Advanced prediction procedure for the underground stress manifested in the undermined coal bed works

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Abstract: In nowadays coal exploitation conditions from Jiu Valley coal undergrounds taking into account the safety requests for adequate support and for assuring the stability for coal face due to extending the coal fields necessary to be uncover and undermined to coal bed method impose to forecast the manifestation and estimation intensity mode of mining prevention state is considered more important for knowing the actual situation and to apply the imposed measurements.
Within the context of assessing retain safety in exploitation, the evaluation system which is presented in the paper assumes that monitoring the pressure from hydraulic pillars using individual timber from undermined coal bed is necessary for estimate the exploitation safety.

Key words: coal exploitation, undermined coal bed, monitoring, hydraulic pillars, mining pressure, exploitation safety, data aquizition, front mining works, electronic wiring, serial adaptor, program PC.

1. Introduction

Once applying the 3rd layer coal exploitation with undermined coal bed, which predicts the coal guided drawing from the base layer, followed by the gravitationaly discharge of the coal from the undermined bed, the exploitation safety conditions are getting worse, the mining pressure which activates on the retaining being much more irregular and harder to controlled.

In that conditions for obtaining the high technical-economical indicators at the coal face level it is necessary to find optimal solutions for stability assuring using frames with a high safety degree and with easy maintenance.

Taking into account the diversificated exploitation conditions from Jiu Valley, the adequate types of supporting which will be used have to base on the permanent monitoring of mining pressure through the adaptable processes in dependence with the pressure manifestation the used frames.

Also, correlated with the pillar's tendency to penetrate into the mining work heart, the assessment of the mining pressure must take into account these phenomena too, in the context of associate the measurement interval of the values recorded for the rigid state of the pillar in the case of ensuring a proper contact pressure of the pillar on the heart.

A kind of evaluation system which supposes the monitoring of pressure from hydraulic pillars used for supporting the frames from undermined coal bed will be present in the following pages.

2. The actual conditions for applying the undermined coal bed method

Today, at Jiu Valley's mines are applied four hard coal exploitation methods, such as:
-   Long mechanized slaughter front;
-   Long cutting slaughter with individual support;
-   Short slaughter front;
-   Undermined bed slaughters on which the coal discharge is made behind the front of the slaughter.

All those exploitation methods have the common particularity the splitting the coal layer (the 3rd layer) into slices, with a descending advance of the exploitation and directing the mining pressure by total collapsing of the roof rocks [15], [16], [17], [18], [20].

By method types and applied technological versions, the share of its participation at accomplishing the whole basin's production is presented in figure 1.

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From the analyses of the evolution of applying the exploitation methods in Jiu Valley, results that on the base of reducing the applying domain of the currently used methods, in this case the long cutting slaughters with individual support and those with short front, from 21,7 %, respectively 25 % in 1990, to 7,5 % and 2,6 % in 2009, and the reducing of using the long mechanized fronts, from 31 % in 1990 at 19, 4 % in 2009, because of the lack of required funding sources for accomplishing the investments to acquire the last generation of mechanized complexes, the undermined bed method recorded a continuous expansion in accomplishing the basin's production, recording a participation increase from 0,9 % in 1995 (as a reference date for applying this method for the first time at E.M. Uricani), to 65,2 % in 2009 [16], [17].
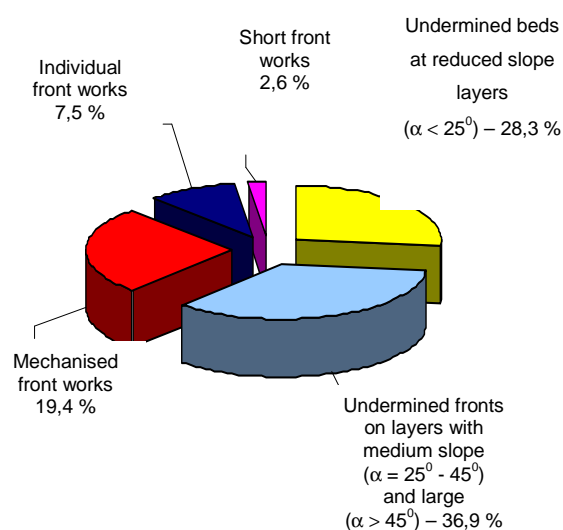

Fig. 1. The type and gravity of participation of the exploitation methods in accomplishing the basin's whole production – 1st trim., 2010 (the difference of 5,3 % from the production's total represents the resulted gravity from preparations)

Depending on the variants of technological exploitation applied, the exploitation method has three technological variants; in percent of 28% for layers of low slope (up to 25%) (Livezeni, Paroşeni, Lupeni, Uricani); 37% for the average slope of layers ($25^0 – 45^0$); and more (higher than 45^0) (Lonea, Petrila, Lupeni).

In a general context, the undermined bed exploitation method consists in coal extraction on the level of base slice, followed by the gravitational discharge of the coal from the undermined bed behind the working front.

Regarding the topology of the mining works applied for opening the deposit, the system of those works is similar to the used one, and in the case of the classic exploitation methods, respectively:
- vertical main pits on the surface;
- blind pits for opening in the depth;
- transversal and horizontal galleries for horizon and block;
- main ventilation climbs.

As a layer preparation method, the systems of the specific mining works applied for the three technological exploitation variants signals the presence of those works in the coal and in the sterile rocks (fig. 2 and 3), the difference being made by the splitting and delimitation method of the layer into slices on slopes and direction of the exploitation panels in the case of reduce slopes exploitation variant (1st variant), respectively horizontal slices and front fields on the layer's direction in the case of high and medium slopes (2nd and 3rd variants).
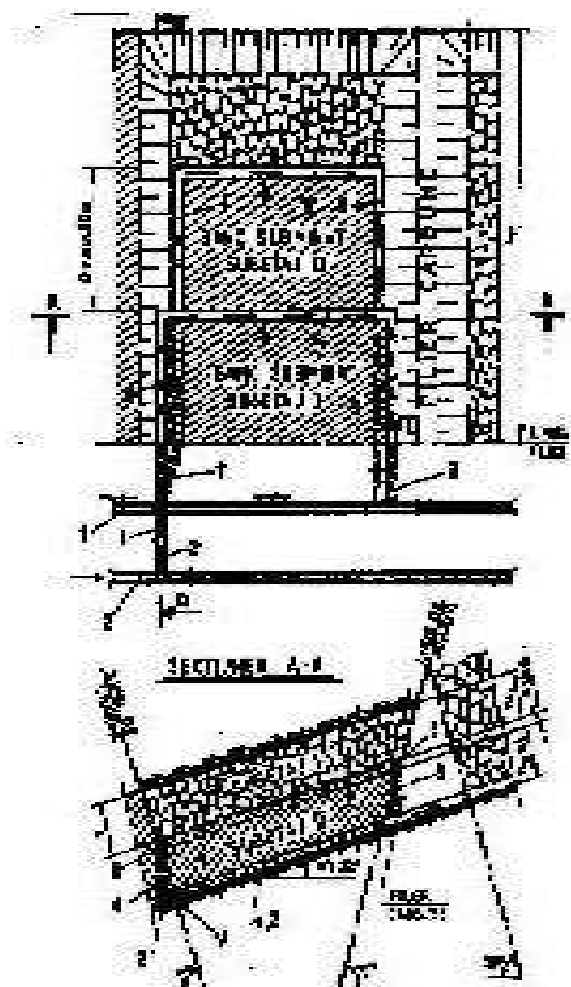

Fig. 2. Undermined coal exploitation method – 1st variant (α layer $< 22^o$ and local α layer $< 25^o$): 1, 2 –

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ventilation and transport plans emplaced in sterile; 3, 4 - link mining works, 1st undergrowth; 5, 6 – directional ventilation and transport galleries made on layer, 1st undergrowth; 7 – attack plan, 1st undergrowth; 8, 9 – directional ventilation and transport galleries made on layer, 1st undergrowth; 10 – attack plan, 2nd undergrowth; 11 – link mining work, 2nd undergrowth; D – horizontal gap between front, m; Lp – exploitation panel length; h_b – undermined bed heigth; h_{sb} – undergrowth exploitation height

Regarding the technology itself applied in the mining works, for all the three current undermined bed exploitation variants, the work phases are simultaneous succeed, on short sections along the mining works line, with compliance of the specific rules of security and work safety, starting with the preparation gallery which have a role of transport (base) to the ventilation gallery (main).
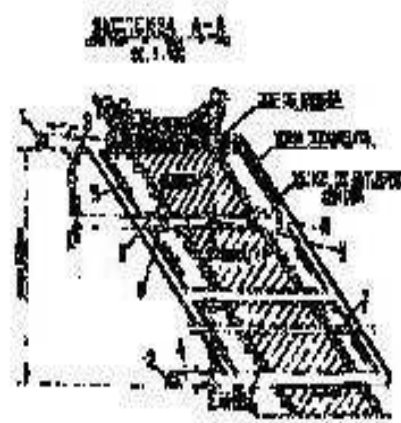

Fig. 3. Undermined coal exploitation method – 2nd and 3rd variants ($25^0 < \alpha_{LAYER} < 45^0$, respectively $\alpha_{LAYER} > 45^0$): 1, 2 – main directional galleries (ventilation) and base (transport) in sterile; 3, 4 – main and base transversal galleries (shoulder galleries); 5 – in bed shoulder slopes; 6 – short transversal attack galleries; 7 – in roof shoulder slopes; 8 – preparing directional gallery made in the bed sterile rocks (2nd variant), respectively in coal, on bed (3rd variant); 9 – directional preparing gallery made in sterile rocks from the layer's roof
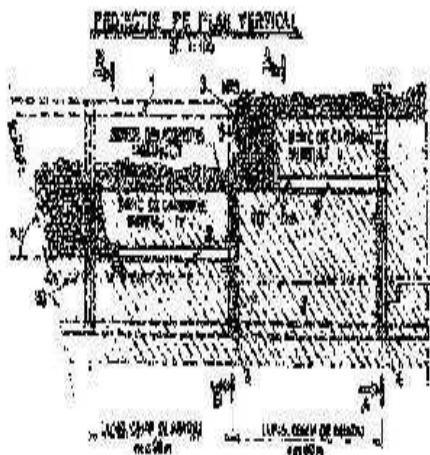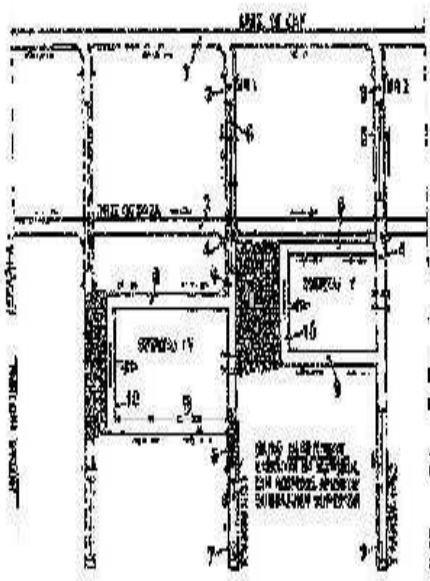
Indifferent of the applied technological variants, the particularity of the exploitation method consists in using of individual support columns and articulated beams SVJ 2500 (maximum 5 pillars/frame) and GSA 1250(maximum 3 beams/frame) and short beams GS 570, mounted in cross system on hanging roof. On the coal face level, the cutting of coal is made using classic perforation – blasting process and mechanical hewing method and high maintenance.

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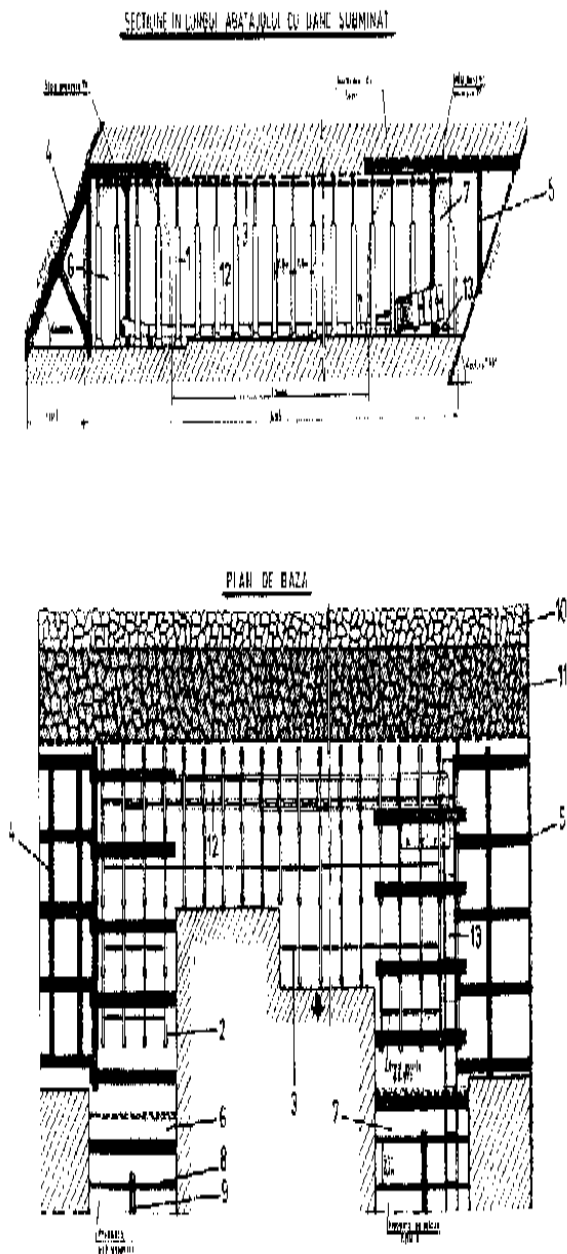SECTIUNE IN LUNGUL ABATAJULUI CU DAME SUBMINAT

PLAN DE BAZA

Fig. 4. Support monograph and work equipment for undermined bed work: 1 – SVJ – 2500 hydraulic pillars; 2 –GSA – 1250 articulated beams; 3 – stretchers (GS – 570 short beams); 4 – roof support pom; 5 – bed support pom; 6 – base directional pre-hewing (ventilation); 7 – main directional pre-hewing (transport); 8 –GDM – 8 metallic support; 9 – bail rafter; 10,11 - sterile, respectively mellow coal; 12, 13 –TR 3 scrapers, in hewing and respectively in transport pre-hewing.
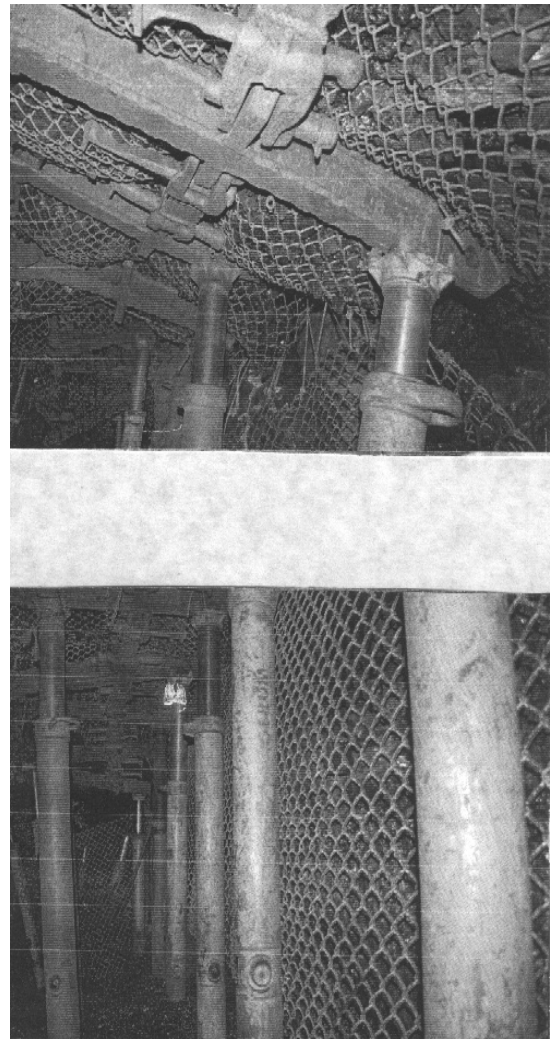

Fig. 5. Individual support composed by SVJ - 2500 pillars, GSA – 1250 articulated beams and GS – 570 short beams (stretchers), plus metal net for dressing used on undermined bed hewing

The hewing coal transport and support equipment layout mode is presented in figure no. 4, and details regarding the assembly mode of the individual support components are presented in figure no. 5.

At the hewing level, the coal cutting is made with the classic drilling-blasting procedure and partially with the pick hammer in the case of low-strength and high friability coal.

Besides the advantages, the undermined method, in its variant of using the individual support, records a series of disadvantages, such as:

- High timbering density using hydraulic pillars which determs a havy work on the coal face level and a high degree for disaster riscks;

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- Using the articulated support beams mounted on network it is necessary supplementary work volume as in the supporting phase of new cutting layer even as in the mining pressure leading phase when the coal is gravitational unloaded from undermined coal bed. Due to the fixing wedge- arch stone system between beams, the coal face cycle duration is growing till 20 shifts, respectively 5 days/4 shifts/6 hours each which involve unsatisfactory results and huge work consumptions.
- A big duration of coal face cycle favor the manifestation of maximum pressure vector which work above the frame, the hydraulic race is made with difficulty for assuring convergences of 300-400mm and forces about 300kN/pillar. Through the uncontrolled hydraulic courses appear some shortcomings in the supporting pillar operate which involve the shutting off and stiffing them, or losses under control of race through the destroying of hydraulic elements.

The importance of using in this case of some performing mining pressure monitoring processes from undermining coal face become as so warrant taking into account the rational mode to occur in prevention and control of drawbacks as to repair or replacing total or partial the damaged frame's elements. On the other hand the approaching is important for necessity to find new types of frames based on reducing the number of elements and the mechanization of mounting-demounting operation.

3. The describing and presentation of monitoring system

The monitoring system proposed take into account an electronic equipment for information acquisition and a program for PC for memorized data process and take the results under diagram's form. Between the acquisition system and PC appear a serial adaptor.

3.1. The data acquisition system

The achievement of the desired performance can be accomplished by using 8 bits microcontrollers, built in "LOW POWER" technology. The data storage will be made in the internal RAM. The time base will be ensured by a timer incorporated in the microcontroller.

Basically, the data acquisition system provides in its parts a signal level adaptation block of the electrical signal supplied by the pressure transmitter, an adaptation block for the serial communication and PC presence detection, a supply block and a microcontroller (fig.6).
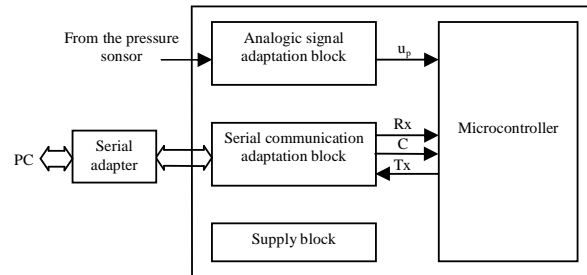

Fig. 6. The block scheme of the acquisition system

Notice that between the acquisition system and PC is interposed an serial adapter. This couldn't be included in the acquisition system because it will be translated in a substantial electric consumption increase .

The establishment of the required memory size for covering the imposed requirements are made starting with the sampling period (1 minute), from the minimum operating interval (2,5 days = 60 hours = 3 600 minutes) and from the memory space required for storage a record (1 byte):

$$2,5 \times 24 \times 60 = 3600 \text{ bytes}$$

To acquire an analogical signal with a resolution of at least 8 bits, is proposed the using of a microcontroller type ATMEGA 128 L, with 4 Kbytes RAM memory and 4 Kbytes EEPROM memory. This type of microcontroller is produced by ATMEL and is optimized for a low energy consumption [1], [2], [3], [6], [16].

The electronic scheme of the acquisition system (fig. 7) overhear as a central element the ATMEGA 128 L microcontroller of which safe reset is guaranteed by the Q1 component, of MCP 120 type. Was chosen a low speed for the oscillator, respectively of 1 MHz. The J1 connector allows the programming of the code memory flash type of the controller. The J2 connector intercedes the electric supply. An incorrect polarization have as effect the entry of the diode into a direct conduction and the disconnection of the F1 reset fuse.
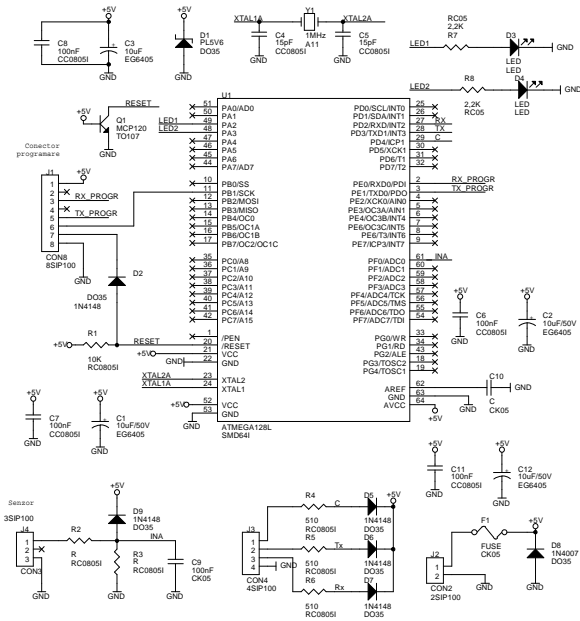
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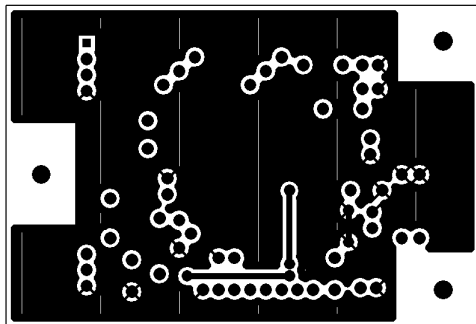Fig. 7. The electronic scheme of the acquisition system

Fig. 9. The electronic wiring of the acquisition system – the soldering side

The J4 connector must be available from the outside, allowing the coupling of the acquisition system to the force sensor. Another outside available connector is J3, its main function being the insurance the serial connection between the system and a computer.

The electronic wiring is double plated, being scheduled with a mass plan on the both sides (fig. 8 and 9).

Due to the fapt that the used microcontroller is SMD type SMD, was chosen the variant of its placement on the soldering side, although it is not visible from the component side, its pills being visible only on the soldering side (fig. 10).

The serial adapter interposed between the acquisition system and computer contains a TTL/RS 232 driver (fig. 11, 12 and 13).
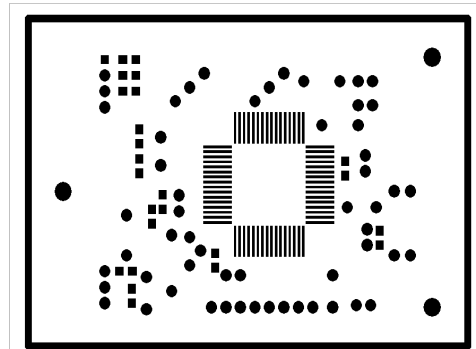

Fig. 10. The electronic wiring of the acquisition system – pills emplacement (soldering side)
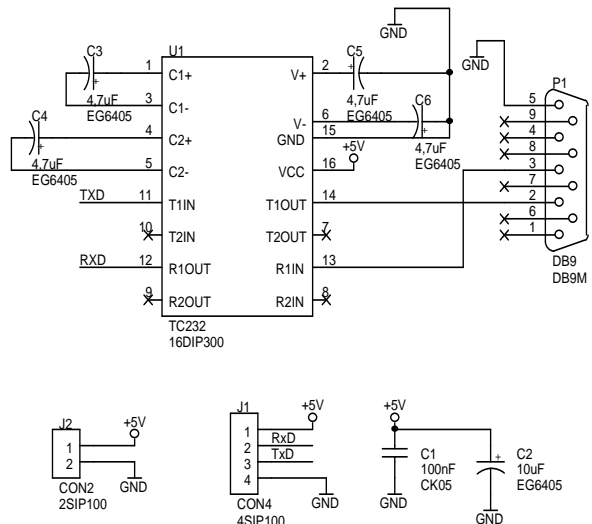

Fig. 8. The electronic wiring of the acquisition system – the component side

Fig. 11. Electronic scheme of the serial adapter

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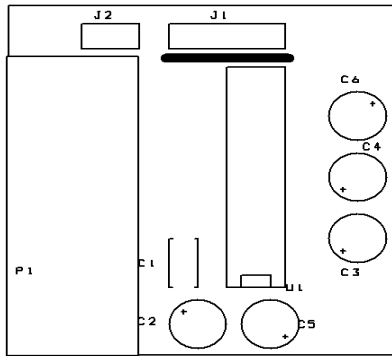Stochiloiu, Gabriel Vasilescu, Doru Cioclea

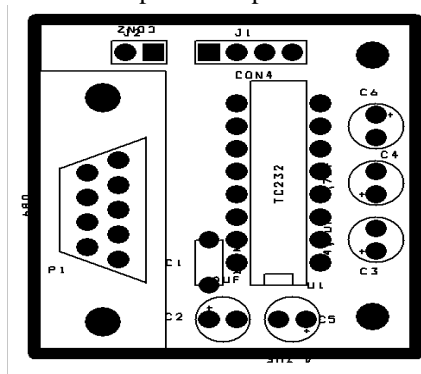Fig. 12. Electronic scheme of the serial adapter –
component emplacement

Fig. 13 Electronic scheme of the serial adapter –
component and pills emplacement

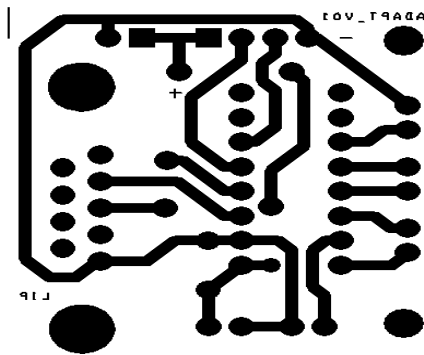The electronic wiring is double plated (fig. 14 and 15), being, also with a mass plan on the both sides.

Fig. 14. Electronic scheme of the serial adapter –
soldering side

3.2. The PC program achievement

The program for PC contains a main window (fig.16), which overtakes the application name and able to choose three based functions: data discharge, data viewing and clock synchronization/ memory initialization.
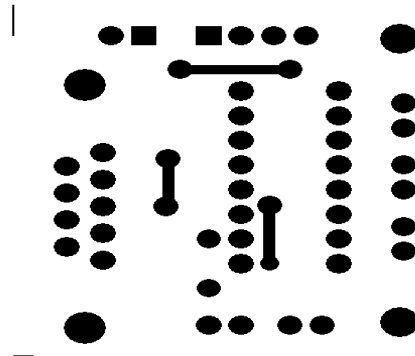

Fig. 15. Electronic scheme of the serial adapter –
component side

Also, with the help of **Diverse** menu (fig. 17) it can be selected the serial port by whom it can be made the serial communication between computer and acquisition system (fig. 18) or can be identified the program's references (fig. 19).

Using the **Diverse** menu (fig. 20) it can select the serial port which realizes the serial communication between PC and acquisition system or it can identify the program references [3], [10], [11], [12], [19].
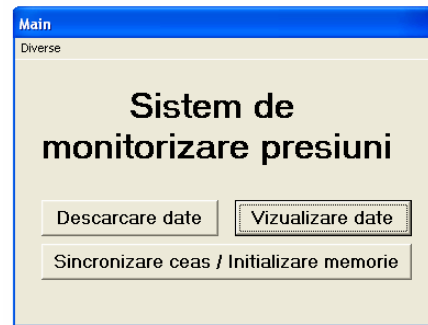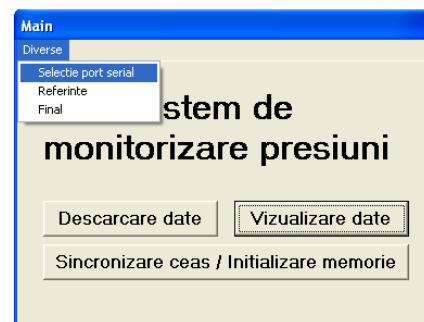

Fig. 16. The main program window

Fig. 17. Window activation for choosing the serial
communication port

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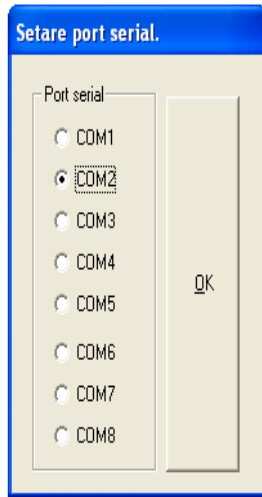Stochiloiu, Gabriel Vasilescu, Doru Cioclea

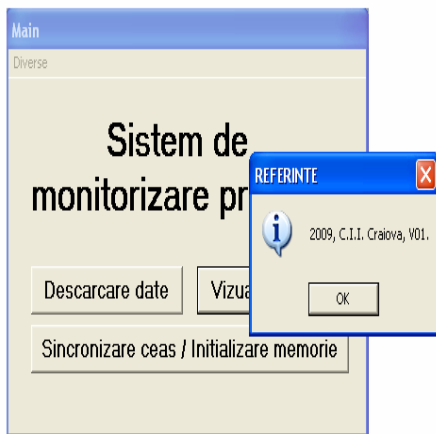Fig. 18. Ilustrativă pentru selectarea portului de comunicație serială

Fig. 19. Showing the mode for serial commutation selection

Fig. 20. Showing the data transfer initiation between the computer and the acquisition system

After the acquisition turn off it can realize the equipment preparing for a new acquisition through the pick out of **Sincronizare ceas/inițializarea memoriei** function.In this case the operator is supplementary asked above his intention because the begun operation has an effect like the irrecoverable data losses from equipment.

The most important part of application is the part which request the viewing the transfer data from the acquisition system. This is possible through activating the function **Vizualizare date**. A possible form of the acquired data is pictured in figure 21. In this case the record catch the 1000 minutes period, interval in which the pressure had constantly grow, evolving from 6 000 kPa to about 7000 kPa [9], [16], [20].

The program also is able to **dilatarea** on horizontal or vertical register for overtake as true as possible the interesting aspects.
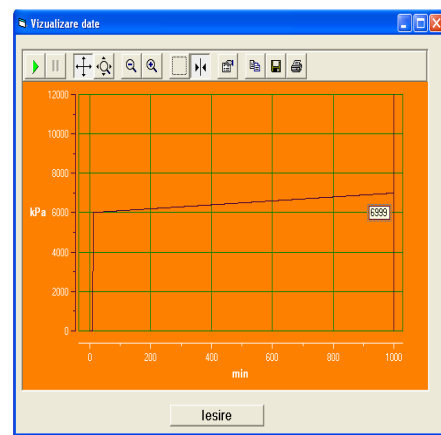

Fig. 21. View of the transferred data

For the operator has a global view for the monitored phenomena evolution the program is able for a strong `compression` of whole register. The evolution diagram for dependence of pressure from hydraulic pillars and time is shown in figure 22.
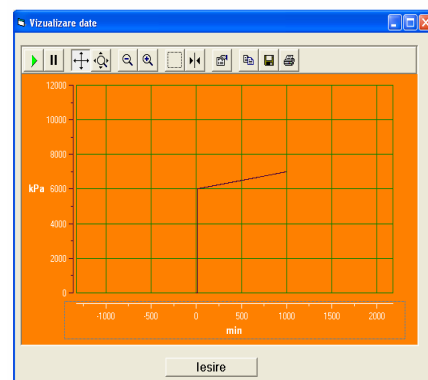

Fig. 22. The view of the transferred and processed data regarding the pressure evolution in time

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The monitoring system through the electronic data acquisition system and PC program allow overtaking a good precision for pressure evolution from hydraulic pillars for take rapidly measurements for stopping the possible instabilities for coal face.

4. Conclusions

Today, the main exploitation method applied in the Jiu Valley mines is the one with undermined bed coal, which schedules the coal discharge and evacuation behind the hewing front.

Within the exploitation method, the work technology assumes the cutting by the classing drilling-blasting procedure from front face of the base hewing slice, followed by the coal's gravitationally discharge from the undermined bed..

The hewing support is an individual one, being composed by SVJ hydraulic pillars and GSA articulated beams with a stretcher role, with all the unfavorable consequences regarding the increase of working volume necessary for frequent mounting and dismounting of its components, resulting an increase of the hewing cycle and supplementary stress of pillars and beams.

In the context of ensuring the optimal safety conditions in exploiting the undermined bed coal, besides the technical requirements required by the work technology applied at the long front hewing, is imposed the knowing of the mining pressure manifestation regime, from the intensity point of view and from the point of view of its development stage.

In order to monitor the pressure from the undermined bed fronts, the presented system proposed for appliance, by its electronic assembly for data acquisition and the computer program, allow the assessment of the pressure from the hydraulic pillars of the support, which is extremely important in rational and opportune intervention for taking prevention measures for eventual instabilities of the hewing working fronts..

So, it can be established the adaptability requirements of the support system used in various deposit conditions, specific to one mining perimeter to another.

Bibliography:

[1] X1. Alboteanu, L., Manolea, Gh., Ravigan, Fl. *Automatic System for orientation of the autonomous photovoltaic panels.* Proceding of the 13th National Conference on Electrical Drives, Tour 43 (67), 2008, pp. 1 – 6, ISSN 1482 – 7193.

[2] X2. Alboteanu, L., Ravigan, Fl., Nedelcut, C., Manolea, Gh. *Monitorizarea circulaţiei energiei de la panouri solare la consumatori cu priorităţi ierarhizate.*

Buletinul AGIR – Asociaţia Generală a Inginerilor din România, nr. 4/2006.

[3] X3. Bâlteanu, M.S., Manolea, Gh. *Contribution for health and safety training of personnel using monitoring computer systems.* International Health and Safety Symposium SESAM 2007, 3rd Edition, Petroşani – October 2007, ISSN: 1843 – 6226, pp.56 - 60.

[4] X4. Bernardo, J., Smith, A., F., *Bayesian Theory. John Wiley & Sous,* New York, ISBN: 0 – 471 – 92416 – 4, 1994.

[5] X5. Chen, W.K., *Linear Networks and Systems (Book style) Belmont* CA: Wadsworth, 1993, pp.123 – 135.

[6] X6. Dan, M. *Digital Control for Electromechanical Systemy.* Ed. Didactica Nova, Craiova, 1996.

[7] X7. Dumitrescu, I., Pleşea, V. *Presentation regarding the hard coal technological extraction level in Jiu Valley.* Scientific Works of International Symposium „Continuous surface mining", Petroşani, October 2008.

[8] X8. Holm, R. *Electric contacts,* 4 – th ed., Springer – Verlag. Berlin/Hedelberg/New York, 1987.

[9] X9. Ivanov, S. *Modelarea şi simularea sistemelor electromecanice.* Ed. Universitaria, Croiova, 2002.

[10] X10. Jula, D., Popescu, Fl., Dinescu, S., Andraş, A., *Reabily Assesment for Continnos Minning Technological Systems, XXIV Microcad – International Scientific Conference,* Martie 18 – 20, 2010, Miskolc – Hungary, ISBN 979 – 963 – 661 – 925 – 10.

[11] X11. Manolea, Gh., ş.a. *Computrized system for testing the rubber products, Proceedings of the Conference „Electrotecnics applied in industrial Eco – Construction",* Sibiu, 23 – 24 october, 2005, Ed. MEDIAMIRA, Cluj – Napoca, ISBN 973-739-138-1.

[12] X12. Ocoleanu C., Fl., Popa, I., Manolea, Gh. Dolan, A.I*., Temperature Measurement in Contact Pantograph - AC Contact Line, 1st WSEAS International Conference on URBAN REHABILITATION AND SUSTAINABILITY (URES'08),* november, 7 - 9, Bucarest, Romania.

[13] X13. Ocoleanu, C., Fl., Popa, I., Manolea, Gh. *Study of the Skin Effect Influence on Electric Railway System Supply Line Heating.* Environmental problems and development, Proceeding of the 1st WSEAS International Conference on Urban Rehabilitation And Sustainability – URES 2008, Bucharest, Romania, November 7 – 9, 2008.

[14] X4. Parker, J.R., *Algorithms for image processing and computer vision.* Wiley, 1996, ISBN: 978 – 0471140566.

[15] X15. Pleşea, V. *The undermined coal bed exploitation method – subject of the dispute regarding alignament to technical, economical and security requests of hard exploitation in Jiu Valley.* Revista Minelor, vol. 15, nr. 9, 2009, pp. 15 – 19.

[16] X16. Pleşea, V., Manolea, Gh., Ghinia, S., Stochiţoiu, M., ş.a. *Tehnologie eficientă de exploatare*

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mecanizată a cărbunelui cu banc subminat la minele din Valea Jiului aliniată la performanţele înregistrate în ţările U.E. – Elaborarea tehnologiei de exploatare mecanizată a cărbunelui cu banc subminat. Etapa a 2 - a de cercetare la contractul de finanţare nr. 269/29.10.2008, încheiat între ICPM Petroşani şi AMCSIT – Politehnica Bucureşti la Program Naţional de Inovare, noiembrie 2009.

[17] X7. Pleşea, V., Ghinia, S., Dumitrescu, I., Radu, S., Orban, M. *Hard coal profitability predictions in Jiu Valley for improved mining methods.* Sustainable exploitation of natural resources – Proceedings of the third International Seminar ECOMING – EUROPE IN 21ST CENTURY, Milos Island, September 4 – 5, 2009, Grecee, ISBN 978 – 973 – 741 – 136 – 5, pp. 76 – 85.

[18] X18. Pleşea, V., Lupu, C., Radu, S., ş.a. *Soluţii tehnice şi de securitate la aplicarea metodei de exploatare cu banc de cărbune subminat.* Revista Minelor, nr. 3, 2006, pp. 16 – 19.

[19] X19. Poor, H., *An Introduction to Signal Detection and Estimation.* New York: Springer - Verlag, 1985, ch.4.

[20] X20. Radu, S.M., *The Mechanized Face as a System.* Proceedings of the 8th WEAS International Conference on SIMULATION and OPTIMIZATION (SMO 08), Santande, Cantabria, Spain, September 23 – 25, 2008, ISSN 1790 – 2796, ISBN 978 – 960 – 474 – 007 – 9, pp. 89 – 94.