

OPTICAL TESTING METHODS AND THEIR REALIZATION IN THE INSTRUMENTS DEVELOPED BY JSC “SPECTRUM” – RII”

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Abstract: The basic area of development of means based on optical method of NDT is optic-location systems, search-watch instruments and equipment for criminology.

The latest developed optic-location instruments are based on the cat-eye phenomena. These devices are portable and provide visualization of remote up to 15 m camouflaged video-observation systems and detection of optic-electron means, sights, long focus lenses, etc. at distance up to 1000 m.

Improvement and development of new search-inspection equipment designed to examine difficult to access areas and internal cavities of objects follows the path of implementation of new, miniature TV-cameras. The list of latest samples of equipment comprises TV-systems presenting miniature TV-camera mounted at the end of telescopic rode and equipped with IR illuminator and various endoscope systems. In latest modification of endoscopes the LED illumination, distal tip operation mechanism, the blocks of illumination and power supply are integrated in one small housing with “pistol” type handle. Such a design makes the use of this instrument very convenient and simple.

One more direction of development – equipment for criminology designed for verification of authenticity of documents, bank notes and securities. This kind of equipment includes portable instruments for express verification in case of mass documents examination on-site, stationary and mobile systems providing check of standard documents protection parameters as well as specialized systems for careful study during criminological investigation.

Introduction: At the Research Institute of Introscopy (JSC “Spectrum” – RII”) several directions of optical instruments development exist, below will be presented basic instrument of each group.

Optical-location systems. The principal of operation of optical-location systems designed for detection of optic objects is based on the feature of such object to reflect radiation falling on them in the reverse direction at an angle approximately equal to angle of incidence. This type of reflection is called **light reflection (or cat eye) phenomena** as distinct from mirror or diffusion reflection phenomena. Many optical objects have the feature of cat’s eye phenomena, in particular, optical components and schemes of video cameras, sniper sights, and long focal length lenses. More evident this property becomes when the object of interest is “sounded” by narrow, directed beam of monochromatic laser radiation. In this case the level of signal reflected from light reflecting object in the direction close to the angle of incidence can be on one and more order greater than level of background signals reflected from other surfaces. If such an object happens to be within the limits of laser illumination “sounding” area then during visual observation by eye or with the help of special equipment in the observation point on the axis of reflected signal the response for presence of object becomes apparent in the form of bright point like glare that disappears as soon as the illumination is switched off.

The latest results of work in this direction are demonstrated by the portable instruments «Antiwatch–1» (Fig. 1) and «SPIN–L» (Fig. 2) designed for visual detection of optical objects at near and far distances correspondingly. As sources of “sounding” illumination used are the semi-conducting IR lasers. In both instruments the signal reflected from the object of interest are registered by high sensitive video cameras.



Fig. 1. “Antiwatch -1”



Fig. 2. “SPIN–L”

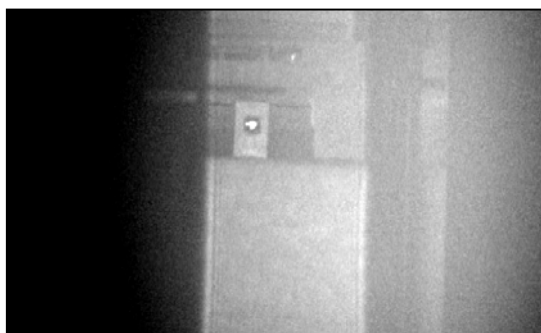
These instruments can be used both in conditions of complete darkness and in presence of intensive background expose to light. This provides use of interference filter with narrow spectral pass band that correlates with the spectral band of “sounding” illumination and automatic masking of receiving channel. The instruments help to detect hidden optic-electron devices behind such obstacles like glass (including smoked one), plexiglass and semi transparent mirrors.

The “Antiwatch-1” instrument designed for detection of micro video cameras at distance range 0.6 – 15 m. In it implemented is parallax-free optical scheme, i.e. scheme in which optical axes of receiving and transmitting channels are reconciled. This scheme makes possible the efficient detection of objects with cat’s eye feature at small distances. The view field of the instrument’ video camera is $8^\circ \times 6^\circ$. The laser beam is formed in the shape of vertically oriented rectangular pattern that occupies some part of the view field. To improve the contrast of the visualized image and hence to increase the probability of detection of objects with cat’s eye feature used is the divergence adjustment of the laser illumination pattern. It is necessary to mention that the detection (position marking) angle of micro cameras, which search for, correlates to view field angle, i.e. if video camera “sees” the instrument, the instrument will detect it with practically 100% probability.

The image of observed area is displayed on the built in view finder. To have better quality image their is an option of connecting to the instrument of portable 5” LCD monitor. The instrument has output socket with video signal in CCIR format through which the external devices (video monitor, video recorder or computer) can be attached. The instrument can be powered both from built in accumulator (+6 V DC, 4200 mApms·h) or mains (220 V AC/ 50 Hz) via mains adapter. Time of continuous work without accumulator replacement/charge is not less than 5 h.

In Fig. 3(a) & 3(b) presented are examples of detection of video camera with “pin hole” type micro lens with diameter of input pupil 1 mm at distance of 6 m in complete darkness (background illumination $E < 0.001$ lux) and room illumination ($E \sim 400$ lux) correspondingly.

The instrument «SPIN-L» designed for detection of sniper sights at distances 20 – 1000 m. Angle divergence of the laser illumination pattern is $1^\circ \times 3^\circ$ at general receiving channel view field of $7.3^\circ \times 5.5^\circ$. Laser is operating in



a) $E < 0.001$ lux, distance 6 m



b) $E \sim 400$ lux, distance 6 m

Fig. 3. Example of micro video camera with “pin hole” type lens detection by instrument “Antiwatch-1” in various illumination conditions (The video camera reveals its presence like bright sport over the background image)

the continuous mode. The vertical rectangular pattern of illumination makes it convenient the horizontal scanning of the space. To operate the instrument during day / night time on its housing their is a special switch “DAY/NIGHT” that sets required operation mode. The instrument can be mounted on tripod. The image of observed area is displayed in built-in view finder. It is powered from accumulator. Time of continuous work without accumulator replacement/charge is not less than 1.5 h when in “DAY” operating mode and 3 h in the “NIGHT” mode. In Fig. 4(a) presented is an example of possibility to detect the sniper sight of PO4x34 type with the help of “SPINI-L” at distance of 500 m and switched on laser illumination. In Fig. 4(b) presented is scenario when laser illumination is switched off.

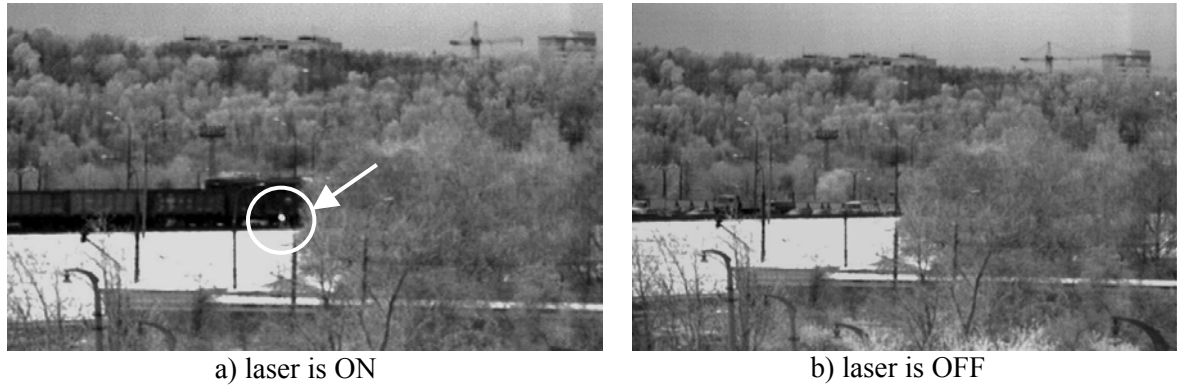


Fig. 4. Detection of sniper sight of PO4x34 type (distance 500 m) with the help of «SPIN-L» instrument

Search-inspection means for observation of difficult to access areas of objects and internal cavities. One of the means for visual inspection of difficult to access areas is technical endoscopes. The list of these items manufactured by the company includes all basic types, i.e. rigid and flexible ones as well as video endoscopes.

The standard manufactured rigid (Fig. 5) and flexible (Fig. 6) endoscopes with optical channels of image input and illumination output have mains and self contained power supply blocks for illuminators.

The rigid endoscopes (or boroscopes) are manufactured with the length of working part equal to 0.18 – 0.6 m and diameters 0.2 to 8 mm. Flexible endoscopes have the length of working part equal to 0.6–2 m at diameters 3.5–8 mm and distal tip articulation angle $\pm 90^\circ$. As a rule the instruments are equipped with photo and video adapters.

One of the ways of endoscopes technical parameters improvement is the replacement of optical channels of image registration and output by the TV channels. An example of such instruments are video endoscopes of ETVG series (see Fig. 7). Proposed is the instrument with the diameter of working part of 10 mm. Soon will be completed the development of the instrument with diameter of working part of 8 mm.



Fig. 5. Rigid endoscope

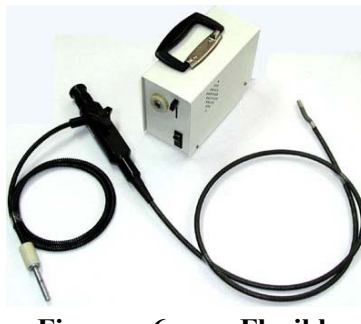
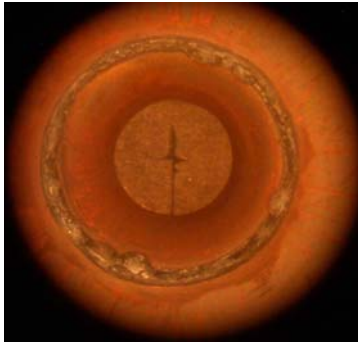


Fig. 6. Flexible endoscope

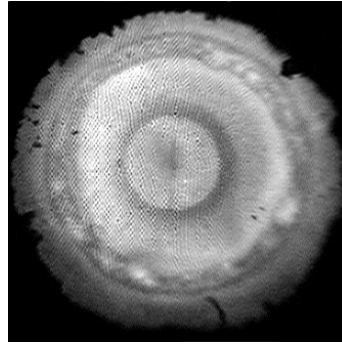


Fig. 7. Video endoscope of ETVG -10-3.0 type

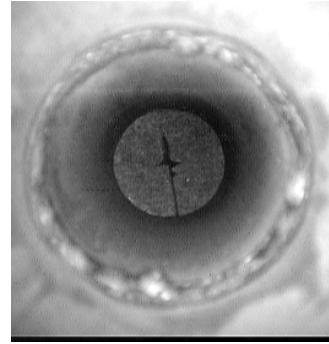
Below in Fig. 8 presented are the images of welded joints obtained with the help of various types and modifications of endoscopes manufactured by JSC “Spectrum” – RII”.



Rigid endoscope equipped with digital photo camera



Flexible endoscope equipped with video camera



Video endoscope

Fig. 8. Images of welded joint inside the pipe



Fig. 9. TV-endoscope with fibre glass illuminator at the working tip

Another direction of endoscopic systems improvement is replacement of power consuming bulb type illuminators by LED illuminators. This essentially reduces the power consumption of the illuminating system as well as weight and overall dimensions.

Two types of illumination were developed.

In the first variant the working tip of the endoscope is equipped with matrix of small size super bright LEDs installed by methods of surface assembling.

An example of this type of equipment is the specialized video endoscope with working part length up to 30 m (Fig. 9), at its working tip mounted is the high sensitive, small-size color video camera and matrix of four white color LEDs of increased brightness.

In the second variant the use is made of input of light generated by the ultra bright LED through focusing optics into fiber optic bundle. This type of equipment is presented by autonomous, portable flexible endoscopes of ETA series, in which the mechanism of distal tip control,

Illuminating module and power supply module (four accumulators of AA type) are placed in common, portable housing with "pistol" type handle (Fig. 10).

Besides described above endoscopic systems more simple in operation inspection means are manufactured as well.

For example, this is carried set "Poisk -TV" (Search-TV) designed for visual observation on-site of difficult to access areas. It comprises telescopic rod with fixed at its end in a hinge miniature video camera equipped with IR-LED illuminator and power supply, control unit (with accumulators) and LCD monitor where the image of observed area is displayed. Envisaged is the possibility to build in the memory module for image recording.

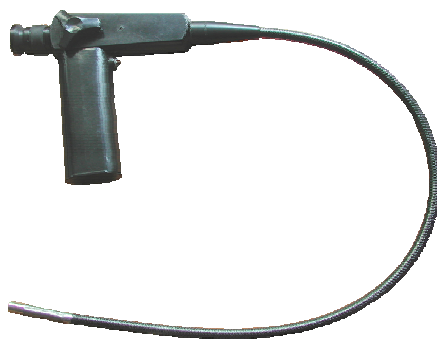


Fig. 10. Portable, autonomous endoscope of ETA series with LED illuminator



Fig. 11. TV- device “Poisk-TV” for observation of difficult to access areas

Equipment for criminalistic verification of documents. The main goal of the criminalistic equipment development is verification of documents, securities and bank notes authenticity. In the list of such equipment there are: carried instruments for efficient verification of widely used authenticity parameters and types of imitations of documents that can be used on-site as well as stationary and mobile systems of efficient verification of the basic assembly of authenticity signs and traces of falsification; and computerized complexes for complete criminalistic examinations.

In the above equipment various sources of initial illumination in the range 254 – 1100 nm in various combinations and modes of illumination are used. The informative parameter about the features of object substance is the secondary radiation in visible and IR ranges (400 to 1000–1100 nm), comprising reflected radiation, passed through the object radiation, luminescence of paper bearer and substances used at documents fabrication and performance (including anti-stokes one).

The widest area of applications is to solve the tasks of frontier passport control, where the priority is given to the verification of ID documents with various types of performance and in conditions of the people flow. By this very special requirement is explained the fact of selection for use of documents visual examination, when talking visual it means direct examination or examination with the help of image brightness amplifiers or TV-channels.

For documents on-site verification manufactured is portable IR magnifier “Korund –IR” (Fig. 11) and a number of portable ultra violet (UV) illuminators operating in the A wave length range (365 nm) and some others.

The IR magnifier “Korund –IR” provides visual verification of documents in presence of reflected IR radiation. The IR image visualization is performed by means of image converter. The instrument comprises IR illuminator providing illumination of area under examination.

From the list of carried UV illuminators operating in A wave length range the “Grif-2M” instrument (Fig. 12) should be mentioned. It contains two UV bulbs with power of 4 W each. The observation is carried out through Fresnel lens (multiplication factor 2^X). The view field under the magnifier is evenly illuminated by UV light and its intensity is up to 1.0 mW/cm^2 . The instrument comprises illuminator, power supply (accumulators) and



Fig. 11. IR magnifier “Korund-IR”

control unit as well as mains power supply and charging unit. Besides main task (social security) the instrument proved to be very efficient for luminescent defectoscopy.

When developing the new tabletop type of equipment the main selected design principle was modular structure of equipment that provides easy modernization and improvement of characteristics due to addition of new units and blocks and hence enhancement of functional abilities and possibility to combine various existing systems.



Fig. 12. UV illuminator “Grif-2M”

As a rule, in these systems for data processing and files storage the personal computer is used.

Lately developed the IR video magnifier “Genetika – LTV” (Fig. 13) and criminalistic block “Genetika-02.01” (Fig. 14) are examples of new approach to design. IR magnifier is designed for documents verification in reflected and luminescent IR radiation with use of two-range illuminators (IR top and IR lateral) and green-blue illuminator. The image from black and white video camera with input filter is displayed on the LCD monitor. Maximal size of examined object image field is ~24 x 36 mm.



Fig. 13. IR video magnifier “Genetika-LTV”

Criminalistic block provides verification of A4 format documents. In it the use is made of UV illuminator; and top, bottom and lateral illuminators of visible radiation range. The block is designed to be used in cabins of frontier passport check points.

At the design stage the possibility of its use in combination with complex “Genetika – 02.02” was foreseen. The complex provides detailed verification of most authenticity features of most important documents and detection of traces of typical falsifications on site.



Fig. 14. Complex “Genetika-02.02”

One more direction of mobile means and devices development is development of mobile systems for on-site detailed documents verification. The system “Korund-TV” (Fig. 15) is an example of such system, it is placed in case and its weight is 7.5 kg. With its help the user can carry out the verification of examined object in reflected, passed through and luminescent visible and IR radiations. In it the use is made of UV illuminators as well as top, lateral and bottom illuminations of visible and IR radiation ranges. The last ones can be remote or built-in.

At the final stage is the development of a number of specialized instruments, for instance, coaxial illuminator for marks of laminated coatings inspection. Foreseen is the use of new instrument together with the complex “Genetika-02.02”.

Separate direction of the company activity is development of specialized instruments for passports examination. At the final stage is the development of the “Konpas” instrument that will provide display on the screen of passport page or visa presented in UV, visible and IR radiations together with the area of machine-recognizable lines and output for further storage in external databases.

Simultaneously with the latest technical developments continuously are improved the video comparator systems. The improvement is in direction of registered radiation spectral range extension, use of polarization effects, examination of anti-stokes luminescence, magnetic-optical and other phenomena and computerized processing and hierarch storage management (HSM) of verification results with further output of information and transfer to external databases.

Below presented are the results of application and abilities of developed equipment.



Fig. 15. Mobile system “Korund-TV”

