NEW ACHIEVEMENTS IN THE FIELD OF DEVELOPMENT OF MOBILE X-RAY TV-SYSTEM

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Abstract: Among various directions of employment of radiographic testing method one of the most important is development of new and improvement of existing equipment designed for search and supervision tasks within the limits of anti-terrorism activity. Wide experience is gained in the field of development of technical means based on X-ray that are varying in types and applications, stationary and portable, from simple fluoroscopes to computerized scanning systems. In the paper will be presented and discussed the multipurpose mobile X-ray TV-systems designed for use on-site.

Introduction: The problems connected with terrorism expansion; transportation of weapons, drugs and forbidden contraband goods across the state boundaries; activity of criminal communities are the most urgent and painful ones in spite of all efforts done by States and Society. The law-enforcement services face the task of thorough security provision of individuals, transportation means, living premises, enterprises and organizations. To ensure efficient work of these services of great importance is availability of technical means that is appropriate for tasks to be solved. In particular the equipment to detect means used for sabotage and terrorist activity. Between such means the following can be listed:

- Firing arms and ammos;
- Grenades, mines and bomb;
- Explosive substances (ES);
- Radioactive substances (RS);
- Incendiaries;
- Other materials and devices.

To date a number of means providing detection of listed above items is available. For example, explosives can be detected with the help of equipment based on ion spectroscopy; radioactive materials – with the help of ionizing radiation meters. But the most universal is equipment that helps to examine various objects by means of low dose X-ray equipment and complexes, providing visualization of examined objects internal structure.

Among these are stationary X-ray systems mounted at the large and purposely equipped check points, for example, at the airports or at thoroughly secured establishments. The majority of them are based on scanning principle of operation designed for examination of items like hand luggage, containers, lorries and vans as well as human body. Well known are «Heimann Systems», «Astrophysics Research Corporation» and AS&E installations. Russian scanning X-ray systems are also available, for instance, installation developed by MRTI of Russian Academy of Science. Along with the stationary systems there are mobile scanning ones, they usually are placed in cars.

For Russia there is another very urgent task – objects inspection on site, i.e. not within the checkpoint area, as well as during examination of area when some object are found and presence of arms, explosives, bombs, etc. is suspected. This is situation when without initial examination it is dangerous to move suspicious object due to potential possibility of explosion occurrence.

To solve the tasks of on-site detection the use is made of low dose, mobile, small size X-ray systems and, first of all, X-ray TV systems.

Several basic types of mobile X-ray complexes are available at the moment; they differ by principle of operation of the radiation-optical transformer and the methods of image visualization. The basic goal of such a transformer to convert the X-ray radiation into optical image that will be further on registered by receiving chamber and changed to electrical signal transmitted to the system of image visualization. This task is well solved by low dose, mobile, small size X-ray TV system.

Standard mobile X-ray complex comprises:

- X-ray radiation source;
- X-ray – optical transformer;
- Visualisation system.

The requirements imposed on the equipment by security and inspection services can vary but the equipment itself shall be universal, reliable and productive independent on the manufacture brand name. In Russia today one can find a number of such systems proposed by domestic and foreign manufacturers.

Russian company JSC “Spectrum” – RII” (Research Institute of Introscopy) developed mobile X-ray TV complex “Ochertanie –TV” (Contour – TV) designed to solve the tasks of terrorism fighting.

Results: Proposed mobile complex (see Fig. 1) provides visualization of internal structure of various objects, solution of wide range of anti-terrorist tasks, boundary and custom inspection, flaw detection of items from light-weight materials and this is done like express diagnostics when obtaining information about internal structure of examined objects. The complex can operate from mains (220 V AC/ 50 Hz) as well as from autonomous power supply unit. The complex generates low dose radiation impact on tested objects and practically safe for operators and is easy to operate.
The complex comprises:

- One of standard portable X-ray generators of the next type:
  - RAP-70,
  - RAP-100 or RAP-150;
- Exchangeable blocks of X-ray-optical transformer comprises:
  - Dark chamber with fluoroscopic X-ray screen 150x200 mm or 300x400 mm,
  - High sensitive video camera;
- Control and visualization unit built in the portable, water resistant case and comprising:
  - Video processor providing visualization, adjustment, processing and recording of image;
  - Portable video display,
  - Mains and battery power supply blocks;
  - Device for information recording and reading based on flash-card;
- Connecting cables;
- Flash-card to store obtained images;
- Tripod for X-ray apparatus mounting;
- Tripod for X-ray-optical transformer mounting.

Optionally the portable computer can also be included.

Fig..1. Mobile X-ray TV complex “Ochertanie-TV”

X-ray apparatus RAP -70 (Fig. 2) is designed to be used in the set of mobile X-ray TV system like a source of stabilized X-ray radiation with regulated anode voltage and current of X-ray tube. It has protection from: overheat of the high-voltage block, from excess of a current and voltage in the tube; from break of a circuit with switching-off of a power supply with indication of the reason of switching-off on the external control and visualization unit. The apparatus can be operated from various voltages (30 kV, 50 kV, 70 kV) without necessity to switch on high voltage as such switch on is performed from external control and visualization unit.
The X-ray generator is placed in metal cylindrical housing. In it is located the high voltage transformer for power supply and X-ray tube with cooling system. To suppress the radiation outside the working beam there is lead

Fig .2. X-ray apparatus RAP -70 with tripod

shelter At the lateral side of the lead shield there is output window forming conical working radiation beam with opening angle 40º.
At the opposite from output window face side there is a connector for 10 m cable, it connects the generator with the control, visualization and image processing unit.
Maximal thickness of penetrated obstacle is 20 mm (Al equivalent).
The possibility to adjust high voltage on the X-ray tube output within wide range makes examination of low density objects, including post correspondence containing various powders, explosives and etc. easier.

Sharp focused apparatuses RAP-100 & RAP-150 (Fig. 3) initially were also designed to be used like a part of mobile X-ray TV system. Operating voltage ranges are as follows: 20-100 kV (RAP-100) and 10-150 kV (RAP-150). Maximal thickness of penetrated obstacle (Al equivalent) is 50 mm for RAP-100 and 80 mm for RAP-150.

Both apparatuses are powered from battery blocks or from mains (220 V AC / 50 Hz) through mains adapters.

The control, visualization and image recording unit as was mentioned before comprises the **video processor**. It provides presentation, processing and recording of image. As well it switches ON and OFF the X-ray apparatus.

The video processor has a number of optional functions that control the selection of operating mode, for instance, type of image registration, image presentation and processing, recording and output. Also processor generates command to switch the X-ray radiation after the image is recorded.

Fig. 3. X-ray apparatus RAP-100

The modes of image registration are as follows:

- Accumulation of shorts on the CCD matrix of video camera;
- Accumulation/averaging of shorts on the video camera output;
- Analog amplification of the TV camera output signal.

The processor has option of auto selection of combination of shorts accumulated / averaged at the camera output and accumulated on the CCD; as well as selection of analog amplification factor based on 4-5 initially registered shorts reasoning from the parameters of image field on the X-ray – optical transformer (range and absolute values of brightness; or provides their combinations 64 x 1, 32 x 2, 16 x 4, 8 x 8 and 16 x 16 at 10 values of analog amplification factor within limits from 1 to 10 depending on operator's choice.

The image is recorded in 1024 gradations while the image output is in 256 gradations.

The processor provides the image output in the next modes: full record range, range of image densities histograms and 7 sub-ranges with 256 gradations overlapping the total record range. Such an approach makes it possible to analyze the image details more thoroughly in both "dark" and "light" areas of registered images.

Besides mentioned above the processor has several useful functions to process obtained image that are listed below:

- Two high frequency filters can be applied to the image;
- Increase the image scale;
- Invert the image (positive, negative).

The processor is controlled via keyboard. The general keyboard overview is presented in Fig. 4.

The "Menu" key calls on the display the menu of video processor (see table 1). The key «Input» confirms selection of required option.

Fig. 4. Keyboard overview

Table 1. Menu scheme (presented on display)

№	Menu option	Status (on defualt)	Possible status
1	Accumulation	AUTO	2, 8, 16, 32
2	Quadrant	OFF	OFF, 1, 2, 3, 4, 5, 6, 7, 8, 9
3	Inversion	OFF	OFF, ON
4	Filter	OFF	OFF, HFF1, HFF2
5	Range	AUTO	AUTO, COMPLETE, 1, 2, 3, 4, 5, 6, 7
6	Amplification	0	0, 1, 2, 3, 4, 5, 6, 7
7	Short number	1	from 1 to 63

The arrow keys help to scroll the menu. After repeated use of “Menu” key the menu on the display disappears. If menu is de-activated the arrow keys call from flash-card the previous or next image short correspondingly.
The key «Range» calls on the display the menu of this function. Any changes can be done by means of arrow keys. The key «Scale» calls on the display the menu QUADRANT by means of which it is possible to change the image scale. The jumps between quadrants are provided with the help of arrow keys. When the key “Read mode” is pressed the image is read out from the flash-card. The number of read short is selected from the menu line “SHORT NUMBER”. When “Start” key is pressed the processor inputs the short with preset parameters (ACCUMULATION, AMPLIFICATION) as well as generates a command to switch on the X-ray apparatus, i.e. to start the exposure. After image input the processor converts in the freeze mode. After this the image can be recorded in flash-card by pressing key «Short record». The number of recorded short is determined automatically. Recorded short is output on the display immediately after recording and at the same time the number is registered in menu “Short number”. When working in the autonomous operating mode this option is not available. When the “Stop” key is pressed the processor converts in the mode of “real-time” video.

Conclusions: The mobile X-ray TV complex provides efficient solution of problems relevant to checking and inspection of various items and equipment. Besides bombs it provides detection of hidden eavesdropping devices as well as dangerous inclusions like poisoning, harmful and radioactive substances in the containers. The shadow image obtained during object exposure provides clear identification of its internal structure. When necessary it is possible to make a record of object internal structure image that can be used like reference sample.
In Fig. 5 presented are examples of images obtained with the help of described complex.

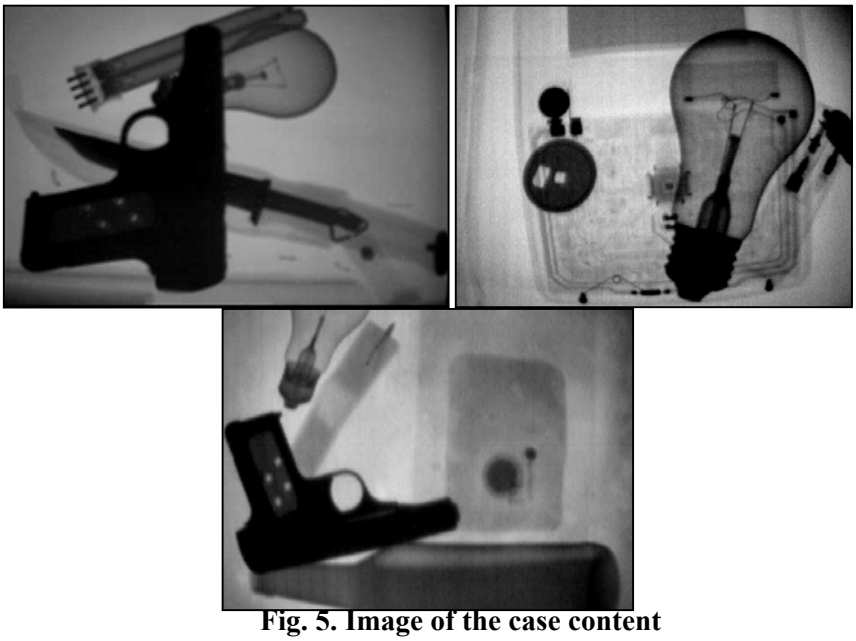

Fig. 5. Image of the case content

Easy and convenient to use the complex guarantees high productivity at high grade detection ability and low radioactive impact on operating personal.

The complex also can be used like a defectoscopy instrument on site. In Fig. 6&7 presented are examples of various type of flaws detected with the help of complex.

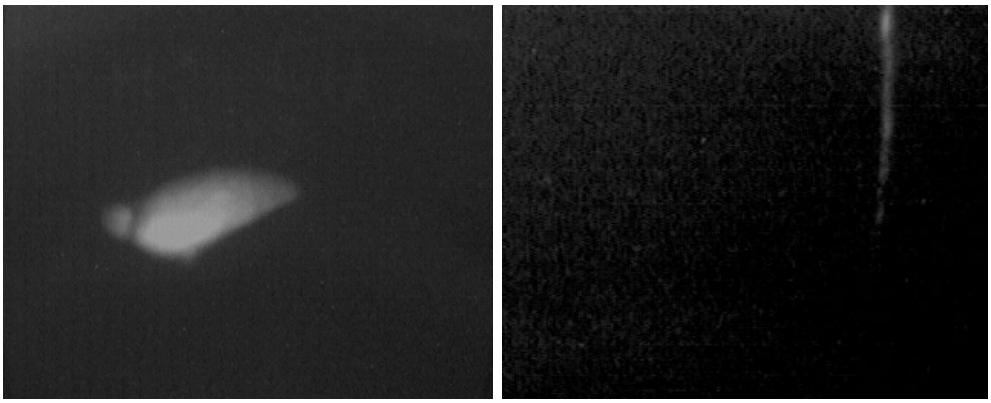

Fig. 6. Detection of blister and crack in the coupler fabricated from light-weight cast iron (the images are obtained in case of projecting amplification)

Fig. 7. Detection of wire connection rupture in all-in-one contact assembly (the images are obtained in case of projecting amplification)