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DISTRIBUTION OF STRESSES IN THE INTERVENING PILLARS AT MEDIUM AND STEEP DIPS

Nowadays both single-stall and stoop - and - room methods are widely being put into practice for winning minerals. While projecting those methods determination of their geometrical parameters (e.g. chamber spanning, overall sizes of pillars, thickness of arch stratum and cap pillars in case of horizon mining) should always be given priority, because economical indices of the particular enterprise as well as safety mining will mostly depend upon said parameters.

When estimating the strength of pillars similar to that of any other structure there should be determined:

1. Loads actuating on the pillars.
2. Values and character of stress distribution in pillars affected by the mentioned loads.
3. Strength of pillars with due account of their stressed condition and also strength characteristics of their rock components.

Stressed condition of the pillars is one of the most important factors that determine their strength in general.

It is an extremely difficult problem to determine the stresses actuating inside the pillars. Therefore, the scientists in their theoretical investigations found it necessary to determine first the stresses in the pillars formed in the process of round, elliptical and slotted openings, and, hence solution of the problem (1, 2, 3) would be considerably simplified.

Since chambers in the process of mining are generally of the rectangular shape the s[illegible]ations obtained will have a partial application e.g. determination of the stresses actuating upon the pillars.

Therefore some experimental methods have been found to determine the intrapillar stresses. The photoelastic method can serve as one of them. A number of problems have been solved due to employment of the particular method concerning mainly the determination of stresses in the pillars when mining gently dipped minerals (4,5) .

Stressed condition of pillars at gentle and steep dips is not yet properly studied.

In the USSR such experiments have been carried out, for instance, by Borisenko S.G. (6). However here the influence of side thrusts on the rocks have not been taken into account.

On the basis of the analyses of the existing ideas about the stressed condition of undisturbed rocks and also on the basis of mining data and that of laboratory measurements there can be concluded that:

1. Rocks in the unmined solid masses are in the stressed condition characterized by the vertical component of stresses in the given point of the massif that corresponds to the weight of the covering rock and horizontal component depending upon the properties of the rocks under consideration ;

2. Proceeding from the mining data and that of laboratory measurements side thrust factor for different types of rocks can vary within the range of 0.5 (for hard rocks) to 1.0 (for soft rocks) (7,8).

The authors of the present paper have carried out experimental investigations on models using the photoelastic method to study the influence of the angle of dip, side thrust factor and the shape of pillars upon the stressed condition of the rock .

The models have been manufactured of igdantine and celluloid i.e. optically active materials. The models imitated stopp - and - room method and six chambers have been reproduced with pillars between them. The relation of the pillar height h to its width b was accepted 1 and 2. Distribution of stresses in the pillars has been studied with the angle of dip being 30°, 45°, 60° and 90° accordingly.

The investigations have been conducted with different values of the side thrust in order to find the influence of the stressed condition of the unmined rock upon the velue and character of stress distribution in the intervening pillars. As the material the pillar models and surrounding rocks were made from is operative within the limits of elactic deformation there should exist a linear dependency between the loads acting on the models and the stresses formed inside them.

Therefore it turned to be sufficient to determine experimentally the stresses in the models with two meanings of side thrust factor, whereas for all the other meanings to determine their value in accordance with the formulae mentioned below.

Two systems of forces actuate in our case upon the model: weight of the material the model is manufactured from and the forces of the side thrust. Now using the principles of mutual independence of acting forces and superposition there can be concluded that the stress in some point of the model will be.

$$\sigma_1 = \sigma_B + m_1 \sigma_z \qquad (1)$$

where

σ_B - stress in the given point caused either by the weight proper of the model material or the load applied from outside.

m_1 - side thrust factor

σ_z - stress in the same point of the model caused by the side thrust forces which equal the forces of the weight proper.

With the change of the side thrust values in the model and the vertical load remained, stresses in the considered point of the model will be:

$$\sigma_2 = \sigma_B + m_2 \sigma_z \qquad (2)$$

where

m_2 - new value of the side thrust factor.

Now bringing together both equations (1) and (2) we shall have

$$\sigma_B = \frac{m_1\sigma_2 - m_2\sigma_1}{m_1 - m_2} \quad \text{and} \quad \sigma_r = \frac{\sigma_1 - \sigma_2}{m_1 - m_2}$$

Thus to find the value of the stresses with the meanings of the side thrust factor of m_n the following equation should be used

$$\sigma_n = \sigma_B + m_n\sigma_r \,,$$

or

$$\sigma_n = \frac{(m_1 - m_n)\sigma_2 - (m_2 - m_n)\sigma_1}{m_1 - m_2} \qquad (3)$$

This method can successfully be used when finding the stresses in the models made of igdantine since with the method of investigation accepted favourable conditions can be created for flat deformation inside said models with the side thrust factor being one. Besides there can be every opportunity for flat stressed condition with the side thrust factor being 0.5.

In this case formula 3 will be modified into:

$$\sigma_n = 2\,(I - m_n)\,\sigma_2 - (I - 2\,m_n)\,\sigma_1 \qquad (4)$$

As the model was made of celluloid the plate with the cut out rooms was uniformly stretched in the first and then in the second normal direction as a result of the applied load. Stresses in the given point have been determined from the equation

$$\sigma_n = \overset{\sigma_B + m_n\sigma_r}{\cancel{(I + m_n)\,\sigma}} \qquad (5)$$

~~Where σ - stress applied to the model.~~

Fig.1 illustrates the pillars and covering rocks with the side thrust factor values varying from 0.4 to 1.0

4

obtained as a result of investigating on the models the values of the mean normal and tangential stresses. The stresses are given in the units of the normal stresses actuated upon the pillar.

The mean normal stress of the pillar at a flat pitch has been taken as a unit.

Fig.1 shows that the normal pressure, actuated upon the pillar, is decreased with the increment of the angle of dip except the case of hydrostatic pressure in an undisturbed rock massif i.e. the case when the value of the normal pressure actuated on the pillar does not depend upon the angle of dip and equals the full weight of the covering rock, whereas the shearing stresses constitute zero.

Both the increase of the angle of dip and decrease of the side thrust factor lead to decrease of the value of the normal stress upon the pillar at inclined beddings. For instance, with the angle of dip being 45° maximum decrease of load with the side thrust factor being 0.5 consitutes 25% of the load that could be observed in case of a gentle dip. Accordingly, these values for the side thrust factors of 0.4 and 0.6 will be 30 and 20 per cent.

From Fig.1 it becomes obvious that maximum decrease of load takes place with the dip angle being 90° i.e. when it is two times less compared with the flat pitch having the side thrust factor of the order of 0.5.

Shearing stresses appear in the pillars at inclined beddings and their values can also be determined by the dip angle and the value of the side thrust factor in an undisturbed rock massif. Peak values of the shearing stresses are obtained (see the diagram on Fig.1) with the dip angle being 45°.

The diagram brings the mean values of the shearing stresses actuated upon the stratification planes. Though these stresses are not considerable as compared with the mean stresses normal to the stratification plane, still under certain favourable conditions they can result in shifting the pillar.

5

Checking the possibility of disturbing the intact pillars by the shearing stresses can be obtained by comparison of the created shearing stresses that should be refered to the normal ones with the friction factor on the plane of thickness being as follows:

$$\frac{\tau}{\sigma} < \operatorname{tg} \varphi ,$$

where φ - angle of friction on the planes of weakness.

The meanings of $\frac{\tau}{\sigma}$ at $m = 0.5$ are brought in Table 1 for different dip angles

Table 1

α	0	10	20	30	40	50
$\frac{\tau}{\sigma}$	0	0.087	0.176	0.248	0.310	0.333

For example, if there are clay partings in the pillar the value of φ can be taken as 10°. In this case with 20° there will be a danger of crushing the pillar by its displacement.

The values of the mean normal and tangential stresses at medium dip obtained by the investigations of the models are in good conformity with the data calculated from the formulae 7 and 8 which in turn have been deduced by means of decompositioning the stresses actuating on the pillar as shown in Fig.2

$$\sigma = \gamma H \frac{S_{kp}}{S_y} \left(\operatorname{Cos}^2 \alpha + m \operatorname{Sin}^2 \alpha \right) , \qquad (7)$$

$$\tau = 1/2 \, (I - m) \, \gamma H \frac{S_{kp}}{S_y} \operatorname{Sin} 2\alpha \qquad (8)$$

where

γ - volume weight of the covering rocks

H - depth of the pillar

S_{kp} - pillar exposure area

S_y - pillar sectional area
α - angle of dip
m - side thrust factor

Figs 3, 4 and 5 illustrate the general character of stress distribution on the pillars the axis of which is normal to the stratification at the dip angles being 30°, 60° and 90°. The figures show the isometric lines of the maximum tangential stresses τ max expressed in fractions of γ H.

The data obtained testify that stressed condition of the pillars in the case of moderate dip substantially differs from that of gentle dip. In the latter case a great deal of experiments carried out on models proved the mean vertical section of the pillar be the weakest point and, therefore, estimation of the supporting stress of any pillar (5) should proceed from the said point. For high pillars e.g. $h/b > 1.5$ (Fig.6) when the greater part of the pillar is under conditions of uniaxial compression, estimation of its supporting strength should be proved by the uniaxial compression test results.

With the $h/b < 1.5$ (Fig.7) this method becomes ineffective because of good conditions for the all-round shrinkage in the pillar, and, therefore, the theory of ~~maximum~~ limited equilibrium should be applied calculating by this the resulting load from the mean section. The pillars in case of medium dip are loaded unevenly relative to their axes normal to the stratification plane. The mostly loaded parts of the pillar are those at the roof up-over and near the soil by the dip. Meantime the areas of a pillar near the roof by the dip and at the soil uprising turn to be underloaded. Therefore the supporting strength of such pillars is not employed completely and especially of those which have big sizes by the dip.

In the places of stress concentration with the direction being next to vertical, the meanings of horizontal stresses seem to be almost zero. Consequently, the material of which the pillar is made is under conditions of uniaxial compression in said places as compared with the pillars of a gentle dip that possess all-round compression. Stresses in a medium dip pillar are concentrated along the line connecting the pillar angles (Figs.3 and 4) . The presence of such a concentration of stresses results in shearing along the same line.

Shearing stresses in the pillar can be lessened if the pillar size is increased.

However investigations carried out by the authors show that the irregularity of pillar loading with normal stresses does not become less at all (9).

In connection with the said statement it seems to be of certain interest to consider the question of leaving the pillars the axes of which are deveiated towards the uprising by a certain angle so that it gives an opportunity to decrease both concentration of stresses in the pillars and the shearing stresses. Assymetrical character of loading the pillars the axes of which are normal to the stratification appears due to uneven forces of proper weight and the side thrust applied to the rock massif. Because of assymetrical character of pillar loading the maximum normal stresses actuate on the directions deviated from the pillar axis at a certain angle.

For the models with $\alpha = 30^\circ$ this deviation in the central part of the pillar constituted $\delta = 10^\circ$. To prove the aforesaid statement new models have been manufactured , with the dip angle being 30° and the deviation of the pillar axis up-over from the normal towards the stratifidation at an angle of 10°. Investigations on such models showed that the shearing stresses in the pillars have decreased by 10 times as compared with the pillar located normal to the stratification. By this concentration of stresses in the pillar area at the roof up-over has also decreased and obviously brought to the more even loading of the pillar. The simple comparison of Figs 3 and 8 is also indicative of this statement. In another model with the same geometrical parameters the pillar inclination towards uprising was already 18°. As shown in Fig.9 the pillar in such a case is loaded more evenly and stress distribution here is similar to that in the gentle dip pillars.

The required value of the pillar inclination towards the plane, normal to the stratification, can be found proceeding from the fact that the employment of the pillar supporting stress will mostly be effective when the resultant of the applied forces will actuate along the pillar axis.

As it is clear from Fig.10 the value of the resultant can be found from the following equation:

$$R = m \gamma H S_{kp} \frac{\sin \alpha}{\sin (\alpha - \beta)} \qquad (9)$$

where

S_{kp} - roof square per pillar

β - angle of hade of the normal to the stratification which equals

$$\beta = \alpha - \operatorname{arctg} (m \operatorname{tg} \alpha) \qquad (10)$$

The values of angles β depending upon the angle of incidence α with the side thrust factor m = 0.5 are given in Table 2.

Table 2

β	0	10	20	30	40	50	60	70	80	90
α	0	5	10	14	17	19	19	16	9	0

The values of loads calculated from formula (9) and expressed in load fractions on the pillars at low dips are given in Table 3.

9

Table 3

α	0	10	20	30	40	50	60	70	80	90
Load	1	0.99	0.96	0.91	0.83	0.75	0.66	0.58	0.52	0.5

Stress distribution in the pillars inclined at an angle of β as well as in the low dip pillars is characterized by formation of the all-round shrinkage areas near the roof and the soil. Concentration of stresses takes place in the room corners whereas stress distribution in the middle part of the pillar with the correlation of the pillar height to its width $h/b > 1.5$ becomes practically even.

Thus the middle part of the pillar is under conditions of uniaxial compression directed towards the pillar axis, and the stresses inside it can be determined by the formula

$$\sigma = \gamma H \frac{S_k}{S_y} \cos \beta \sqrt{\cos^2 \alpha + m \sin^2 \alpha} , \qquad (11)$$

where

S_y - cross-sectional area of the pillar.

The experimental studies accomplished by the authors of the present paper showed that leaving pillars at a medium dip, with the pillar axis normal to the stratification, brings to formation of shearing stresses and intensive concentration of stresses. Though the stresses actuating on the pillars are somewhat decreased the pillars as a result of the similar stress distribution may turn to be less stable as compared with the case of a gentle dip. Therefore it is reasonable to leave the pillars inclined towards uprising at an angle of β where stress distribution will be similar to that of a low dip one. Angle of hade of the pillars towards uprising will be determined by formula 10 and the value of actuating stresses will be found using formula 11. The methods used for calculation of pillars at a low dip can successfully be employed for calculation of the pillars in the vertical seams.

10

DESCRIPTION TO THE DRAWINGS

Fig.1. Dependence of the mean normal and shearing stresses at the pillar contact with the enclosing rocks from the dip angle and side thrust factor.

Fig.2. Diagram of decompositioning of the forces that actuate upon the pillar, the axle of which is normal to the stratification.

Fig.3. Distribution of stresses τ max in the pillar with $\alpha = 30^\circ$

Fig.4. Distribution of stresses α max in the pillar with $\alpha = 60^\circ$.

Fig.5. Distribution of stresses σ max in the pillar with $\alpha = 90^\circ$.

Fig.6. Distribution of the maximum normal stresses σ_1, and σ_2 in the pillar with $\alpha = 0$ and $h/b = 2$.

Fig.7. Distribution of the maximum normal stresses σ_1, and σ_2 in the pillar with $\alpha = 0$ and $h/b = 1$.

Fig.8. Distribution of stresses τ max in the pillar the axis of which is deviated towards uprising at an angle of 10° with $\alpha = 30^\circ$.

Fig.9. Distribution of stresses τ max in the pillar the axis of which is deviated towards uprising at an angle of 18° with $\alpha = 30^\circ$.

Fig.10. Diagram of decompositioning of the forces actuated upon the pillar, the axis of which is deviated towards uprising at an angle of β.

REFERENCES

1. SHERMAN D.I. About stresses in a semiplane released by two round openings. "THE APPLIED MATHEMATICS AND MECHANICS", V 15, No.3, 1951.

2. SHERMAN D.I. To the question of stressed condition of intervening pillars. "PROCEEDINGS OF THE ACADEMY OF SCIENCES, USSR". TECHNICAL SCIENCES BRANCH, Nos.6, 7, 1952.

3. SCHERMAN D.I. Combined problem of potential theory and that of elasticity for a plane with the final number of linear sections. "REPORTS OF THE ACADEMY OF SCIENCES, USSR" V 27, part 4, 1940.

4. DUWALL W. Stress analysis applied to underground mining problems "BUREAU OF MINES REPORT INVESTIGATIONS". No.4387, 1948.

5. TRUMBATCHEV V.F. and MELNIKOV E.A. Stress distribution in intervening and cap pillars. GOSGORTECHNIZDAT, 1961.

6. BORISENKO S.G. Study of sresses in intervening pillars and enclosing rocks. Collection of articles "METHODS FOR DETERMINATION OF THE SIZES OF THE SUPPORT AND CAP PILLARS"; Edited by the Academy of Sciences, Moscow, USSR, 1962.

7. OBERT L. In situ determination of stress in rock. "MINING ENGINEERING". No.8, 1962.

8. MATVEYEV B.V. Manual on conducting testings of weak side rooks on the side thrust (VNIMI). Leningrad 1961.

9. MELNIKOV E.A.Stressed condition of pillars at medium and steep dips. "Scientific Information of the Instutute of Mining Affairs named after Skotchinsky" part 23, 1963.

12

Fig. 1
Trumbatcher V.F
Melnikov E.A

Fig 10
Trumbatcher V F.
Melnikov E A

Fig.6
Trumbatcher V.F
Melnikov E A

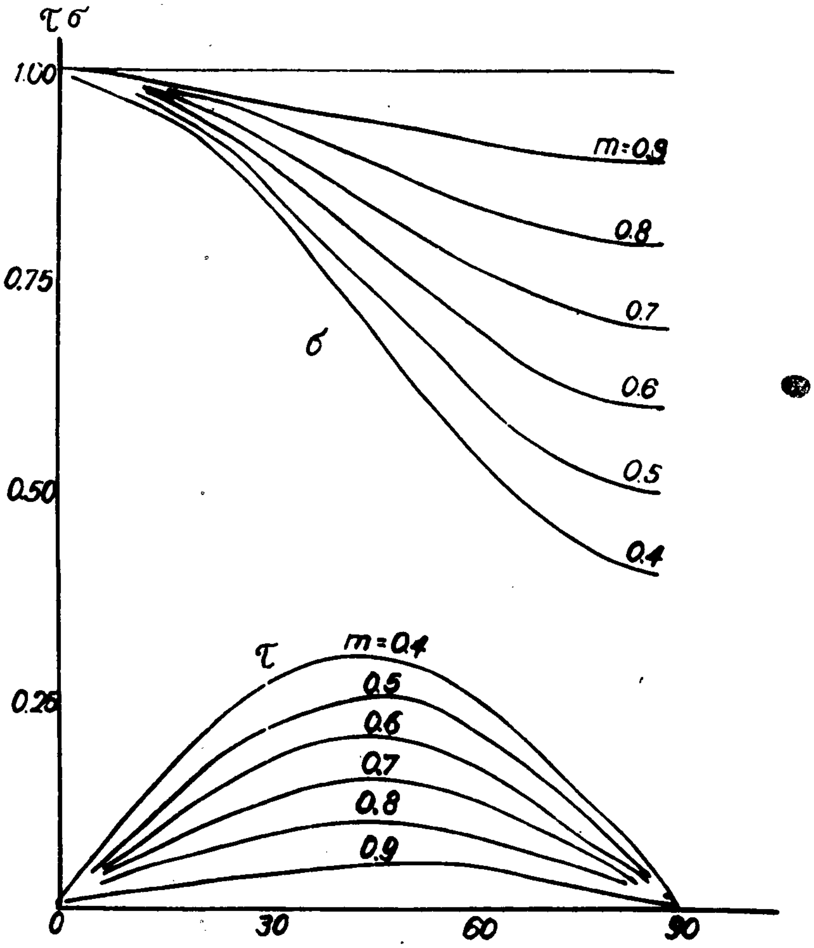

FIG. 1

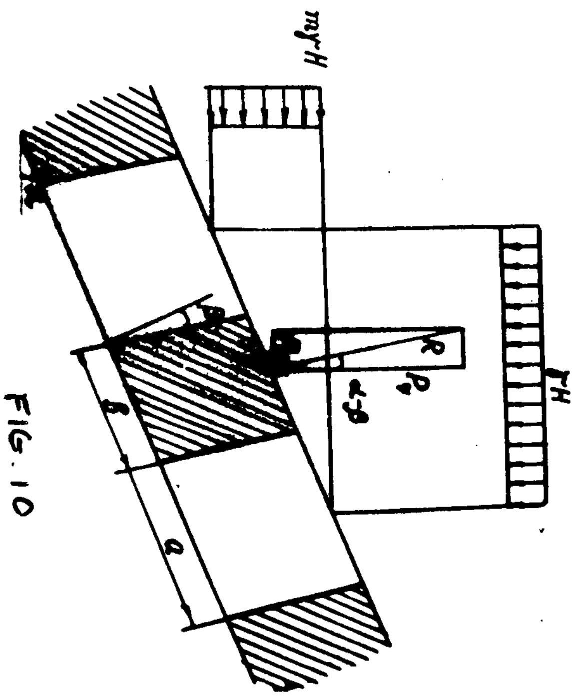

FIG. 10

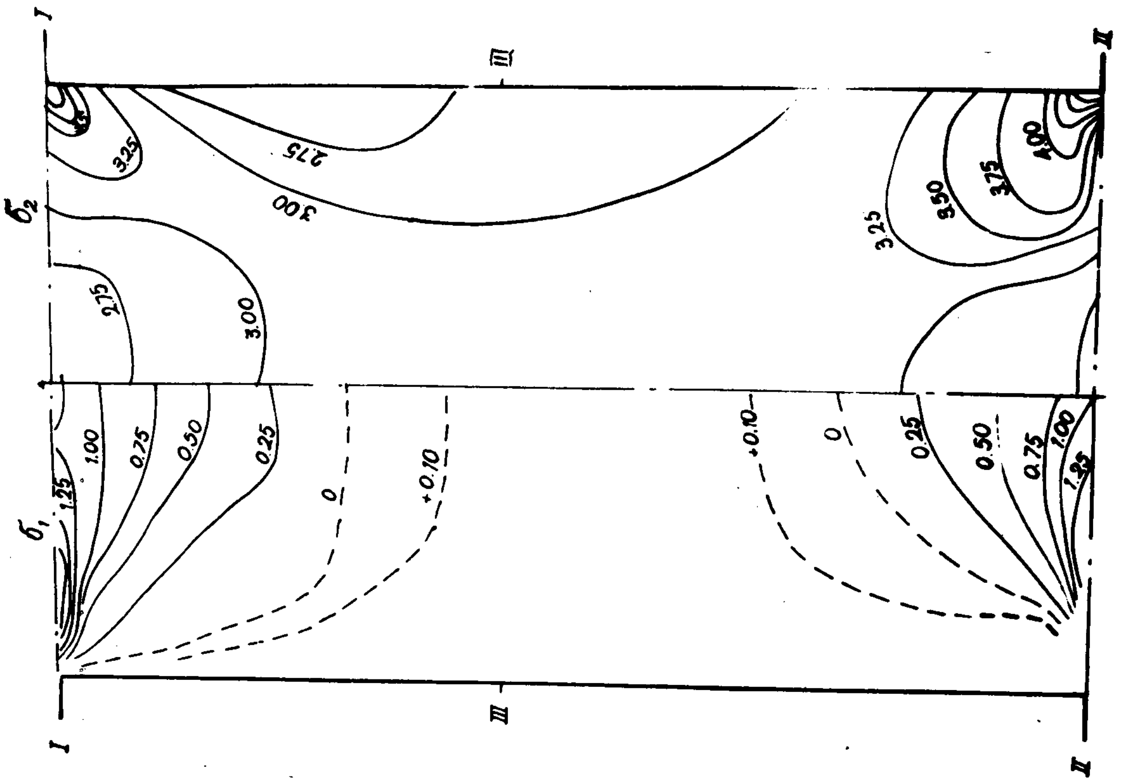

FIG. 6

Fig. 2
Trumbatcher V.F
Melnikov E A

Fig. 3
Trumbatcher V.F.
Melnikov E.A.

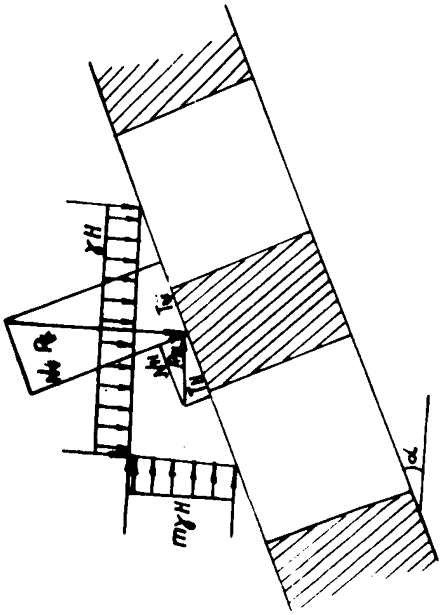

FIG. 2

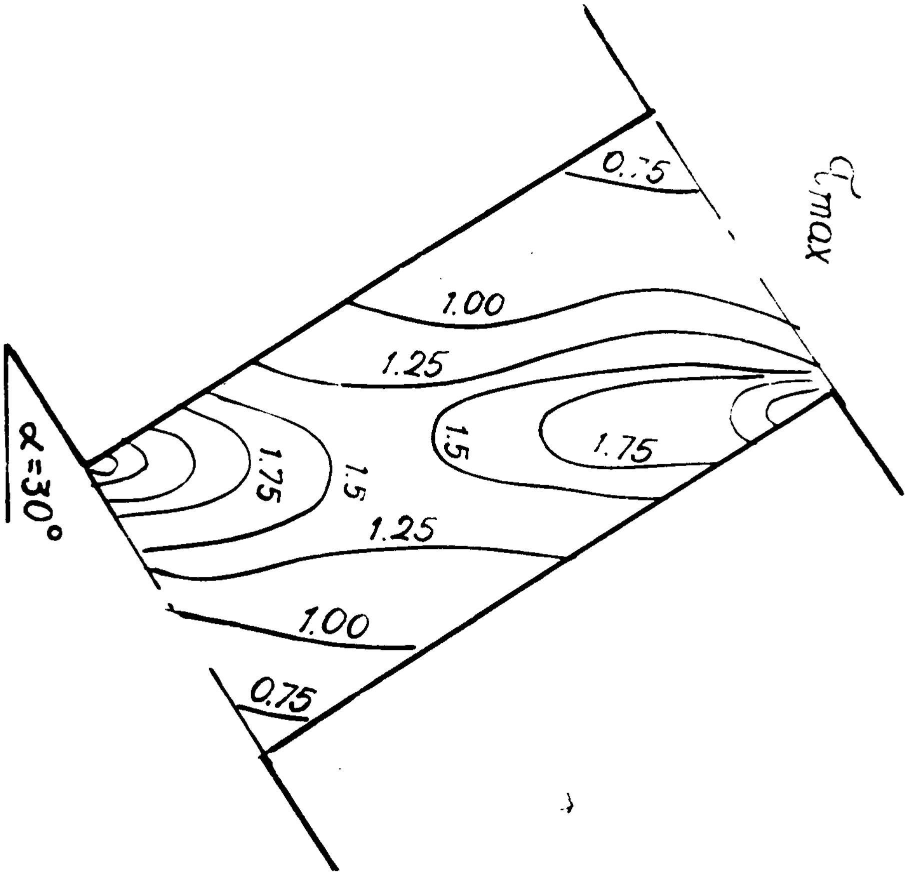

FIG. 3

Fig. 4
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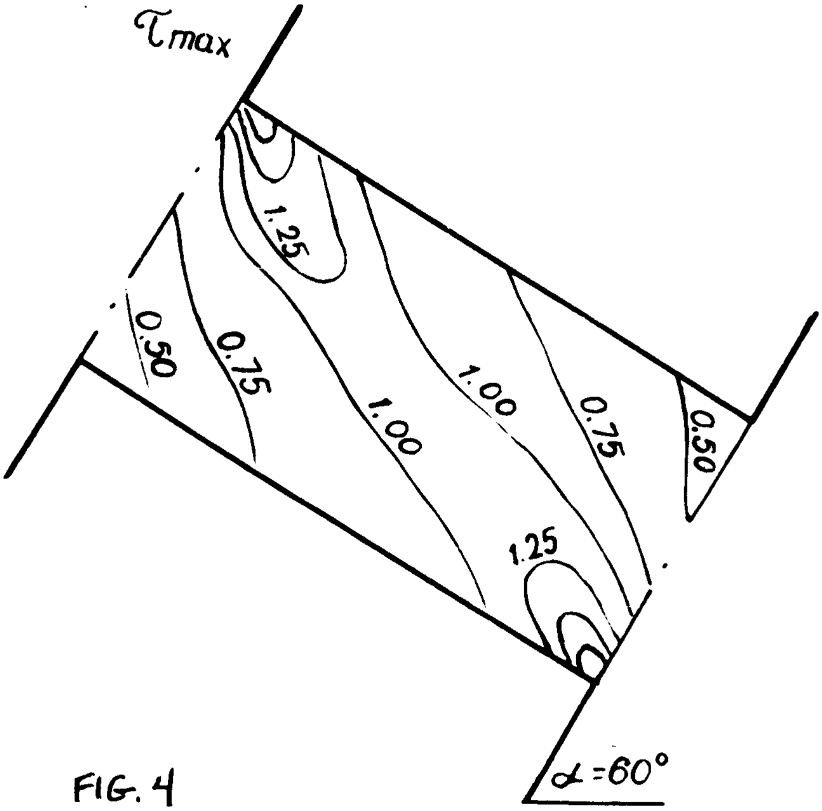
Melnikov E. A.

Fig. 5
Trumbatchev V. F.
Melnikov E. A.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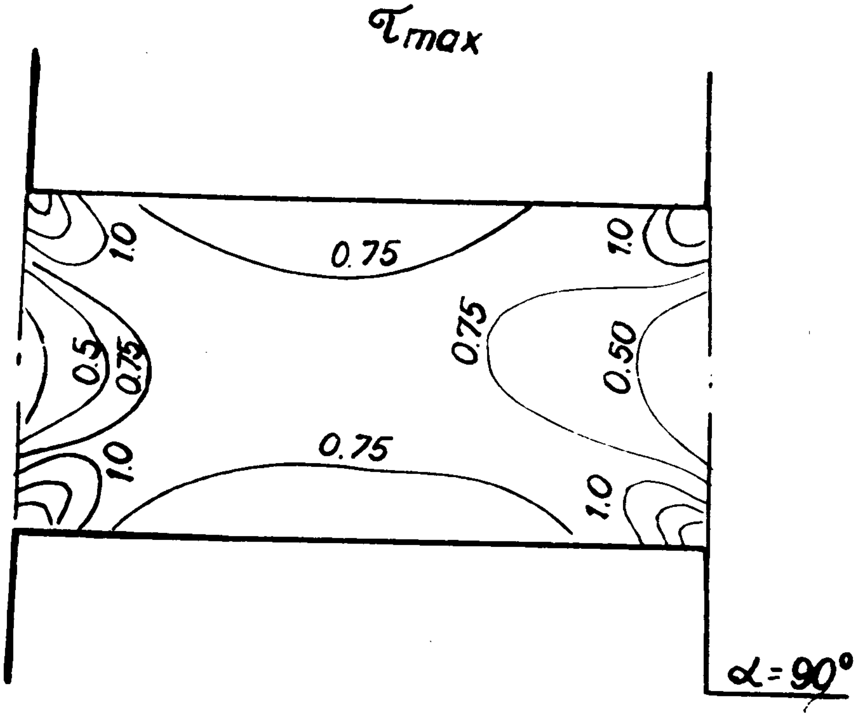
0.75
1.00
1.00
0.75
0.50
1.25
α=60°

FIG. 4


τmax
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0.75
1.0
0.75
0.5
0.75
0.75
0.50
1.0
0.75
1.0
α=90°

FIG. 5

Fig. 8

Trumbatchev V.F.

Melnikov E.A

Fig.7.

Trumbatchev V.F.

Melnikov E.A

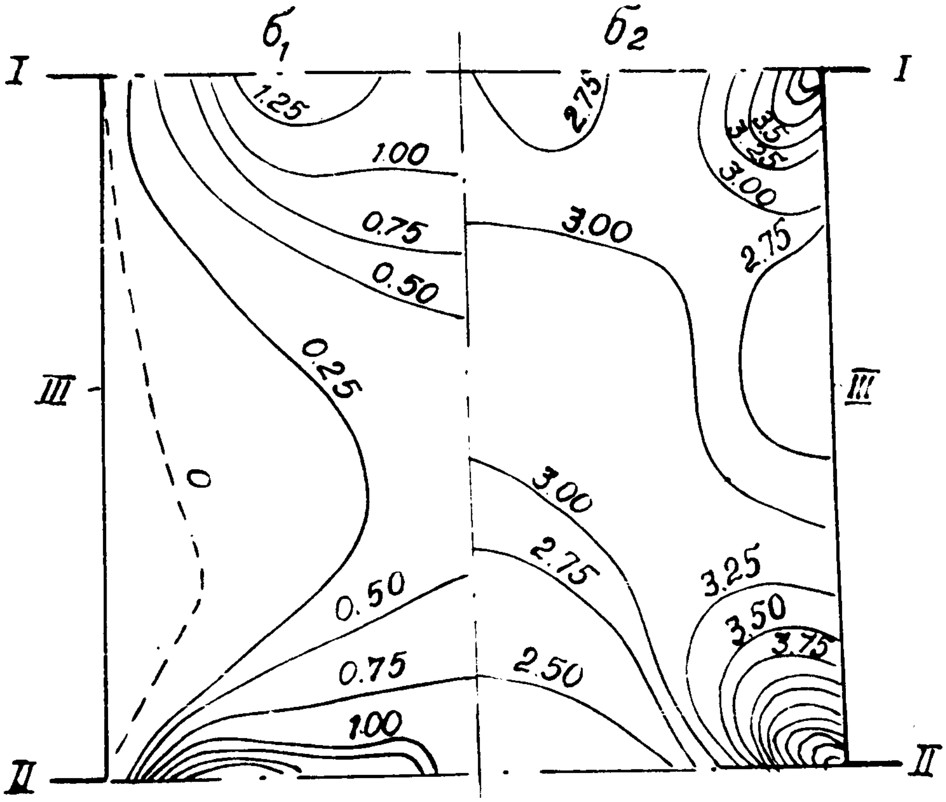
σ₁
σ₂
I
I
III
III
II
II
1.25
1.00
0.75
0.50
0.25
0
0.50
0.75
1.00
2.75
3.5
3.25
3.00
2.75
3.00
3.00
2.75
2.50
3.25
3.50
3.75

FIG. 7

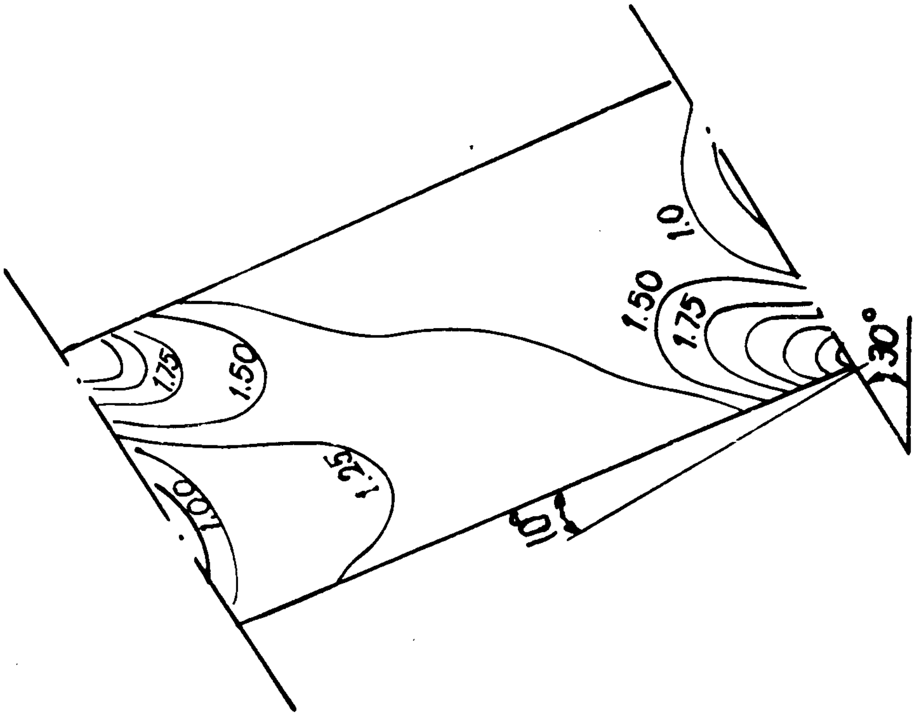
1.0
1.50
1.75
30°
1.75
1.50
1.25
1.00
10°

FIG. 8

Fig. 9.

Trumbatcher V F.

Melnikov E. A.

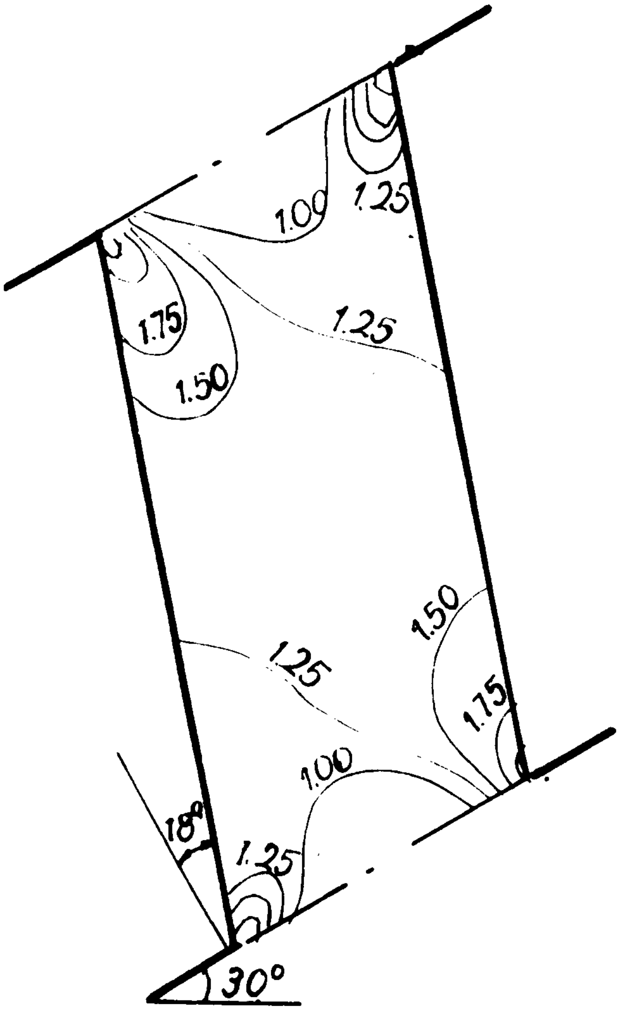

FIG. 9

ON CERTAIN PHYSICAL-MECHANICAL FACTORS DETERMINING THE RATE OF FLOTATION

(Summary)

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23

ON CERTAIN PHYSICAL-MECHANICAL FACTORS DETERMINING THE RATE OF FLOTATION

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ON CERTAIN PHYSICAL-MECHANICAL FACTORS DETERMINING THE RATE OF FLOTATION

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SUMMARY

Numerous investigations have shown that with the increase of the pulp flow rate in continuous action flotation machines the time of flotation required for a given recovery is reduced.

In the investigations by the authors, and by Pogorely this relation has been explained by the fact that with the increase of the pulp flow rate in flotation machines a reduction of the pulp impoverishment due to its mixing is taking place. In earlier investigations certain assumptions have been made in order to prove the validity of this hypothesis. In the latest works these assumptions have been excluded.

A physical model of the flotation process is considered in this paper.

Based on this model a general equation of flotation has been worked out. In order to find out the validity of the assumption that with the increase of the pulp flow rate the flotation time decreases owing to the reduction of the harmful influence of pulp mixing, the authors consider a general system of differential equations for the kinetics of flotation in an "ideal" (abstract) machine without mixing. This system of differential equations does not contain the value for the

26

pulp flow rate, hence, its solution does not depend on it. The equations show that in order to obtain the recovery required, it is necessary to have a fully determined flotation time not depending upon the pulp flow rate. This means that the flotation time in machines without mixing remains unchanged at different rates of pulp flow.

It has been shown by the authors that the increase of flotation time in industrial machines is a result only due to mixing as, otherwise, the industrial machines do not differ from an "ideal" machine.

The paper shows that at a great increase of the pulp flow rate the flotation time in a machine with mixing needed for a given recovery tends to the flotation time in a machine without mixing.

The physical meaning of mixing has been explained on a series of examples. It has been shown that, owing to mixing, the average concentration (for the whole flotation time) has been lowered in comparison with the machines without mixing, while the given concentration of useful mineral in tailings remains unchanged. It is this fact that leads to the delay in flotation.

Essential conclusions which have been drawn from the paper are as follows:

The reason for the reduction of flotation time with the increase of the pulp flow rate in continuous action flotation machines is the reduction of the harmful influence of the impoverishment of a rich pulp by a poorer one due to mixing. With the increase of the pulp flow rate the flotation time is tending to a possible minimum (at other optimum conditions). In practice it may prove expedient to increase the pulp flow rate in order to reduce the harmful influence of mixing, and, respectively, the time of flotation. However, when a certain limit has been reached a further increase of the pulp flow rate may prove not to be expedient.

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NEW METHODS OF SULFIDE CONCENTRATE UPGRADING
(Summary)

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31

NEW METHODS OF SULFIDE CONCENTRATE UPGRADING

SUMMARY

The first part of the paper is dealing with the results of laboratory research as well as with the industrial application of a flotation process for sulfide copper-nickel ore. New high-molecular depressors of readily floated silicate minerals such as carboxymethylcellulose, cellulose sulfuric esters and copper-ammonium solutions of cellulose, have been used. It has been shown that the use of carboxymethylcellulose with optimum physical-chemical variables (degree of substitution - 50, degree of polymerization - 500), instead of the previously used as depressor - sodium silicate, permits: to increase considerably the content of valuable constituents in the concentrate, to obtain clarified tailing water without addition of coagulants and to use it as reclaimed water in flotation. The reagent consumption has been considerably reduced too. The results of the research on the interaction of the carboxymethylcellulose with the surface of sulfides and readily floated silicates have also been considered.

It is shown in the second part of this paper that the conditioning of the pulp with sodium sulfide and active carbon proved to be most effective for the preparation of sulfide lead-copper concentrates. This method ensures a sufficient desorption of the collector from the sulfide surface and its removal from the liquid phase of the pulp without washing and dewatering.

Conditions have been devised for the separation of copper-lead concentrates containing bornite and chalcocite. These are based upon the depression of copper minerals by a complex zinc cyanide. It has been shown too that in order to obtain a stable depression of copper minerals the stability of concentration of the zinc-cyanide complex in flotation is to be ensured. This is achieved by:

a) the reduction of ore and bulk concentrate sliming during the preparation stage (this reduces the rate of the zinc-cyanide complex interaction with chalcocite);

b) by a periodic addition of the depressor every 5-6 minutes in the course of flotation.

The accomplishment of these conditions has allowed to obtain from a bulk concentrate assaying 22 per cent of copper and 11 per cent of lead, a lead concentrate with 60 per cent lead and 3 per cent copper content as well as a copper concentrate with 25.5 per cent copper, 2.7 per cent lead at a recovery about 80 per cent lead and 98 per cent copper into the respective concentrates (of an initial bulk concentrate where 40 per cent of copper are chalcocite).

Item B of the second part of this paper describes a separation process without using cyanide, and the dezincing of lead-~~zinc~~ copper concentrates assaying copper in form of chalco~~cite~~pyrite. This procedure is based upon the depression of galena by sodium sulfite (Na_2SO_3) and ferrous sulfate in a weakly acid medium. The new procedure as compared to the cyanide method and applied to lead-copper concentrate sepa-

33

ration increases the selectivity and reduces the cost of mineral processing. Applied to sulfide polymetallic ore from some ore deposit it has ensured the following metallurgical data: an increase of gold recovery by 3.2 per cent, of copper into a copper concentrate - by 8.8 per cent, of zinc into a zinc concentrate - by 1.9 per cent.

An upgrading of copper, as well as of lead concentrates has been reached.