NEW MEANS OF THE THERMOVISION INSPECTION DESIGNED FOR TASKS OF ANTI-TERRORISM SECURITY AND TECHNOGENIC SAFETY

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Abstract: The principal of remote registration of 2D distribution of thermal fields with the help of thermovision equipment makes it possible not only to survey these fields' intensity and shape but to obtain additional information about dynamics of heat exchange between power saturated and other heat radiating objects.
For diagnostics and search tasks the most promising and interesting are autonomous, compact IR-imagers with non-cooled 2D receivers of IR radiation based on hybrid solid-state matrixes of great capacity.
The results of practical realization and applications are presented in the paper

Introduction: Remote registration of the thermal fields distribution with the help of thermovision instruments is very promising for the tasks of technical diagnostics of comprehensive technical systems, installations and elements of industrial facilities. In most cases thermovision equipment is used for survey purposes but in case if it is equipped with additional pyrometric and TV channels it provides performance of optional functions like remote temperature measurement in check points (that in advance are classified like critical ones and have high temperature). It is always important to know how the heat flows are distributed. To solve the tasks relevant to detection of overheated and dangerous areas the best use can be made of autonomous thermovisors with non-cooled 2D receivers of IR-radiation based on hybrid solid matrixes of great capacity.

Results: Two new types of portable non-cooled IR-imagers (thermovisors) were developed; based on pyroelectric and bolometric matrixes. These new IR-imagers additionally are equipped with TV and measuring pyrometric channels. In the new stationary system with longer focus the optic-electron channel is implemented instead of pyrometric one thus providing the solution of additional task (for security purposes), i.e. detection of various optical means at the distance up to 1000 m.
Developed IR-imagers provide efficient observation of objects and secured (controlled) areas during any time of the day and in IMC. The instruments provide visualization of the heat radiating objects and solution of wide range of tasks including very important ones: technogenic safety (diagnostics of structures, buildings, power supply equipment, detection of leakages at oil- and heat supply pipelines and hidden fires); search and observation tasks (detection and observation of the remote heat radiating objects, like people, transportation means, etc.; detection of hidden anomalies, etc.).
The practical trails at various industrial facilities were arranged on land and from air that proved high efficiency of developed instruments.
In the tables 1&2 presented are the dependencies of distance at which the person (and other heat radiating object comparable to person' dimensions) can be detected depending on the focal length of used IR-lens and required resolution in the object plane.

Table 1

Matrix size	View filed angle, degree.	IR-lens focal length, mm					
		9	18	25	50	100	150
320x240 (1")	Maximal (along diagonal)	-	58°	44°	22°	11,5°	8°
	Along horizontal/vertical line	-	46°/35°	34°/26°	18°/13°	9°/6,8°	6°/4,5°
	Instantaneous value, mRad	-	3,5	2	1	0,5	0,33
160x120	Maximal (along diagonal)	68°	-	24°	12°	-	-

(1/2")	Along horizontal/vertical line	54°/42°	-	19°/15°	9,5°/7,5°	-	-
	Instantaneous value, mRad	7	-	2	1	-	-

Table 2

IR lens	Distance to the object (m)					
	50	100	200	400	600	1000
F/ = 50 мм	Along diagonal 18 m	36	72	145	216	360
	Horiz../vert. line 14,5/11 m	29/22	58/44	116/88	172/128	290/216
Resolution in the object plane, (lines/m)	22 (4,6 cm/line.)	11	5,5	2,7	1,7	1,1
F/ = 100 mm	Along diagonal 8,8 m	17,5	35	70	106	176
	Horiz../vert. line 7/5,3 m	14/10	28/21	56/42	84/64	140/106
Resolution in the object plane, (lines/m)	44 (2,3 cm/line)	22	11	5,5	3,6	2,2

Discussion: In 2001 - 2003 at JSC "Spectrum" – RII" (Research Institute of Introscopy of Moscow Scientific-Industrial Association "Spectrum") were developed the following new portable thermovisors of 3rd generation. These are non-cooled instruments operating in the spectral range 8 – 13 mcm:
- Portable thermovisor TN – 4604MB (Fig.1a) based of 1/2// micro bolometric matrix with capacity 160x120 pixels and Minimal Temperature Resolution (MTR) 0,15 ^{0}C, with built in IR-lens (25 mm/1.0);
- Multi functional thermovisor TN – 4604MP (Fig. 1b) based on 1// pyroelectric matrix with capacity 320x240 pixels and MTR 0,1 ^{0}C, with standard removable IR-lens (50 mm/0.7).

a. b. c.

Fig. 1. Thermovisors TN-4604MBБ (a), TN-4604MP (b) and TN-4604MP-100 (c)

In development of the given direction created is the stationary system TN – 4604MP – 100 (Fig. 1c), in which instead the pyrometric channel used is the optic-electron device mounted on rotating platform. This system

provides detection of various optical instruments at distances 20 - 1000 m and has wide spectrum TV camera with long focal length' zoom.
These thermovisors provide watch and survey actions in any time of a day, at practically zero illumination and at IMC as well as help to solve a wide range of tasks. The most important between them are the next ones:
- Technogenic safety provision:
  - thermo diagnostics of buildings, structures of a power electric equipment and various vehicles;
  - leaks detection and ruptures on oil pipelines and heat supply systems, hidden sources of underground fires in peat beds, etc.;
- Conduction of search operations and solution of anti-terrorist tasks:
  - Detection of remote heat radiating objects (persons, animals, vehicles) in conditions of open sea, mountains, deserts, tundra, etc.;
  - All weather and round-the clock protection of secured industrial and strategic objects;
  - Detection of hidden anomalies (non-authorized emptiness, hiding places, congestions of inflammable liquid) in buildings and other construction structures;
  - Detection of contraband and arms during custom checks of transported cargos.

Many other areas of application of mentioned above types of non-cooled thermovision equipment can be listed.
It is necessary to underline some fundamentally important distinctive features of use of $1^{//}$ and $1/2^{//}$ matrixes, as they have direct influence on temperature sensitivity, geometrical resolution and some other parameters.
Without no doubt for the same view field angle and distance to the watched object the thermovisor with $1^{//}$ matrix has two times better geometrical resolution in the plane of object location than with $1/2^{//}$ matrix or for equal geometrical resolution it provides survey of the objects at the distance twice longer.
Nevertheless, if for user the main parameters are weight, size, power consumption and price of the instrument (with relative deterioration of quality of thermal image that still is satisfactory from the practical point of view) then at identical visualization scale and distance to object the thermovisor with $1/2^{//}$ matrix will have two times less focal length of IR-lens will be and hence it proportionally will have smaller dimensions, weight and price. Besides the $1/2^{//}$ matrix (160 x 120 = 19200 pixels) is less expensive in comparison with $1^{//}$ matrix (its capacity is four times more, i.e. 320 x 240 = 76800 pixels).
The mentioned above features are the basic criteria when selecting the size (format) of matrix and IR-lens required for solution of first class priority tasks.
In table 1 above given are the view field angles of such matrix modules depending on the type of used standard germanium IR-lenses.
As an example let's refer to two basic dependences:

- Simultaneously with preservation of the constant sizes of a view field and geometrical resolution in a plane of the watched object with increase of IR-lens focal length the range of detection and recognition of heat radiating objects will increase proportionally;

- At fixed distance to watched object with increase of IR-lens focal length the size of view field is proportionally decreasing and correspondingly is increasing the geometrical resolution in a plane of the watched object.

The distance of target recognition is 1.5 – 2 times less than the distance of their detection.
In the process of the thermovisor operation often appear a wide range of tasks that can not be solved with the help of any standard IR-lens with fixed focal length.
For example, when carrying out survey of landscape in a wide range of distances with the goal at first to detect and further to continue survey of detected heat radiating objects (with additional requirement to examine detected object with bigger zoom to recognize it) only use of zooming lens with variable magnification (zoom lens) can provide smooth change in wide range of proper focal length (as well as image scale and resolution in the plane of watched object).
The change of a focal length in IR zoom lens is carried out mainly within the limits of 20 - 100 mm (5^x - multiple scaling) or 50 - 150 mm (3^xx - multiple). Simultaneously the TV channel of the thermovisor is equipped with proper small size zoom lens (working in visual spectrum range) with the same range of view field angles.

Below in Fig. 2 & 3 presented are images of persons and vehicles at various distances obtained with the help of thermovisor TN - 4604MP with IR-lens 50/0.7.

50 m 100 m 150 m

Fig. 2. Images of person detected at various distance.

Fig. 3. Example of detected with the help of thermovisor persons and vehicles.

In table 2 above presented are values of view field sizes at various distances to watched objects (for thermovisor with $1^{//}$ matrix and two types of used IR-lenses).
Practical results of development of thermovisors, in which various concepts were realized, essentially expand their functional abilities to solve special and standard (machine building, energy, construction and transport industry) tasks in many areas of application and creates good basis for further prospective development of this direction.

Conclusions: Practical trials of developed equipment (on land and from aircraft) at civilian heat supplying lines, extended oil pipelines, airport runaways, hydro technical constructions, power plants, nuclear power plants and in living premises proved its high efficiency for detection of newly developed heat anomalies in examined objects (see. Fig. 4).

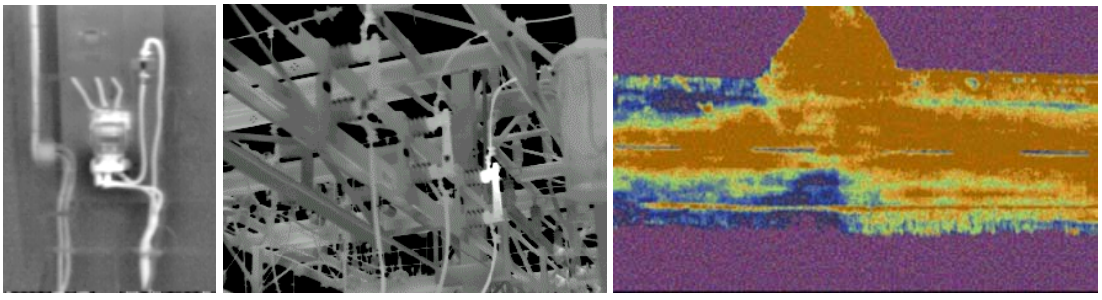

Fig. 4. An examples of thermovisors use for technogenic safety provision: revealing of emergency and fire hazardous elements of electric systems; diagnosing of a condition runaways in airports.
The non-cooled thermovision equipment find more wide use in aircraft, refinery and defense industries due to use of new portable and non-cooled computerized thermovisors providing high geometrical and temperature resolution that help to carry out the thermo diagnostics at higher quality level.

The developed equipment can be used for thermo inspection of energy saturated industrial facilities as well as for solution of anti-terrorist tasks and technogenic safety provision

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