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B.A.Utochkin

ON POSSIBILITY TO USE IHEP MEASURING-PROCESSING CENTER FOR THE SOLUTION OF THE PROBLEMS OF LAND INVENTORY AND CREATION OF THE LAND CADASTER

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Abstract

Utochkin B.A. On Possibility to Use IHEP Measuring-Processing Center for the Solution of the Problems of Land Inventory and Creation of the Land Cadaster: IHEP Preprint 96-30. – Protvino, 1996. – p. 23, figs. 19, tables 1, refs.: 3.

The capabilities of the IHEP MPC systems are considered from the point of view of their applicability for the solution of the problems connected with automatization of processing the information about land resources (land inventory) and creation of the land cadaster.

Functional possibilities and basic technical characteristics of most efficient processing systems, i.e. automatized projectors PUOS-4, projectors-scanners PUOS-4C and high speed scanning device HPD, are discussed.

The results of practical application of these systems for the solution of concrete land problems, e.g., for the creation of electron-digital maps of scales 1:500, 1:2000, and for scanning aerophotos, are presented.

Аннотация

Уточкин Б.А. О возможностях применения измерительно-вычислительного комплекса ИФВЭ для решения задач по инвентаризации земли и создания земельного кадастра: Препринт ИФВЭ 96-30. – Протвино, 1996. – 23 с., 19 рис., 1 табл., библиогр.: 3.

Рассмотрены возможности систем измерительно-вычислительного центра ИФВЭ с точки зрения применения их для решения задач автоматизации обработки информации о земельных ресурсах (инвентаризации земли) и создания современного земельного кадастра.

Обсуждаются функциональные возможности и основные технические показатели ряда наиболее эффективных систем обработки, а именно: автоматизированных проекторов ПУОС-4, проекторов-сканеров ПУОС-4С и скоростного сканирующего автомата HPD.

Приведены результаты практического применения этих систем для решения конкретных земельных задач, например для создания электронных цифровых карт масштаба 1:500, 1:2000 и для сканирования аэрофотоснимков.

In the 70-80's a unique measuring-processing center (MPC, IHEP) was created by the joint efforts of the Institute for High Energy Physics and other institutions and enterprises of the country. The centre was assigned for automation processing of the pictures from bubble chambers, wire and streamer chambers. For the past period more than 12 million events from different stereopictures were processed at the MPC scanning-measuring and automated devices.[1] This allowed the physicists to find out and formulate on the basis of significant statistics a number of new important regularities in the field of high energy physics.

The elaborations carried out together with other institutions and enterprises brought into existence new technologies in electronics, optical mechanics, automatization, computer technique, etc., which permitted to construct numerous up-to-date devices and systems for the national economy [1].

By the middle of the 80's straightforward electronic methods of information readout into the storage of computers and its further processing (without photo-registration of the events) replaced the track chamber technique with optical readout of information. This fact entailed a reduction of the loading on the MPC systems and at the beginning of the 90's the largest part of the measuring facilities appeared to be out of use. Indeed, such a situation did not arise all of a sudden. The IHEP authorities provided an opportunity to look for other problems, not physical among them, so as to avoid idling and writing off the unique and expensive equipment, that was in top conditions.

Numerous possibilities to use these devices of IHEP MPC for automation processing of images of the pictures obtained in different fields of science and technique, e.g. biology, medicine, geology, its cosmic methods included, science of metals, ecology, cartography, etc., were thoroughly investigated. Many of them turned out to be successfully solvable, however, their scale and loading volume were obviously insufficient for the IHEP MPC. And only the problem of making inventory and creating the land cadaster of vast lands of Russian Federation turned out to be an interesting and large scale work [2]. This conclusion was drawn after preliminary thorough elaboration of the problem together with the experts from Moscow Region Land Committee and Russian Federation Land Committee.

[1] All in all MPC had 32 measuring-processing systems.

In 1995 an independent self-supporting department, the regional center of cadaster information technologies (RCCIT), was founded at the SRC IHEP. Its main activity was to solve problems concerning the land. Two principal parts can be singled out in the MPC structure: system-technical, which includes computers, and software.

1. System-Technical Part

The system-technical part of MPC allows one to realize two measurement techniques (automated digitizing) for the images on the pictures:

– manual (semiautomatic computer-controlled one),

– automatic scanning[2]under the computer guidance (a possibility of the operator to interfere at any stage of scanning and processing is foreseen).

All known scanning methods are applied: a fast one using the high resolution CRT light spot, fast optical-mechanical scanning with a rectangular raster and the raster of Arkimedas spiral, fast scanning using the CCD array (lines) with mechanical displacement over the frame, drum-type scanners, etc. All MPC systems are assigned for the operation with the images on films only (the frame sizes are from 70 x 240 mm^2 up to 300 x 300 mm^2). In what follows we shall deal with the systems, that turned out to be applicable and efficient for the solution of the land cadaster problems.

1.1. Semiautomatic scanning-measuring projector PUOS-4

Ten operational scanning-measuring projectors PUOS-4 are available among the apparatus of IHEP MPC. Their operational principles can be understood from Fig.1. The main technical characteristics are given in Table 1.

The PUOS-4 projector is a large-size photomagnifier, occupying two floors. The optical-mechanical part (2 pieces in the room of 25 m^2) i.e. the support, precision frame, projectors and projection objectives, reference systems of high precision on diffractive grids, electric drive and electronics rack (see fig.2)

The working place of the operator is on the lower floor (see fig.1) which consists of a large projection table (the operators "table") on which the controlling computer (IBM PC/AT 586/486 type) and the operator-computer dialogue (interactive) system are located. The operator-computer dialogue system includes a trackball (the position ball), a measurement cross and a signal mouse.[3] The mouse is on the left hand side and the measurement cross is on the table right in front of the operator (Fig.3).

The massive and very stable frame (Fig.4) is displaced along two mutually perpendicular directions with the help of the electric-drive with digital control (either directly by the computer programme, or by the operator who uses the trackball for this purpose). All displacements of the frame are registered by the diffraction grid and forming electronics so that the computer receives all counts of the frame displacements (in the reverse mode

[2]For each of the measured raster the computer receives a 3-dimensional matrix, containing x and y coordinates and blackness density γ.

[3]Separate from the computer mouse.

Table 1. Performances of the Automated Projector PUOS-4

Maximal sizes of frames on films	up to 300x300 mm^2
Optical magnification	15, 60 (in the table-screen plane)
Resolution of the optical channels	80-100 lines/mm
Reference unit	0.5(1.0) mk
Maximal speed of displacing the frame (along X and Y axes)	50-100 mm/s
Number of levels over blackening density	(256 level)
For the version projector-scanner PUOS-4C:	
Resolution of the CCD array (fixed) to the film plane	15(10) mk
Time for one string scanning	1.5 ms
Minimal step between strings in the frame	10 mk
Number of levels over blackening density	8 bits (256 levels)

with the minimal counting unit of 0.5 (1.0) mk). The measuring and scanning procedures consist in the following. First the operator following the given algorithm observes on the optical screen the projection image of the picture, which is being measured at the moment (it is fixed in the frame). Besides a general observation at a wide optical angle the operator with the help of the trackball can quickly bring closer any part of the image and study its detailed structure. The process of preliminary viewing may also be realized in an automatic mode (i.e. using the programme), however, the operator can interfere in this process at any moment. After preliminary handling of the picture image with a significant magnification (15, 60) the operator proceeds to measurements. The measurement procedure consists in the fact that the operator using the trackball brings the points of the image, that he finds interesting, to the cross and with the buttons on the signal mouse sends commands to the computer. At once the computer displays the images of the measured points (contour, fragment) and finally of the whole picture or of its largest part. The automated projector PUOS-4 possesses some constructional advantages:

– the massive and very stable construction of the system as a whole and of its separate units (e.g. the frame, the guides, and the support, etc.), which provides a very high accuracy (0.5 mk) and guarantees durable stability under intense working conditions (up to 16 hours/day);

– indicators of high precision (diffraction grid) of stable construction (Fig.5);

– high quality mobile junctions between the electrical drive and the frame in the form of unique "ball pairs" screw-nut, which are precise helical bearings (7 steps along the shaft of a larger diameter).

During intense and long exploitation (but regular maintenance) no errors or instabilities caused by the optical mechanical system, manufactured on a special order at LOMO and GOI (St. Petersburg) were found on any out of 10 PUOS projectors. The transition to the IBM PC/AT 586/486 control, realized by present made the computer system of the facility as reliable as the optical mechanical one.

1.2. Interactive scanning-measuring projectors scanners PUOS-4C

In preparing the MPC system for the solution of the cadaster problems two out of 10 PUOS-4 were modified in 1995: they were supplemented with the scanners on CCD arrays.

The interactive projectors-scanners PUOS-4C became unique automated devices, which combine, on the one hand, all possibilities of the scanning measuring projectors for the images on a film, and on the other hand, the possibilities of a modern precise scanner for the images on a film [4].

Standard CCD array scanners with a separate interface printed board, that can directly be inserted into IBM PC/AT-586, are used. The frame synchronization is realized through a corresponding bit of the reverse counter of the diffraction grid of the X-channel in the PUOS projector. Fig.1 shows the position of the scanner within the units of the optical-mechanical system of the projector. The scanner and the electronics board are installed under the frame (on the left). With a semi-transparent (rotatable) mirror and an additional objective, some part of the light that has passed through the picture, hits light-sensitive elements of the CCD array and produces an image of a string (high speed scanning along "Y"). Step-by-step mechanical displacement of the frame along "X" gives successively the initial points of each line and hence, the scanning over the whole frame is realized, i.e. during the scanning procedure a reference system with the coordinates of the part of the picture scanned is produced: Y is const, $Y+\Delta Y$ and X=var, where ΔY is a corresponding pixel of the CCD array, and X=var is the current position of the string on the frame.

Operational modes of the interactive projector-scanner PUOS-4C

A. A semi-automatic mode, when the operator observes the optical image greatly magnified on the table and measures it point by point, feeding the data to the computer.

B. An automatic mode, when after the optical analysis of the picture image on the table (in a convenient wide angular form) the operator initiates automatic scanning of the whole picture (successively by lines, equal in their width to the width of the CCD array or of some section of the picture chosen during the optical analysis.

In this case the string-scanning goes at high speed owing to the CCD array and the frame scanning is mechanical by displacing the whole frame with the picture.

The scanning procedure is controlled by the operator both optically on the table-screen and on the colour CRT screen of a high resolution display(the results of scanning).

Any other home made or foreign scanners of the images on a film lack the mentioned possibilities of the interactive (with an operator) projector-scanner PUOS-4C.

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[4]Similar, e.g., to the DISC scanner of IBM (USA), TOBIN International — its distributor in Russia.

1.3. Raster Optical-Mechanical Scanners of the HPD Type

High speed scanner HPD is assigned to measure images on a film with high accuracy (2 mk) and high speed (20 s/frame of 70x240 mm^2). It operates under control of the IBM PC-486 computer.

The scanning is realized with a light microspot (probe) of the flying spot type being mechanically moved over an image on the film, following the rectangular raster with a high speed over the line (33 m/s) and the average speed over the frame. There are three HPDs at MPC. Fig.6 shows the optical scheme of the scanner HPD. A rotating disk with 8 slits sweeps the light microspot along one coordinate. Cylindrical optical lenses are installed in the slits. A fixed lens is installed under the disk. The light from a high pressure mercury lamp falls upon the crossing cylindrical lenses (in fig.6 – fibers). Since the crossing point of the lenses moves along the fixed lens, the light spot moves along the lens too. This is the way how the line of scanning along the "Y" coordinate is formed. The rotation velocity of the disk is 3000 rot/min. The time of sweeping one scan-line is 2.5 ms.

After passing through the crossing cylindrical lenses the light hits a splitting lens, where it is divided into two parts:

– one part of the light flow goes to the reference channel,

– the other one goes onto the measuring track channel.

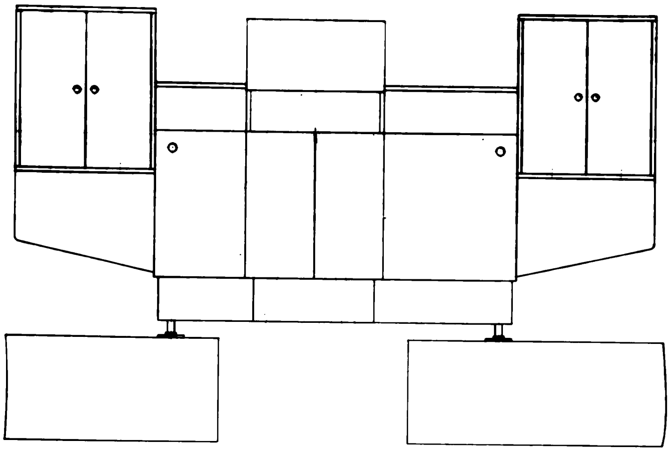
The spot is alligned to the Y coordinate in the reference channel. And in the measuring track channel the light spot crosses a picture with the images of the measured objects. The amount of light that has passed through the film is detected by a photomultiplier (PM) and its electrical signals are fed to electronics to be formed and coded.

The second coordinate of the spot is formed with a counter of the measuring carriage, where the frame is fixed. It is the X coordinate.

Technical Characteristics of the HPD Scanner

Time of sweeping one scan-line	2 ms
Reference unit over Y	2 mk
Reference unit over X	2 mk
Light microspot diameter at the level of 0.5 of Gaussian distribution of luminosity	15-17 mk
Spot velocity over Y	33 mk/s
Carriage velocity X	2-40 mk/s
Resolution over film in the frame	10-12 mk
Measurement time for one coordinate	0.35 mks

The external view of the scanning part of the HPD scanner is shown in Fig.7. Fig.8 shows the electronics and computer, Fig.9 gives an example of digitizing the microfilm of the plane-table.



INTERACTIVE CCD PROJECTOR-SCANNER

OPTICAL SCHEME

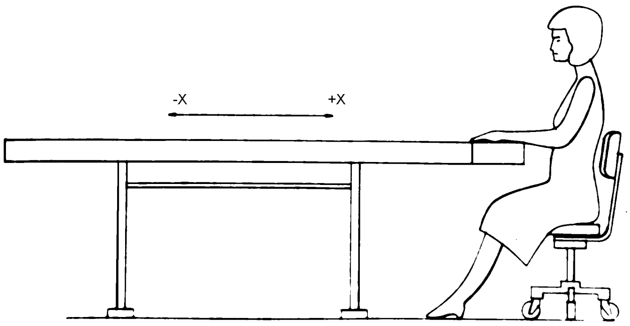


Fig. 1. Working principles of the automated projector PUOS-4.

Fig. 2. External view (photo) of the optical mechanical part of PUOS-4.

Fig. 3. View (photo) of the frame and illuminating system of PUOS-4.

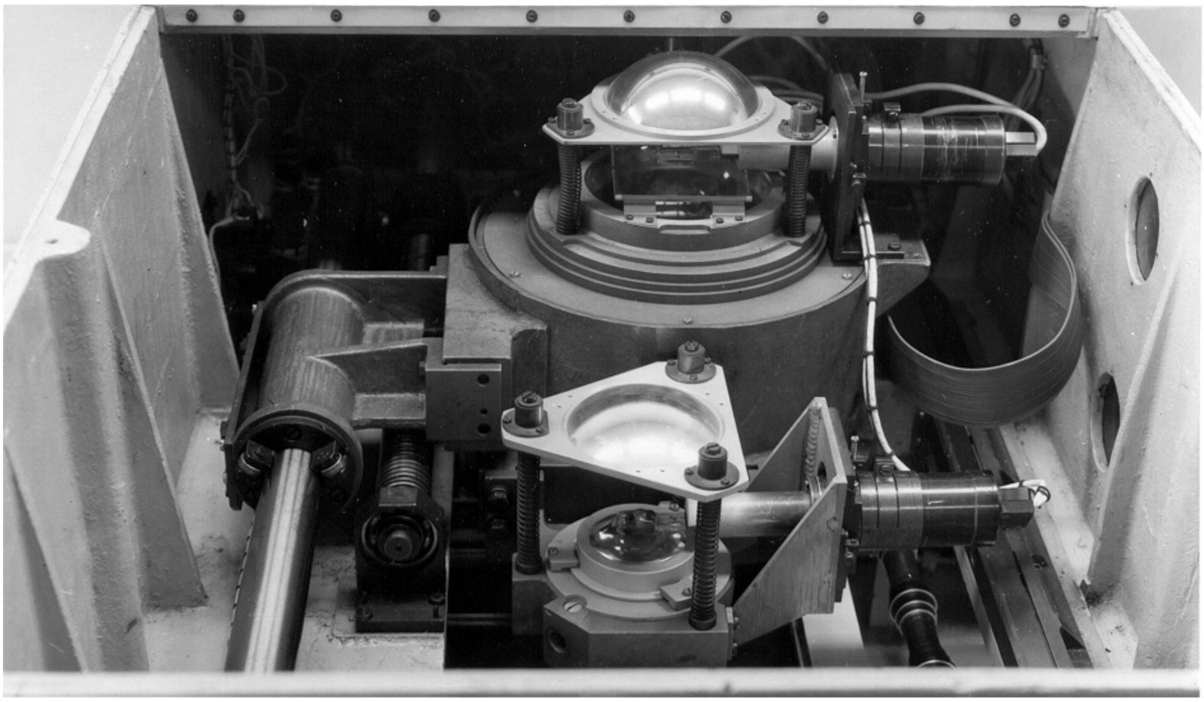


Fig. 4. View (photo) of the frame and illuminating system of PUOS-4.

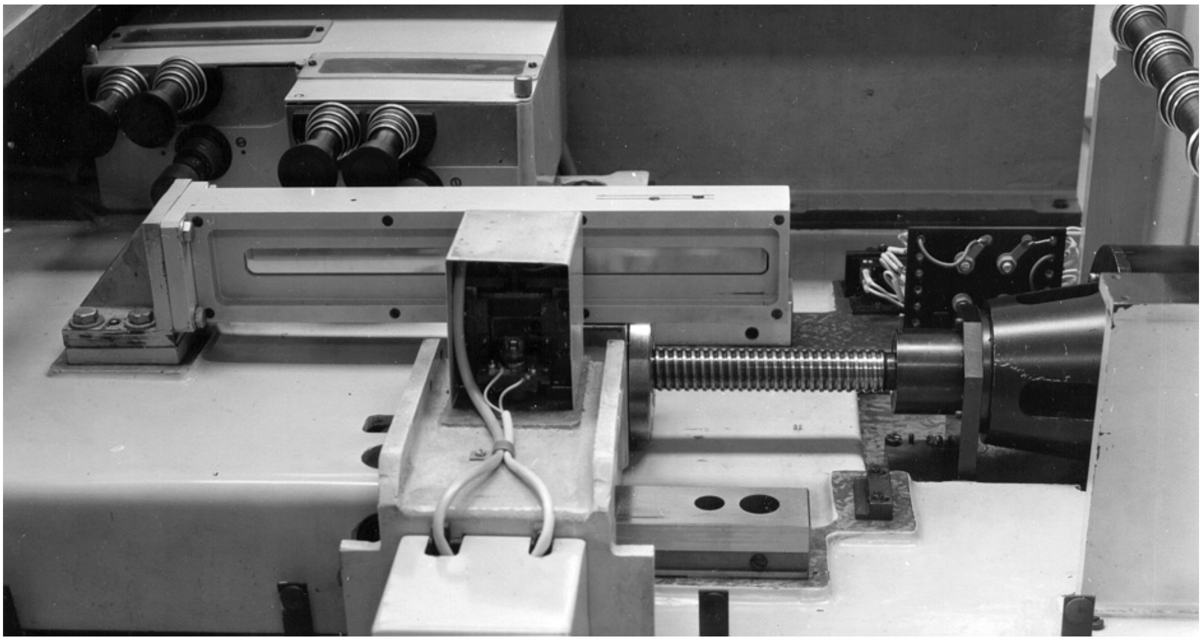


Fig. 5. View (photo) of the reference system — diffraction grid and precision movable device — ball-pair screw-nut.

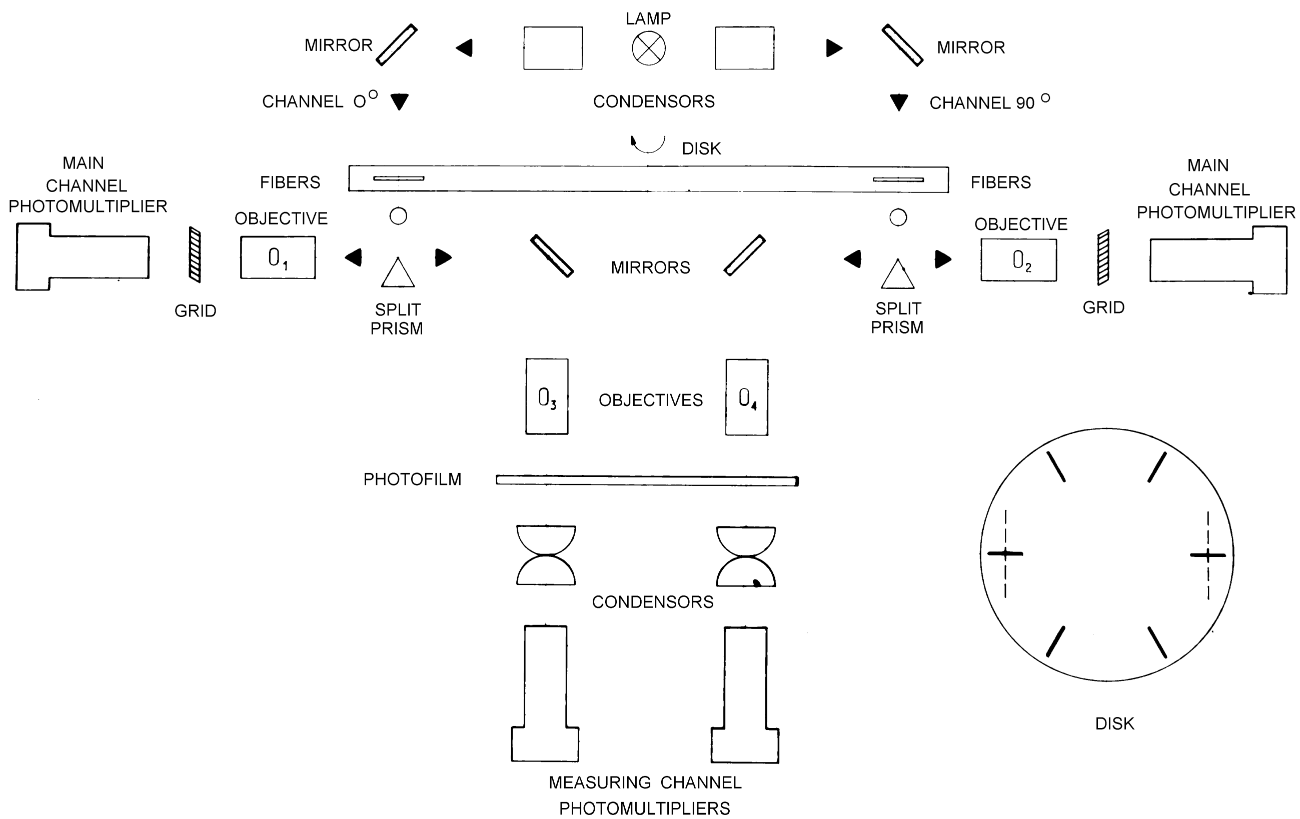
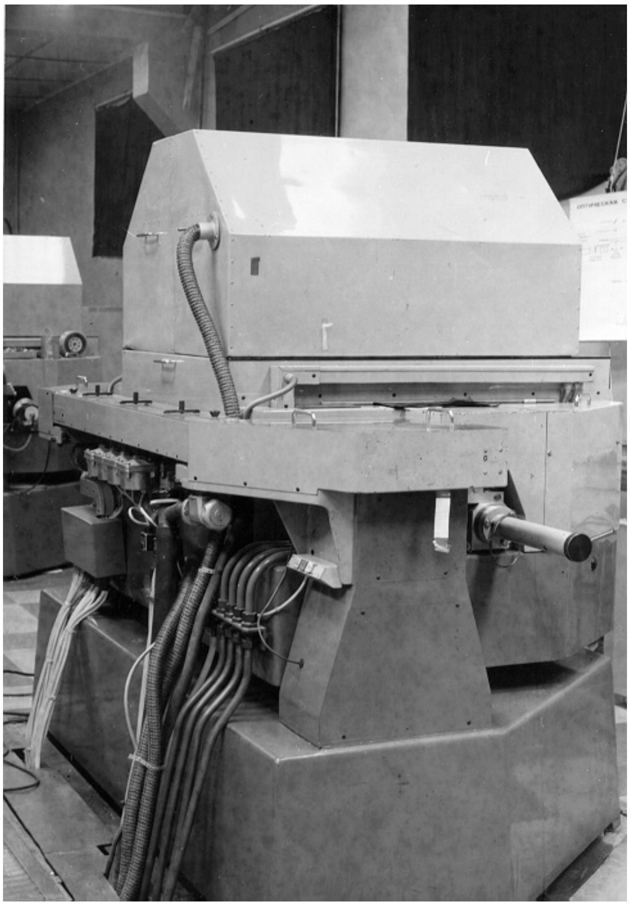
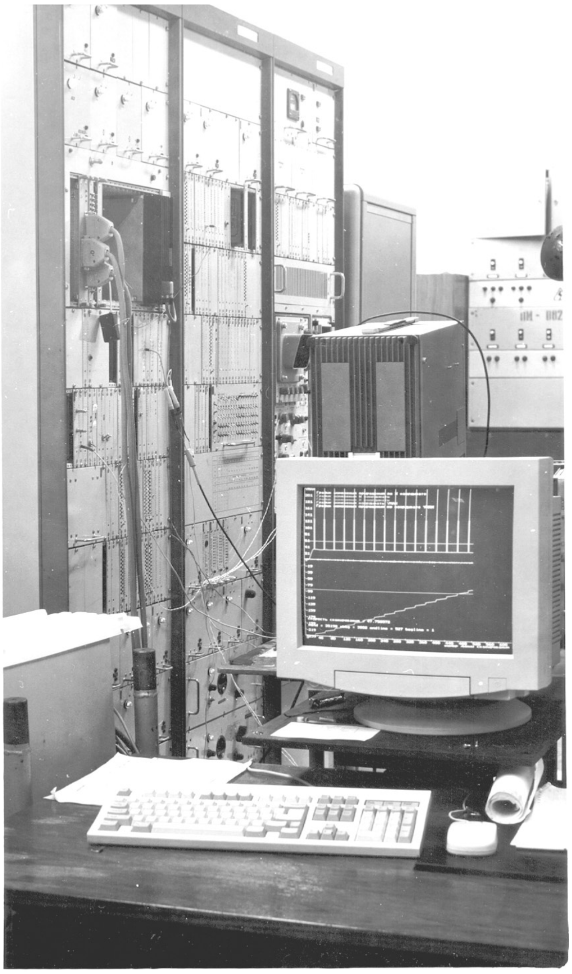


Fig. 6. Optical scheme of the high speed scanning HPD facility.

Fig. 7. External view (photo) of the HPD scanner. ►





◄ Fig. 8. External view (photo) of the HPD control electronics racks.

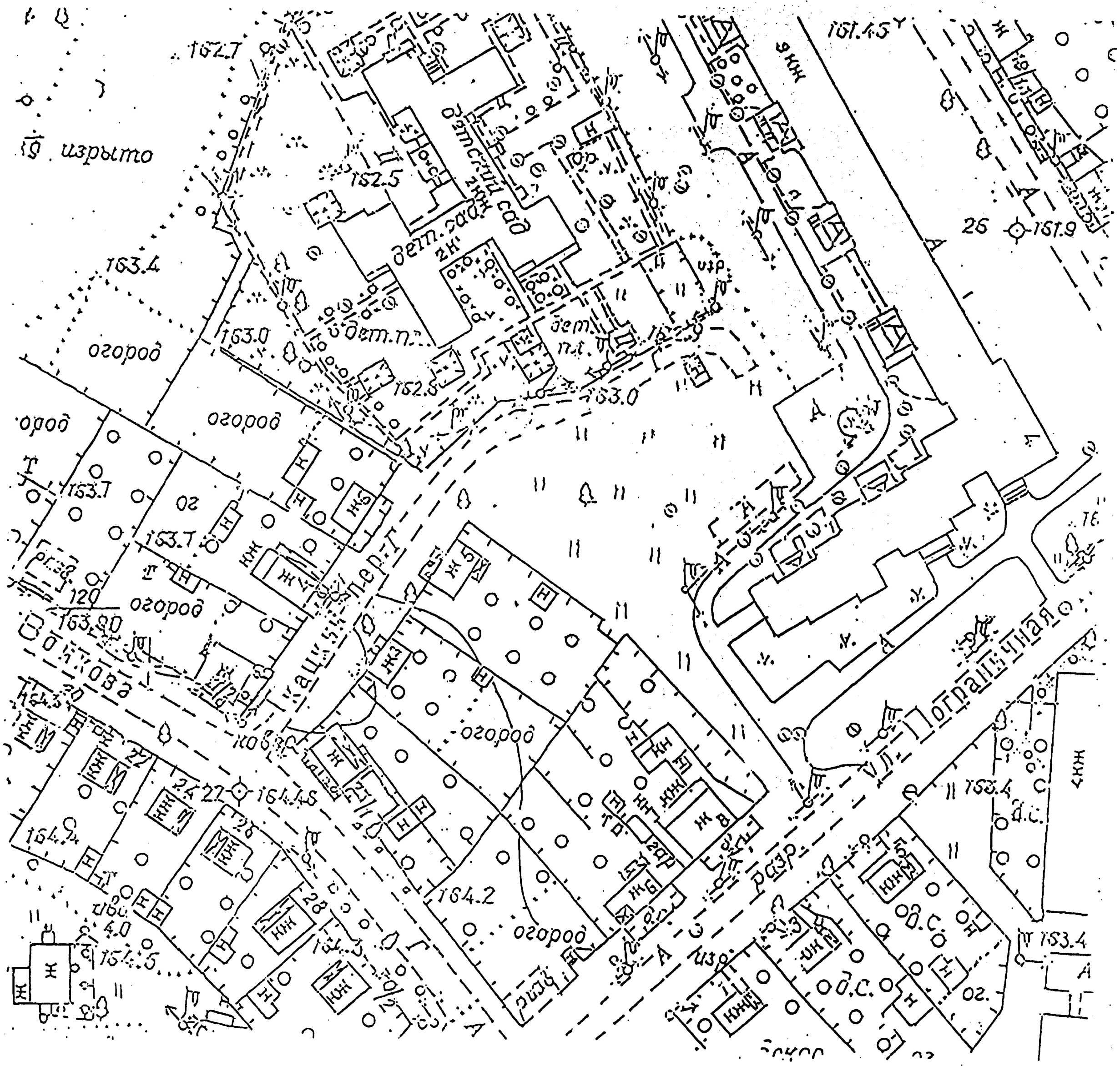


Fig. 9. An example of the results obtained after scanning a microfilm of a plane-table 1:500 with HPD.

2. Digital Cartographing for the Land Cadaster: Peculiarities of the Initial Material and Final Result

The digital cartographing of the land cadaster is aimed at converting different cartographic materials available in a given region of Russian Federation into electronic digital form, namely, of the plane-table of the scales 1:500, 1:1000, 1:2000 for towns and the maps 1:5000 and 1:10000 for countryside, and creating the cadaster computer data base.

Since no large scale maps are available for numerous parts of the territory, and only the data of the cosmic and aerophotography can be used, a particular problem arises, i.e. to find ways of electron-digital conversion of these aerial photographs into large scale plane-tables, e.g. 1:2000 and 1:1000 with further creation of the cadaster data base.

The initial analog cartography material may be in the form:

– plane-tables (plans, maps) 1:500, 1:1000, 1:2000 and 1:10000 on thick paper, on lavsan lining (diazo film) or cardboard; it may be of a square shape (500 x 500 mm) or rectangular (500 x 1000 mm); the lines depicting the locality are black and white, bistable (not half-tint), the minimal width is 100 mk;

– aerophotographs that are nothing else but classical images on a film, the frame sizes – 180x180 mm^2, 230x230 mm^2, 300x300 mm^2, resolution from 30-40 lines/mm up to 100-120 lines/mm, the image is semitinted with a great number of gradation (256 levels and more);

– cosmic photos (will be described separately).

The measuring systems of the IHEP MPC, described above, e.g., the projector scanner PUOS-4C, have large frame windows and allow one to work (to digitize and then to decipher) with aerophotos and cosmic photos on a film.

As for large plane-tables on some non-transparent lining, it is expedient to use first microfilming (i.e. to copy it on a 70 mm film), a plane-table 500×500 mm^2 is photographed on a 70×70 mm^2 microfilm.

Microfilming allows one to solve two problems at once: the initial material is transformed into the form compatible with the MPC measuring processing system and at the same time they will be in the form of modern microfilms. For instance, 427 plane-tables available in Protvino will occupy 10 m of a 70 mm film (or a roll weighing 200 gr) instead of a special storage room.

IHEP has a developed photoproduction and makes microfilms from plane-tables, which is done quite quickly and cheaply.

Hence the input information for processing (to produce cadaster digital maps) at the MPC systems can be provided in two forms:

1) bistable (no half-tint) pictures of the plane-tables on microfilms (sizes 70x70 mm^2);

2) half-tinted pictures of aerophotography on the film (sizes 180x180, 230x230, 300x300 mm^2).

The microfilms of the plane-tables can be processed at any type of the MPC systems (PUOS-4 projector and projector scanners PUOS-4C as well as automatic facilities HPD[5]).

Aerophotos on the films can be processed on the projectors PUOS-4 (in the scanning and point by point measuring mode) and on the projector-scanners PUOS-4C (overwhelming processing, automatic scanning possible). The final result for all variants of the digital cartographing is provided in the form of electron digital maps for the land cadaster and data base.

[5] In the automatic mode of rasters scanning with further vectorization.

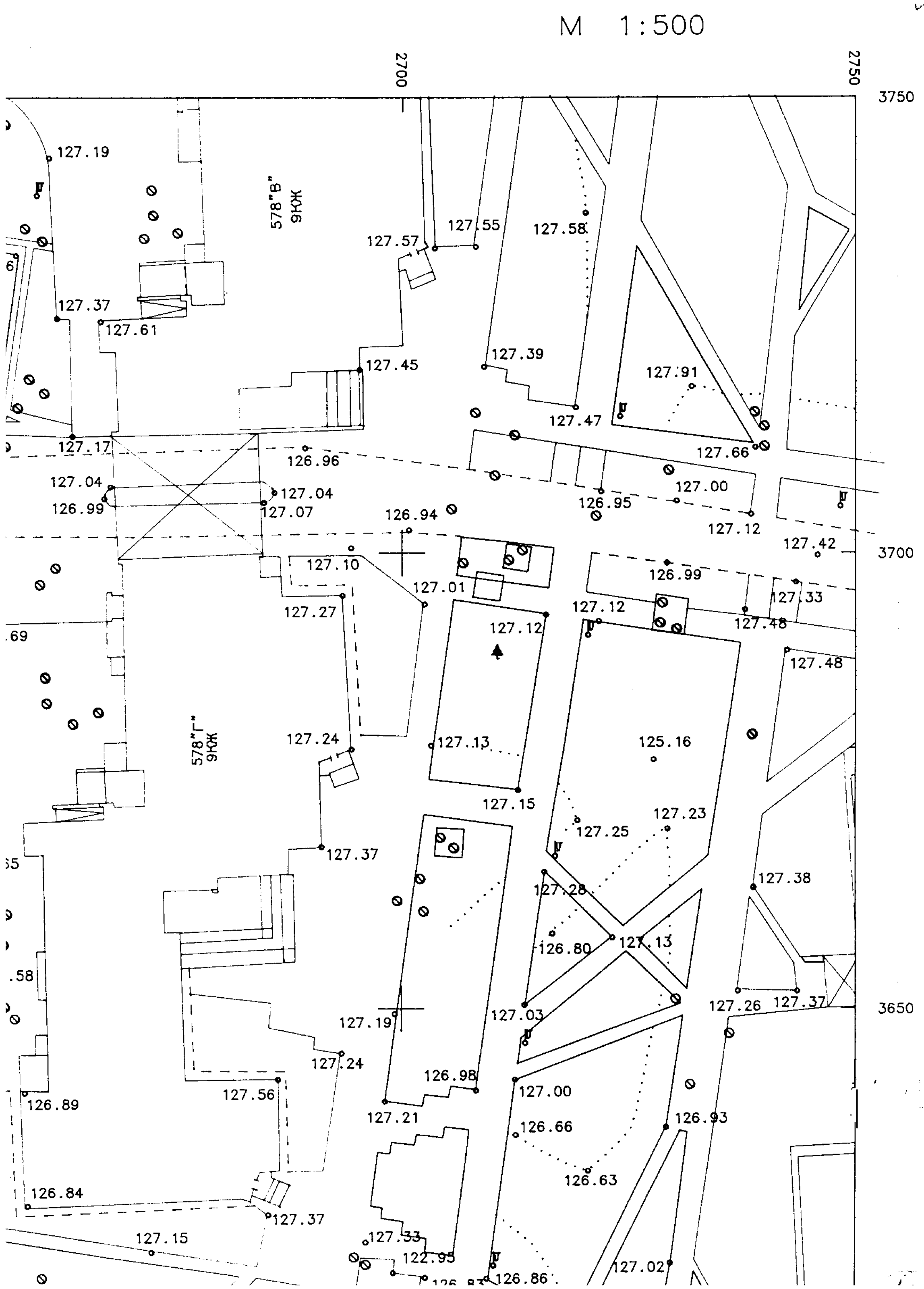


Fig. 10. A fragment (A4) of an electron-digital map 1:500, MPC production.

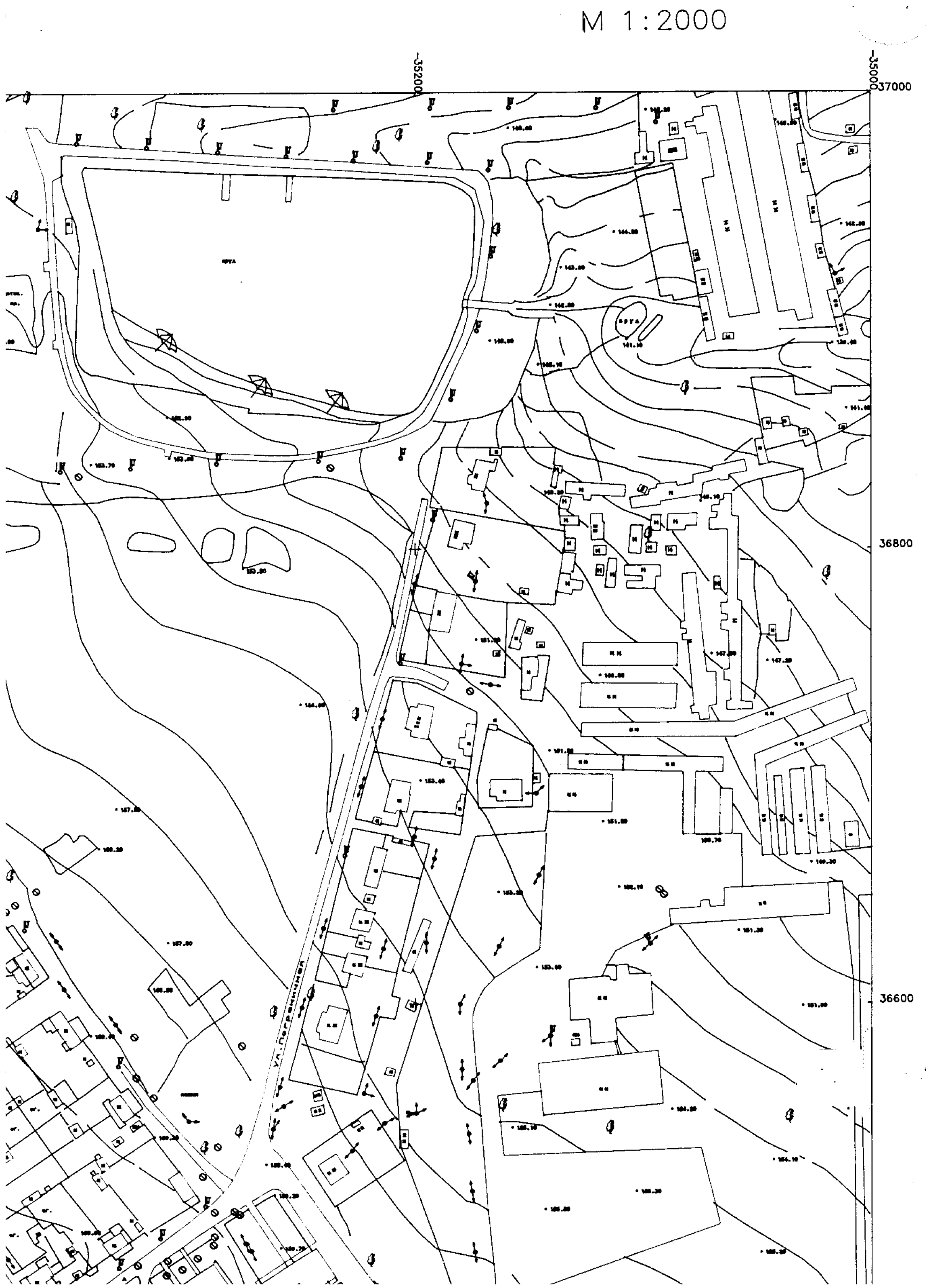


Fig. 11. A fragment (A4) of an electron-digital map 1:2000, MPC production.

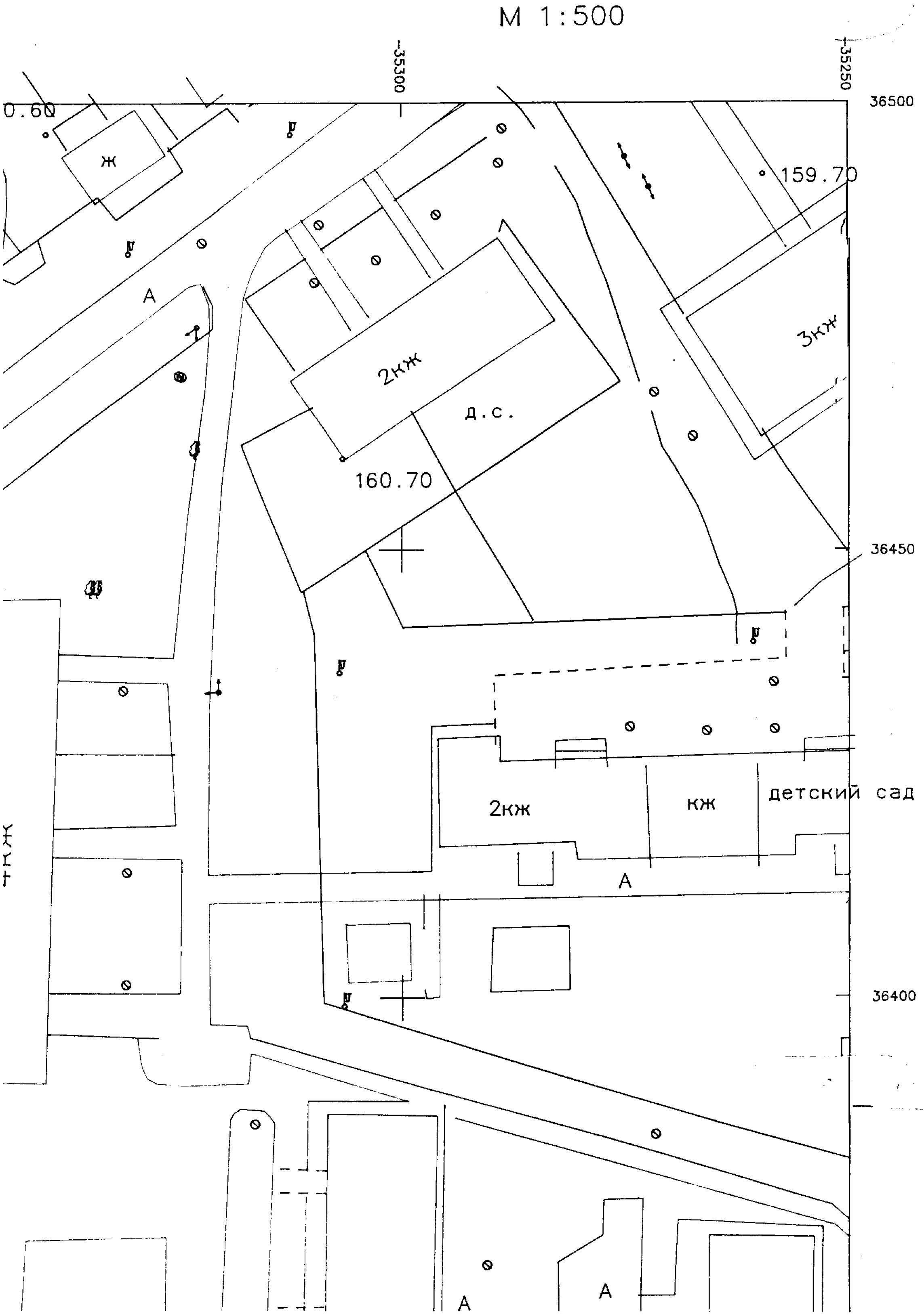


Fig. 12. A fragment (A4) of an electron-digital map 1:500 synthetized from 1:2000.

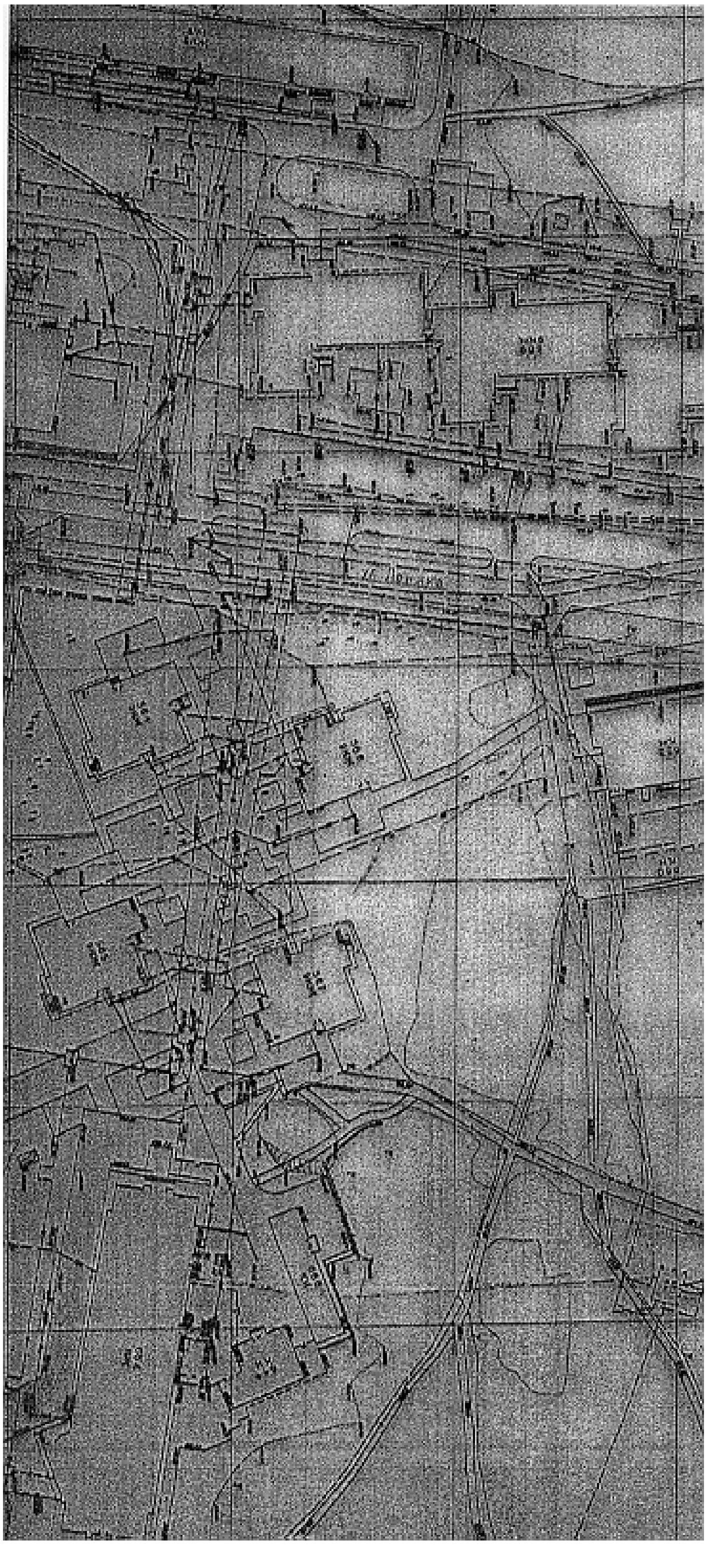


Fig. 13a. The resuslts of scanning a microfilm plane-table 1:500 with PUOS-4.

Fig. 13b. An example of scanning aerophotos (on film) with PUOS-4C.

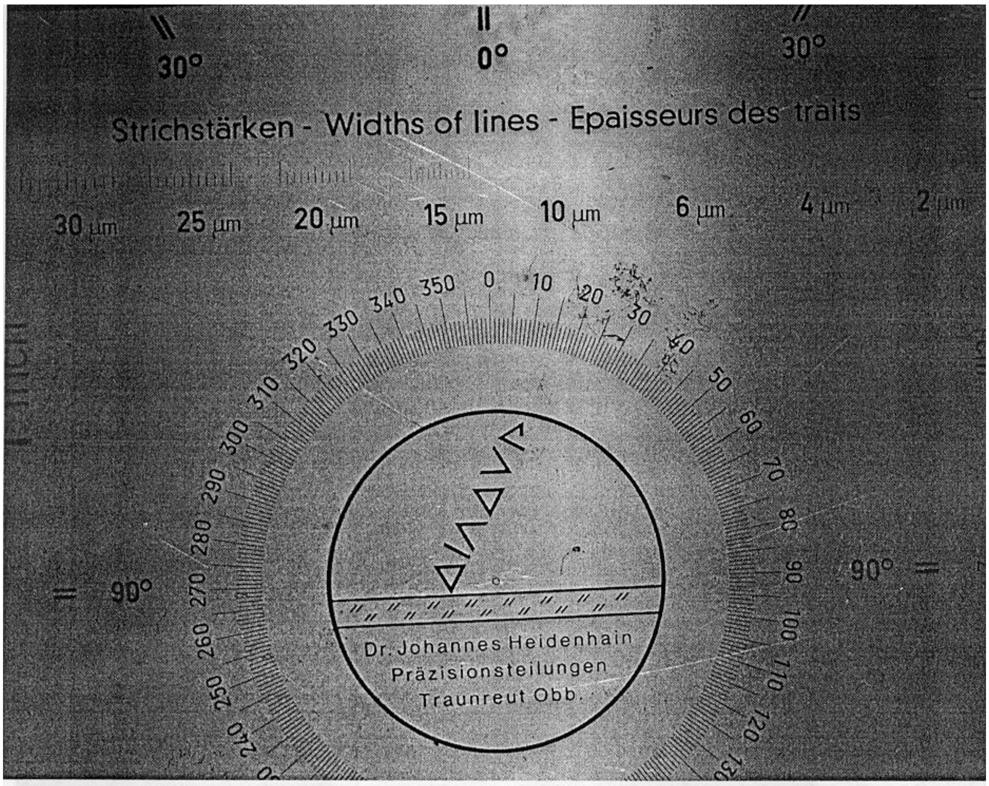


Fig. 14. Test image scanning.

Fig.10 presents a fragment (A4 size) of an electron digital map of 1:500, produced on the basis of an analogous plane-table of the same scale. Fig.11 presents a fragment (A4 size) of an electron digital map (1:2000, produced on the basis of analogous digital plane-table of the same scale.

Fig.12 shows a fragment (A4 size) of a "synthetic" electron digital plan (1:500) made on the basis of digital data, obtained when digitizing the plane-table 1:2000, whose example is shown in fig.11. All in all 16 "synthetic" plane-tables (1:500) were artificially obtained.

Fig.13a,b shows fragments (A4 size) of aerophotos, obtained after scanning (Fig.14) on the projector-scanner PUOS-4C.

3. Software of the Processing System for Cartographic Information on the Basis of the Scanning-Measuring Facilities and Automatic Devices

One of the acute problems of the automated processing of cartographic information is the problem of automatization of the procedure of land cadaster creation. The solution of this problem consists in the following:

– creating digital electron maps (plans) of a region, their maintaining (edition, storage, direct access, etc.), forming and issuing documents on paper carriers, etc;

– creating semantic data base for the storage of textual information on the land cadaster, coordination of this information with a geographic object on electron maps, forming and issuing different kinds of documents.

In accordance with the measuring equipment used at IHEP MPC the software (SW) for the complex is divided into PUOS-4 SW, PUOS-4C SW and SW for the optical-mechanical scanner HPD.

3.1. Software for PUOS-4 and PUOS-4C systems

The basic components of the software for these systems are:

– programmes that directly control the operation of the units of the measuring facilities;

– programmes of acquisition of the measured information and its preliminary processing;

– programmes of further information processing with unified commercial packages (vectorization, transformation into geodetic coordinate systems, keeping archives and data base, etc.).

The main functions of the controlling programmes for PUOS-4 and PUOS-4C facilities are:

– to control the motion (displacement) of the measurement table;

– to control the illuminating system;

– measurement of the object coordinates following the operator's command;

– testing the electron and optical-mechanical subsystems of the devices;

The measurement programme elaborated at IHEP MPC for the land cadaster programme (digitization programme):

– identifies the objects and gives the information about the objects (fiducials, geodetic coordinates, measured points, etc.);

– enlarges the list of the types of objects;

– displays the measured data (objects) corresponding to their types on monitors;

– writes the measured information in a file in the format, suitable for the further processing with the programmes of the automatization system;

– scaled image on the display screen and cancellation of fault images.

The accumulated information is then processed with the programme package CADdy, i.e. additional semantic information is introduced (names of streets, blocks, objects), the plans are matched and put into archives, the cadaster information is introduced (the boundaries of plots, their owners, etc.). Later if needed any fragment of the region can be chosen, its drawing made and then output on the graphplotter. The CADdy package also creates the data base of landowners. The description of the plot was enriched with the landowner's map, invented by Mosoblzem.

Figs.15-19 show the photos taken from the monitor screen, demonstrating the digitizing process and operation of CADdy programme.

When PUOS-4C system works in the automatic mode all the measurement results obtained with the scanner on the CCD array are accumulated in the raster form. Modern systems of processing cartographic information include as a rule developed procedures of processing the raster information from the scanners with CCD arrays (vectorization procedure). At present we are making our choice of a modern commercial programming product (COREL, R2V, IntelVec).

Fig. 15. Digitization of a microfilm of the plane-table 1:500 at PUOS-4 (the beginning of the process).

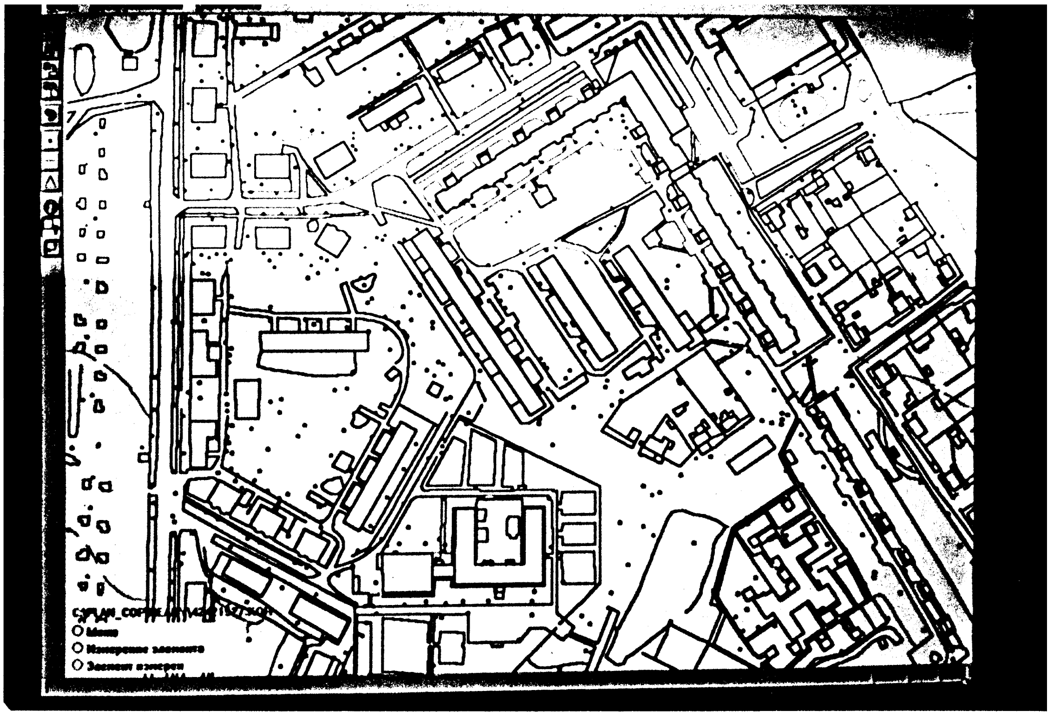


Fig. 16. Digitization of a microfilm of the plane-table 1:500 at PUOS-4 (a fragment).

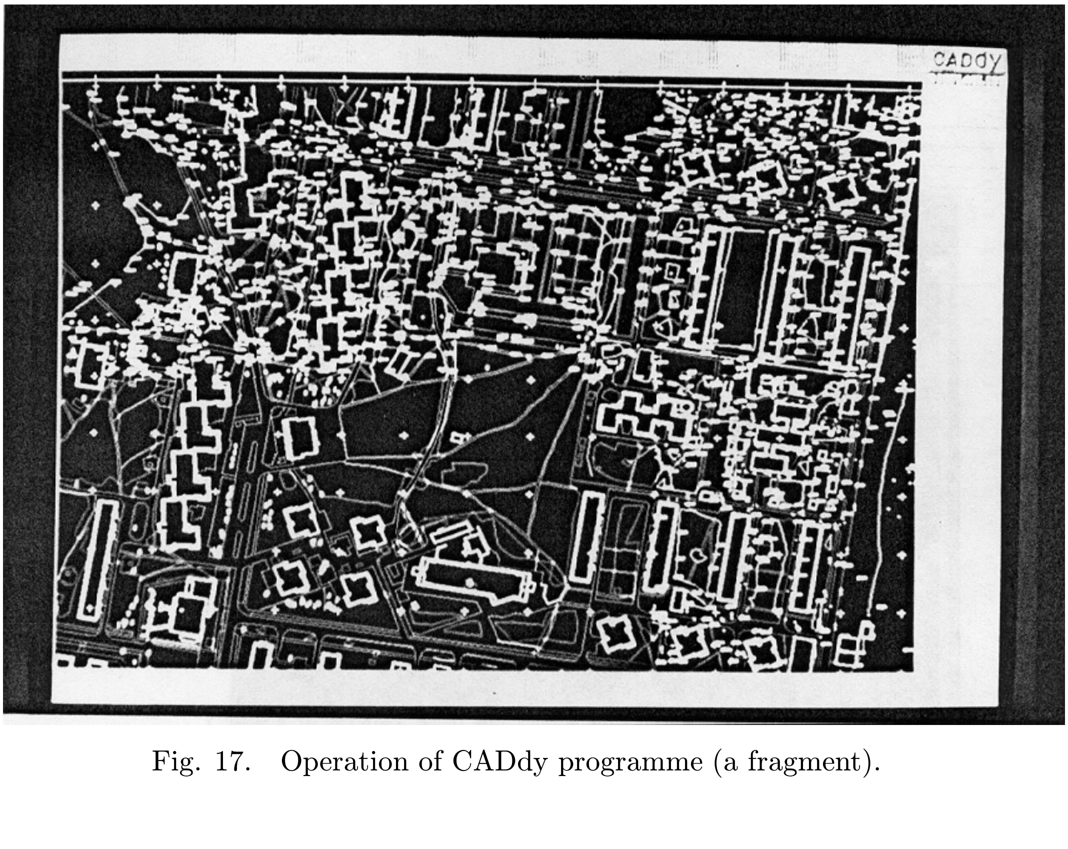


Fig. 17. Operation of CADdy programme (a fragment).

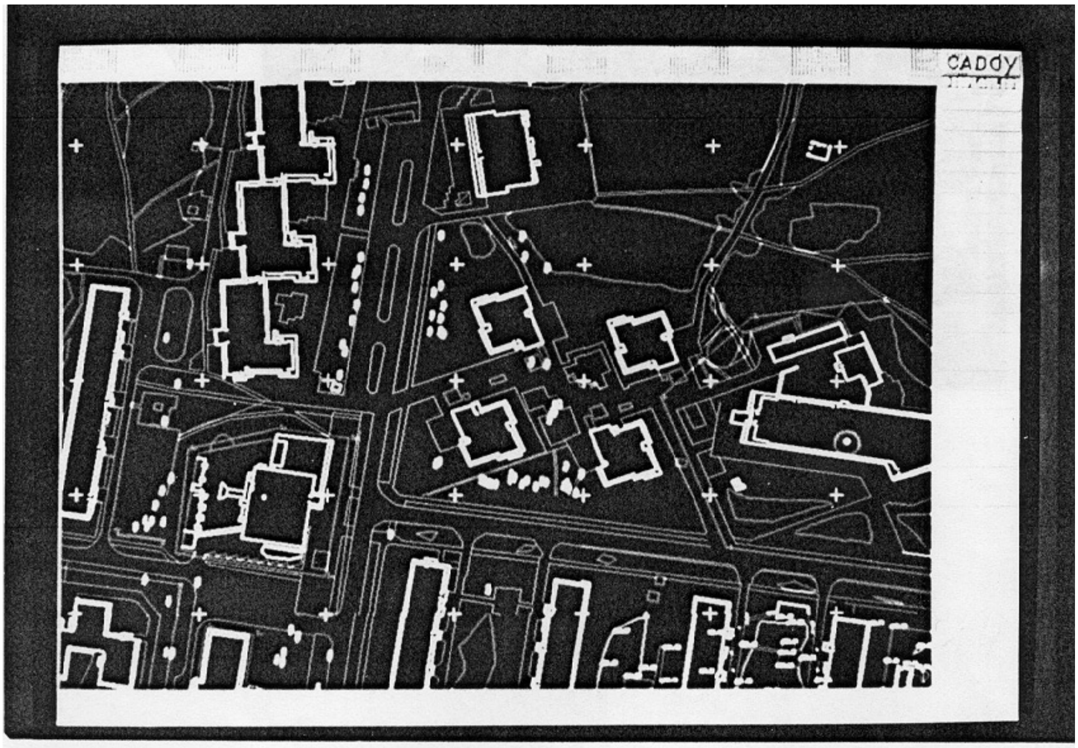


Fig. 18. Operation of CADdy programme (a fragment).

Graphics

Region 50 — Moscow region	**Land category 1**
Area 59 — Protvino	**Land type 2**
Zone 2 — inhabited	**Purpose**
Massive 3 — A8-9B	**Formal area 120000000**
Block 1	**Real area 124008309**
Parcel 1	**Number of buildings 4**
Ownership	**2**
Owner	**IHEP**
Type of right	**1**
User	**Scientific Club**
Document	**2 — - - -**
Series/number/date	
Issued	**Mayorat**
plot	**protvino**

Fig. 19. Operation of CADdy programme. Concluding steps - cadaster passport of the object.

3.2. Software for the scanning automatic facility HPD

The control programme for the HPD-based measuring system receives the results of scanning in two mutually perpendicular directions (normal and abnormal scans), writes them in the disk file of the controlling computer and performs some functions concerning diagnostic and testing the equipment.

For matching normal and abnormal scans calibration coefficients obtained from the processing with the programme of adjusting the measurements of the standard sample, which is a glass plate with crosses drawn on it with high accuracy at an equal distance from each other, are used. The alignment programme fixes the correlation between the coordinates, obtained under normal and abnormal scanning, determines the distortions, connected with the nonlinearity of the scan line and estimates the precise characteristics of the HPD facility. The programme-convertor converts the scanning results into one of standard, widely used graphic formats - PC Painbrush(pox), which is understood by any modern graphic system. At the same time the convertor merges abnormal and normal scans, using the alignment data. The resolution (the sizes of the image in pixels) is given by the operator. The raster file, obtained at the convertor output, may be used in any available system of processing raster information (the upper level) - Corel, PhotoPaint, Photostyler, R2V, IntelVec, etc., and then the data in the vector form is fed to the systems of the CADdy, AutoCAD type.

Conclusion

The goal of this publication is to give a brief description of possibilities to use IHEP MPC potentialities for the solution of some problems concerning the land inventory and creation of the land cadaster after an example of the town of Protvino, Moscow region.

All what has been said above is true for any other region of Russia, particularly for the neighbouring regions: Kalyzhski and Tul'ski.

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In future publications concrete technical and software solutions, created by the researches of IHEP MPC will be described.

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Б.А.Уточкин
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