC) to display either the positive or the negative image of the investigated microscopic object on the monitor screen;
- the black color level lock-in code (BLBC);
- the white color level lock-in code (WLBC);
- the control code of the output signal polarity (CCP) for the coordination with data presentation devices;
- the quenching pulses mix (QPM);
- the synchronizing pulses mix (SPM);
- the photoelectronic multiplier signal (PEMS) transmitted by the PEM.

The input amplifier (IA) with the controlled gain is designed for the signal amplification up to the standard value of 1 V. The gain depends on the output code (GCC) recorded in the preamplifier gain control register (PAR). The principle of the functioning of the contrast control block (CCB) lies in the input signal amplitude control (increase) and «cutting out» the swing of 1 V from the amplified signal at any level. The range of the amplification control and the level of «cutting out» are identified by the CCC-code recorded in the contrast control register (CCR). The polarity inversion block (PIB) of the generated signal is intended for forming positive and negative images on the monitor screen according to the polarity code (PC) recorded in the signal polarity register (PR). The black color level lock-in block (BLBB) provides the same initial level of the video signal in each image line regardless of its amplitude. The level is identified by the black color level lock-in code (BLBC) recorded in the black color level lock-in register (BLBR). The white color level lock-in block (WLBB) limits the peak amplitude of the signal at a level that corresponds to the peak brightness of the monitor screen. The level of white color lock-in is identified by the white color level lock-in code (WLBC) recorded in the white color level lock-in register (WLBR). The quenching and synchronizing pulses mix block (QSPMB) generates, at its output, a complete video signal consisting of line and frame synchronization pulses as well as line and frame quenching pulses extracted from the quenching pulses mix (QPM) and the synchronization pulses mix (SPM), respectively. The output video amplifier (OA) is intended for amplification of video signal power to the level providing the swing of the complete video signal of 1,2 V on the resistance of 75 Ω. The inverting output video amplifier (IOA) ensures the inversion of the composite video signal and its amplification to the power level necessary for the load of 75 Ω. The switchboard (S) provides the choice of a video signal of a necessary polarity (synchronization pulses upwards – negative polarity, downwards – positive polarity) depending on the polarity control code (CCP) recorded in the output signal polarity code control register (PCR).

The output signal of the block of complete video signal forming (VSFB) is a complete video signal (CVS).

7. Block of video signal processing

The block of video signal processing (VSPB) is to provide:

- the selection of necessary high-pass filter while forming the scanning raster in the television mode;
- the selection of necessary low-pass filter while forming the scanning raster in the discrete mode;
- the selection of the necessary band-rejection filter in order to reduce noises while forming an image in the television mode;
- the commutation of output video depending on the selected mode of the scanning raster.

The structural scheme of the block of video signal processing is introduced in Fig. 7 [7, 8, 9].

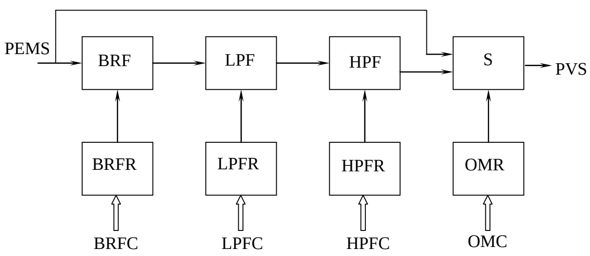

Fig. 7. Structural scheme of the block of video signal processing

It includes the band-rejection filter (BRF), the band-rejection filter selection register (BRFR), the low-pass filter (LPF), the low-pass filter selection register (LPFR), the high-pass filter (HPF), the high-pass filter selection register (HPFR), the switchboard (S), the operation mode register (OMR). The band-rejection filter (BRF) is intended for suppression of interference of the power frequency and of the clock-signal generator frequency of the scanning microscope. The low-pass filter (LPF) is intended for frequency range limiting at low frequencies. The high-pass filter (HPF) is intended for frequency range limiting at high frequencies in order to improve the signal/noise ratio. The switchboard (S) selects the necessary operation mode of the block of signal processing, i.e. with processing or without it (while the scanning raster is being formed in the television standard).

Selecting the band-rejection filter is carried out by means of the output code of the band-rejection filter register (BRFR) where the band-rejection filter code (BRFC) is recorded. Selecting the necessary low-pass filter is performed with the help of the output code of the low-pass filter register (LPFR) where the necessary low-pass filter code (LPFC) is recorded. Selecting the necessary high-pass filter is performed by means of the output code of the high-pass filter register (HPFR) where the necessary high-pass filter code (HPFC) is recorded. Selecting the necessary switchboard operation mode is carried out by means of the output code of the operation mode register (OMR) where the operation mode code (OMC) is recorded.

The input signals of the block of video signal processing VSPB are:

- the selection code of the band-rejection filter (BRFC);
- the selection code of the low-pass filter (LPFC);
- the selection code of the high-pass filter (HPFC);
- the selection code of the operation mode (OMC);
- the photoelectronic multiplier signal (PEMS).

The output signal of the block of video signal processing (VSPB) is the processed video signal (PVS).

The basic technical parameters of the block of video signal processing are:

- the PEM peak current that corresponds to the maximal light signal from the object – 0,1 mcA;
- the lowest frequency of the signal amplification – 5 Hz;
- the highest frequency of the signal amplification – 20 MHz;
- the amplitude-frequency ripple of the video signal processing circuit – no more than 3 dB;
- a signal swing at the output of the block of complete video signal forming – 1,2 V;
- minimum load resistance of the forming block – 75 Ω;
- the parameters of the control signals from the personal computer correspond to the parameters of the TTL-logic.

8. STOM Design

The laboratory mock-up of the STOM is shown in Fig. 8 [10]. Its structure includes the STOM block, the STOM's power unit, the personal computer (PC), the PC monitor and television monitor (TM). On the front face of the STOM the lightproof tube has been embedded with the eyepiece of an optical microscope and a turret with replaceable microscope objectives. Under the microscope objectives an object stage with a slide has been installed. A researcher may observe an investigated microobject conveniently through the optical eyepiece of the microscope. The MO is lit with the incandescent lamp located in a ledge of the STOM in its lower part.

Fig. 8. A general view of the STOM laboratory mock-up

The preparatory stage of the STOM handling includes moving out the ledge in the lower part of the STOM block. In this case the light from the EBT located in the block gets to the MO through the tube and the microscope objectives. The light passes through the MO and through a condenser to a PEM photocathode located in the ledge. To eliminate interference the preliminary amplifier of the complete video signal is located directly on the base of the PEM. Each unit installed in the STOM block is functionally completed and located on a separate printed-circuit board.

On the front face of the STOM the following control elements are located:

- the toggle-switch;
- the potentiometer for EBT brightness regulation;
- the potentiometer for fine focusing;
- the potentiometer for image scale regulation;
- the potentiometers for the raster shift on EBT screen along the axes X and Y.

The unit of power supply provides necessary voltage for all units of the STOM. The television monitor is used for preliminary viewing the images of MO and their separate fragments in the zoomed scale. The STOM and its power unit are installed separately, and so the disturbances of the formed video signal and sweep signals are minimized. When necessary, the MO image can be input to the personal computer in the television standard for storage and further processing.

The basic technical parameters of the laboratory mock-up of the Microscope are:

- the maximal zoom factor – 20000^x;
- the factor of smooth scale changing – 1…10;
- the minimal size of the scanning element of an investigated object – 0,2 mcm;
- the maximum of the luminescence spectrum of the tube screen – 0,54 mcm;
- the minimal size of the light spot on the tube screen– 10 mcm;
- the mode of scanning – the TV standard.

In Fig. 9 the image of an inclined test object (a metal orthogonal grid with the step of 30 mcm) on the screen of the monitor is shown. The objective with zoom of 21^x is used. The size of the cell of the grid is 30x30 mcm.

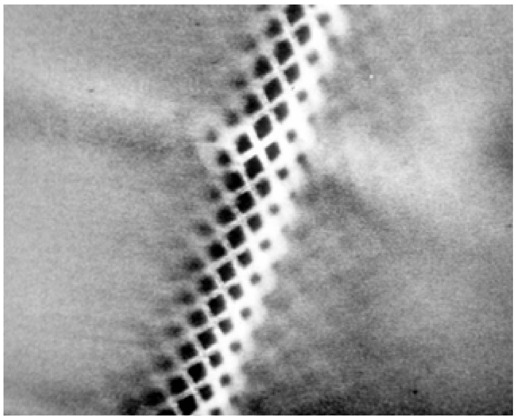

Fig. 9. The image of an inclined test object (a metal orthogonal grid with 30 mcm step) formed on the STOM monitor

In Fig. 10 the image of a fiber glass test object on the screen of the STOM television monitor is shown. Both images have not been processed by the computer.

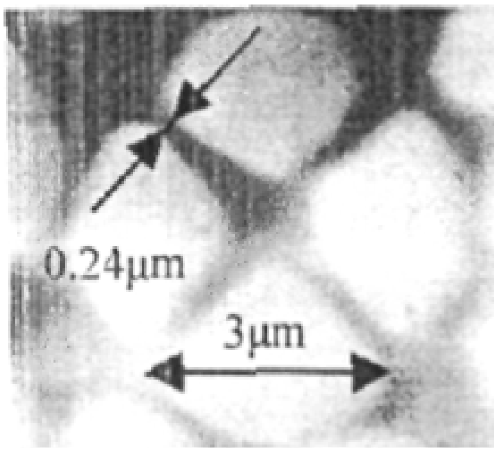

Fig. 10. The image of a fiber glass test object on the STOM monitor

9. Conclusions

1. The structural schemes of STOM and its basic units allowing to investigate microobjects with dimensions exceeding 0,1- 0,2 mcm have been developed.

2. The ways of changing the raster sizes on the screen of the scanning EBT have been proposed what

allows us to change the scale of the formed MO image without any loss in the resolution.

3. The ways of correcting the amplitude-frequency characteristic of the video signal forming block have been offered what allows us to widen a passband considerably.

4. It has been offered to manufacture STOMs with different functionalities and, consequently, in various costs for convenience of a user.

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СКАНУВАЛЬНИЙ ТЕЛЕВІЗІЙНИЙ ОПТИЧНИЙ МІКРОСКОП ДЛЯ ДОСЛІДЖЕННЯ БІОЛОГІЧНИХ МІКРООБ’ЄКТІВ

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Аналізуються шляхи побудови сканувального телевізійного мікроскопа, придатного до використання для дослідження біологічних мікрооб’єктів. Розширено можливості мікроскопа за рахунок формування сканувального растра в телевізійному та малокадровому режимах. Запропоновано шляхи зміни розміру растра при збереженні роздільної здатності зображення мікрооб’єкта.

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