FEASIBILITY OF MINERAL EXTRACTION FROM UNDERWATER DEPOSITS WITHOUT A LOWERING WATER TABLE

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SUMMARY

Extraction of bauxite lenses in great depths using conventional underground mining and active lowering of water table, e faces increasing technical and financial difficulties. Hydraulic borehole mining applied either independently or in combination with other methods of mining, may overcome these difficulties. The optimum parameters of hydraulic borehole mining viz. radius of mining R and depth limit of working H_h can be determined by technical-economical calculations with respect to the actual case.

INTRODUCTION

In mining mineral deposits viz. bauxite, coal etc. exposed to water hazard, the amount of water to be raised increases exponentially with increasing working depth. Preventive--passive water control can ensure mining safety and beneficial technical and economical conditions for deposits not deeper than a certain depth limit. Those parts of the deposits, however, in greater depth can only be extracted if an active lowering of the water table is used.

Active water control not only ensures mining safety but provides water supply of good quality and steady output for civilian and industrial consumers. Nevertheless, the active lowering of the water-table interferes with natural waters, thus it has considerable impact on the environment. If great amounts of water are steadily raised, a depth limit is likely to be approached where costs and technical and environmental difficulties accompanied with water control are overwhelming in comparison with the advantages. Below this depth limit, hydraulic borehole mining without lowering water table is a feasible technological system to extract minerals, as soon as in the early future.

GENERAL FEATURES OF HYDRAULIC BOREHOLE TECHNOLOGICAL SYSTEM OF MINING

The main advantages of the hydraulic borehole technological system of mining are:

/a/ prospecting boreholes found productive can be easily converted into producing wells;

/b/ various processes of mining /winning, loading, transporting etc./ and mineral dressing /classification, concentration/ can be amalgamated into a unified production line using water as a general medium and ensuring highly simple structure of technology;

/c/ water can be used in a closed cycle to provide optimum environmental protection;

/d/ the hydraulic technology can be applied on its own or in combination with other methods of mining /open pit mining,underground mining etc./ within very wide limits in space and time;

/e/ while capacity is high and costs are low, labour requirement is moderate.

The limits of application for the hydraulic borehole mining are:

/a/ extraction processes on the borehole bottom can be controlled only indirectly, i.e. by changing the flow rate and pressure of the medium;

/b/ quantity and quality of products extracted are subject to considerable fluctuation due "blind" remote control of the production equipment;

/c/ pillars left behind to ensure conditions for the remote control and to support mining excavations, bring about higher mineral losses and dilutions than conventional mining technologies do.

Considering the main advantages and limits of the hydraulic borehole technology that uses no lowering of the water table, the most suitable fields of application of effective exploitation of mineral deposits in Hungary, are:

/a/ extraction of lenticular deposits and those with extremely irregular shape and small reserves containing minerals easy to fluidize viz. bauxite, kaoline, bentonite etc.;

/b/ partial extraction of mineral deposits having been worked by underground mining but brought to a halt by intesive water inrush where production is not worth to resume again by underground methods.

EXAMPLES OF ECONOMICAL APPLICATION OF THE HYDRAULIC BOREHOLE TECHNOLOGICAL SYSTEM OF MINING

Fig. 1. shows a practical case where both borehole and open pit mining can be considered feasible. The optimum parameters of the borehole mining can be determined by analysing and comparing the costs of the two systems of mining.

Omitting details, the minimum radius of the hydraulic borehole mining will be calculated with following correlation:

$$R \geq \sqrt{\frac{AB(H+M)k_f}{4\sum K_k - \left[AB\delta_f k_{mf}\left(H+\frac{M}{2}\right) + 4AB\delta_f\left(\frac{B}{2}+z\right)k_{mo}\right]}} \quad [m]$$

while for the depth limit of working

$$H_h \leq \frac{4R^2\sum K_k - \left[ABMk_f + AB\frac{M}{2}R^2\delta_f k_{mf} + 4ABR^2\delta_f\left(\frac{B}{2}+z\right)k_{mo}\right]}{ABk_f + ABR^2\delta_f k_{mf} + 2R^2 V_m \gamma_m k_{mf}} \quad [m]$$

holds, where the denotions are:

- A average dimension of the useful mineral deposit in the direction of strike, [m]
- B average dimension of the useful mineral deposit in the direction of dip, [m]
- H bedding depth of the mineral deposit, [m]
- M average thickness of the mineral deposit, [m]
- V_m -volume of the waste to be stripped in open-pit mining, [m^3]
- R radius of action of the hydraulic borehole mining, [m]
- H_h -depth limit of the hydraulic borehole mining, [m]
- k_f -average specific cost of the producing well, [Ft/m *]
- δ_f -average seam productivity, [t/m^2]
- $\sum K_k$ -total costs of the open-pit mining, [Ft]
- k_{mf} -specific transport cost of the useful mineral in the producing well, [Ft/tm]
- k_{mo} -specific cost of hydraulic transport from the place of production to the processing plant [Ft/tm]

* Ft denotes the Hungarian currency Forint

Fig. 2. illustrates savings as a function of the radius that can be achieved by hydraulically mining 1 million tons of bauxite from a depth of 100 m through boreholes, compared with the costs of open pit mining. The figure suggests that a slight increase in the radius of borehole mining beyond the minimum, may result in substantial savings.

The specific costs of open pit and borehole mining are illustrated in Fig. 3. as functions of depth for the same bauxite deposit and a radius of R = 10 m. The advantages of the borehole method in comparison with open pit mining with increasing depth are clearly illustrated in this figure.

A further major advantage of borehole mining against open pit mining is the fact that prospecting, development and mining phases follow each other rapidly therefore investment and operating costs are repaid within a short time. It is also a beneficial feature of the borehole mining that water-bearing sand beds in the overburden of the deposit have not to be drained before and during mining. Finally, no safety problems occur in connection with the stability of working and waste slopes.

Experience proves that active water-table lowering ensures an extension for conventional shaft-drivage mining to considerable depths. Beyond certain depth limit, however, the active water-table lowering is accompanied with major technical, financial and environmental problems that render conventional underground mining doubtful or impossible to apply.

In this case, depth limit of working can be extended by boreholes drilled from drifts above the natural or artificially lowered water level. A feasible solution in connection with that is illustrated in Fig. 4. The main advantage of borehole mining based on existing network of drifts is that no active lowering of the water table is needed and the drifts can be used to transport the extracted material to the surface. A disadvantageous feature is, however, that cross-headings and entries needed for accomodating drilling equipment have to be driven, considerably increasing fore-winning time.

Fig. 5 illustrates the saving as a function of the radius that can be achieved by hydraulic borehole mining compared with underground technique in the extraction of an approximate one million tonns of bauxite from a deposit in a depth of 100 m below water level. The figure suggests that the radius of borehole mining can be effectively increased to 2-10 m because this is the range where maximum saving will be achieved. A further increase of the radius up to 20-30 m does not yield any significant increase in the results.

Finally, Fig. 6 shows the depth limit of the borehole mining supported by an underground network of drifts as a function of the extraction radius. It can be clearly seen that a linear increase in the extraction radius of borehole mining brings about a parabolic change of the technically and economically achievable depth limit.

CONCLUSION

Engineers concerned with extraction problems of mineral deposits that are exposed to water hazard have to bear in their minds that not only effective water control methods but new mining technologies have to be looked for to reduce the effect on natural water resources to a minimum. In this way a very effective production system can be developed using water in a closed cycle for mining and mineral dressing processes.

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LIST OF CAPTIONS

Fig. 1. Scheme of borehole and open-pit mining of a mineral deposit
1 Bauxite lense
2 Limestone-dolomite
3 Producing well
4 Hydraulic pipeline to consumer

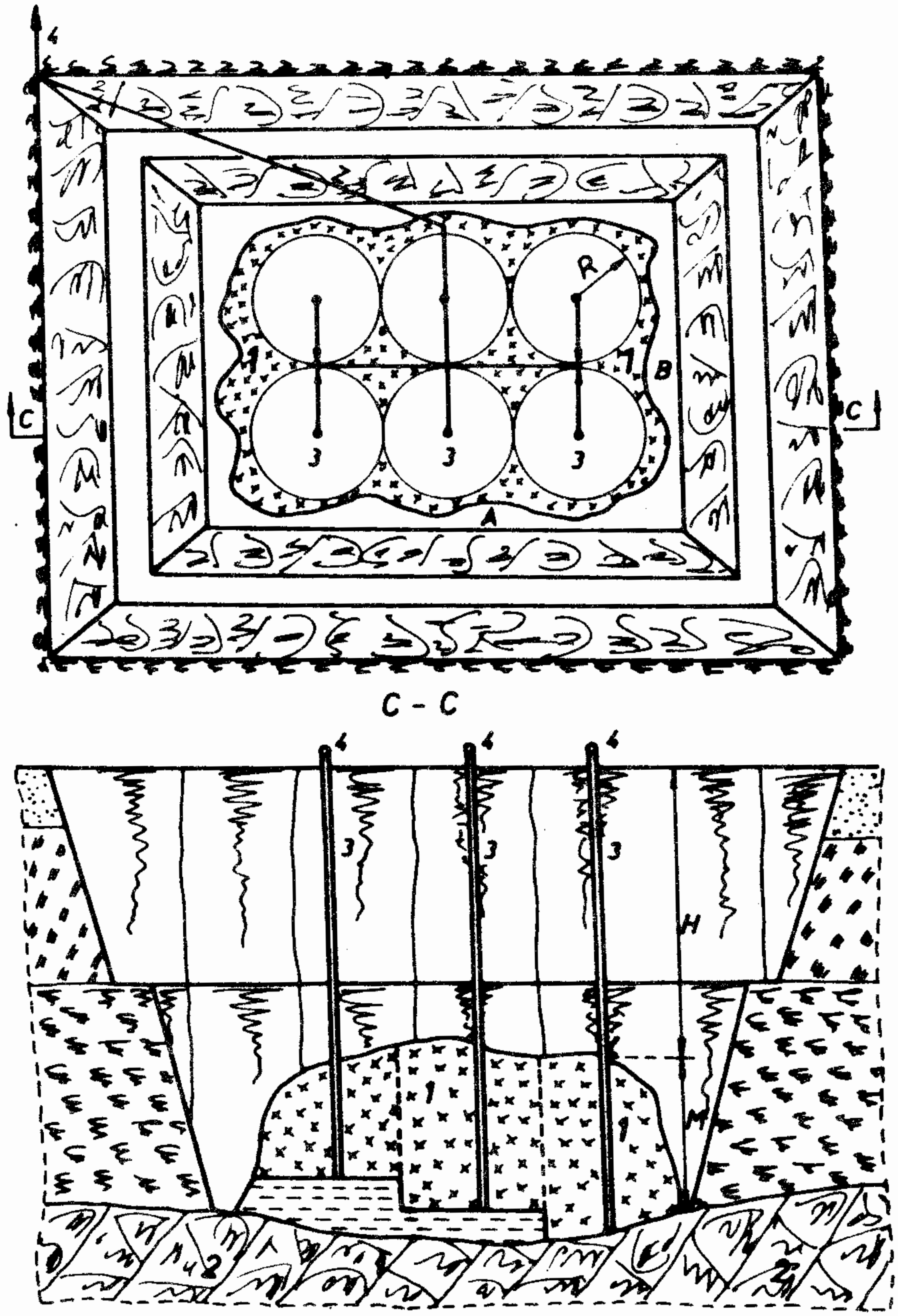
Fig. 2. Saving achieved by borehole mining in comparison with open pit mining as a function of extration radius
A Extraction radius
O Saving achieved by borehole extraction

Fig. 3. Production costs of borehole and open-pit mining methods for a bauxite lense as a function of the working depth
A Bedding depth
O Production costs
1 Open pit mining
2 Borehole mining

Fig. 4. Producing wells drilled from an underground haulageway
1 Hoist shaft
2 Air shaft
3 Underground haulageway
4 Dewatering borehole
5 Limit of water-table lowering
6 Lowered water-level
7 Bauxite lense
8 Producing well
9 Limestone-dolomit

Fig. 5. Saving achieved by borehole extraction supported by underground drifts in comparison with conventional underground mining
A Extraction radius
O Saving achieved by borehole mining

Fig. 6. Depth limit of borehole mining as function of the extraction radius
A Extraction radius
O Depth limit of working



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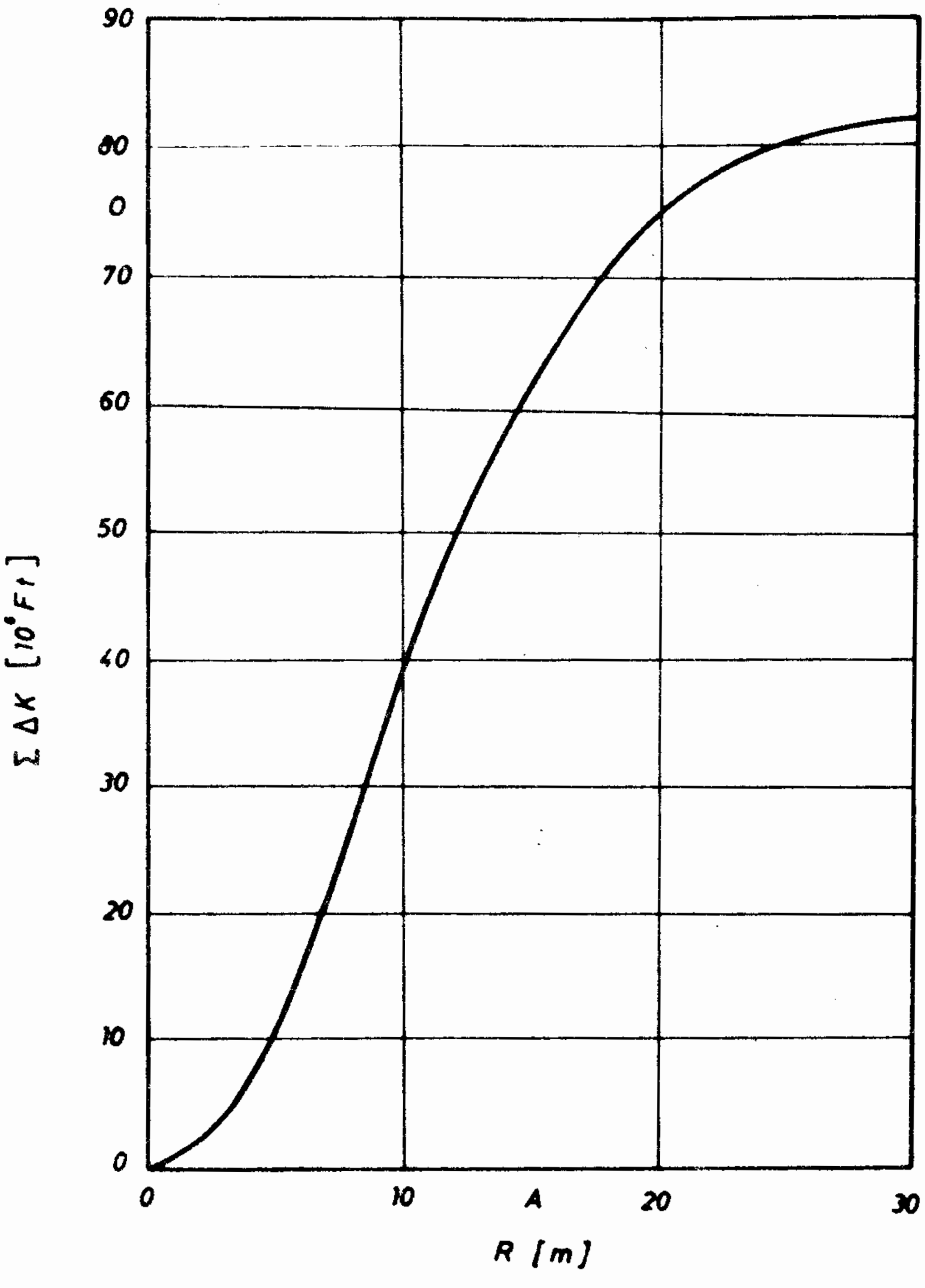

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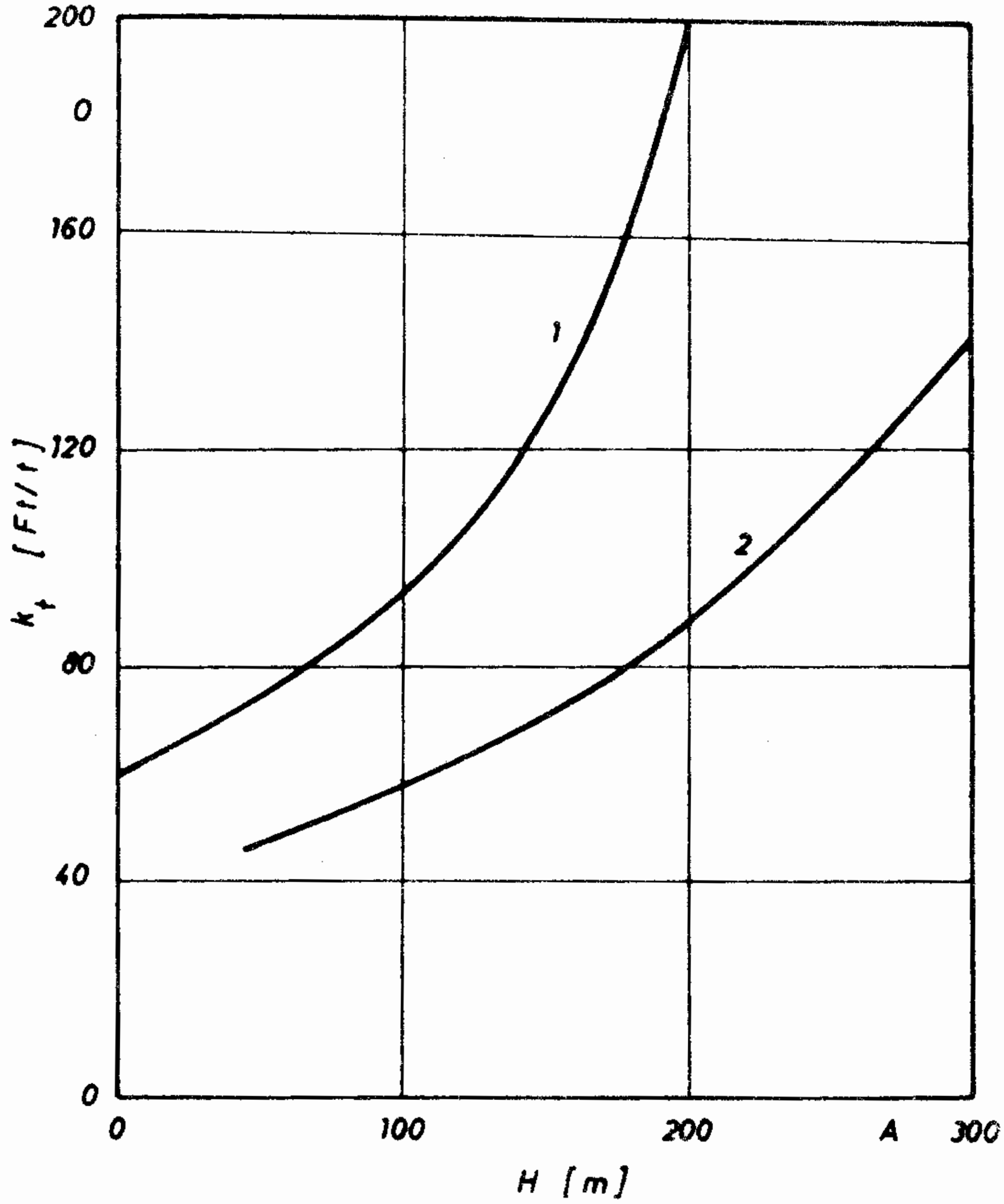

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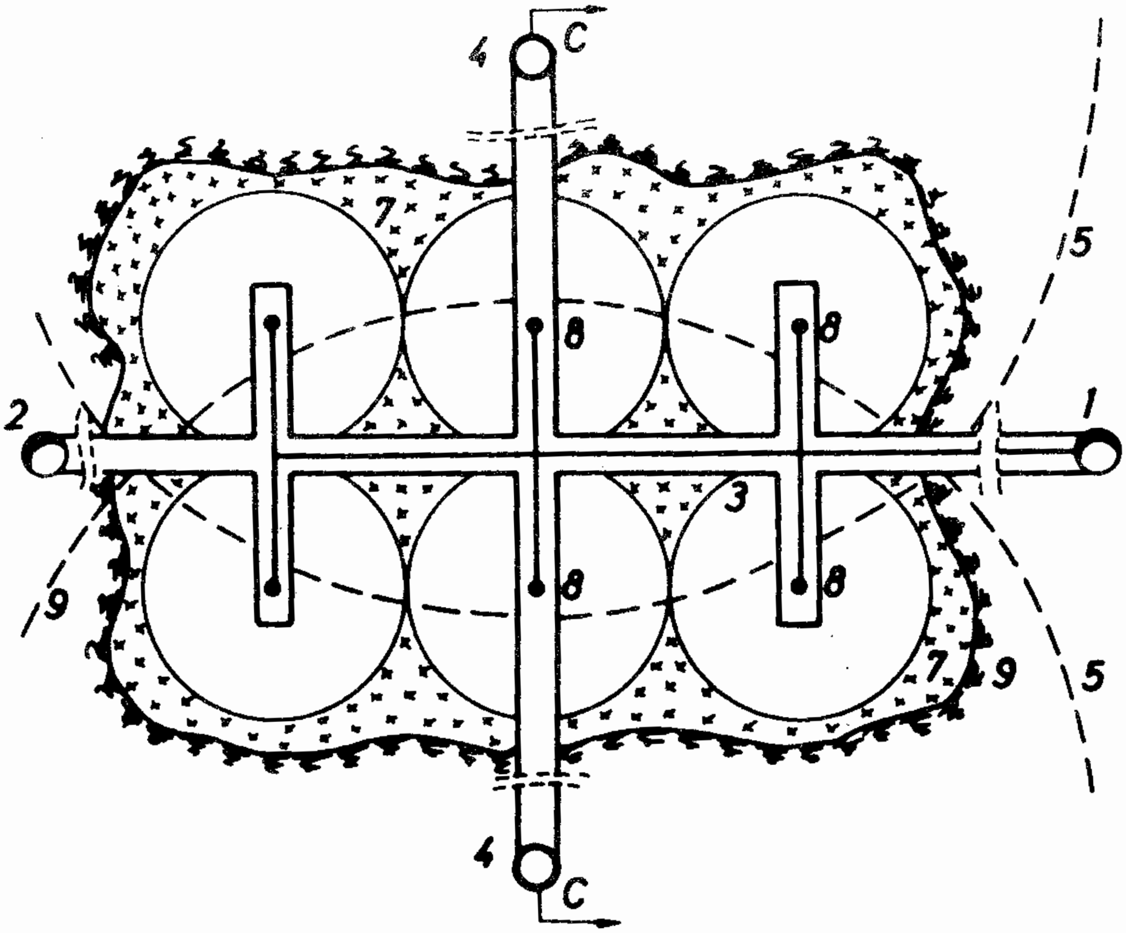

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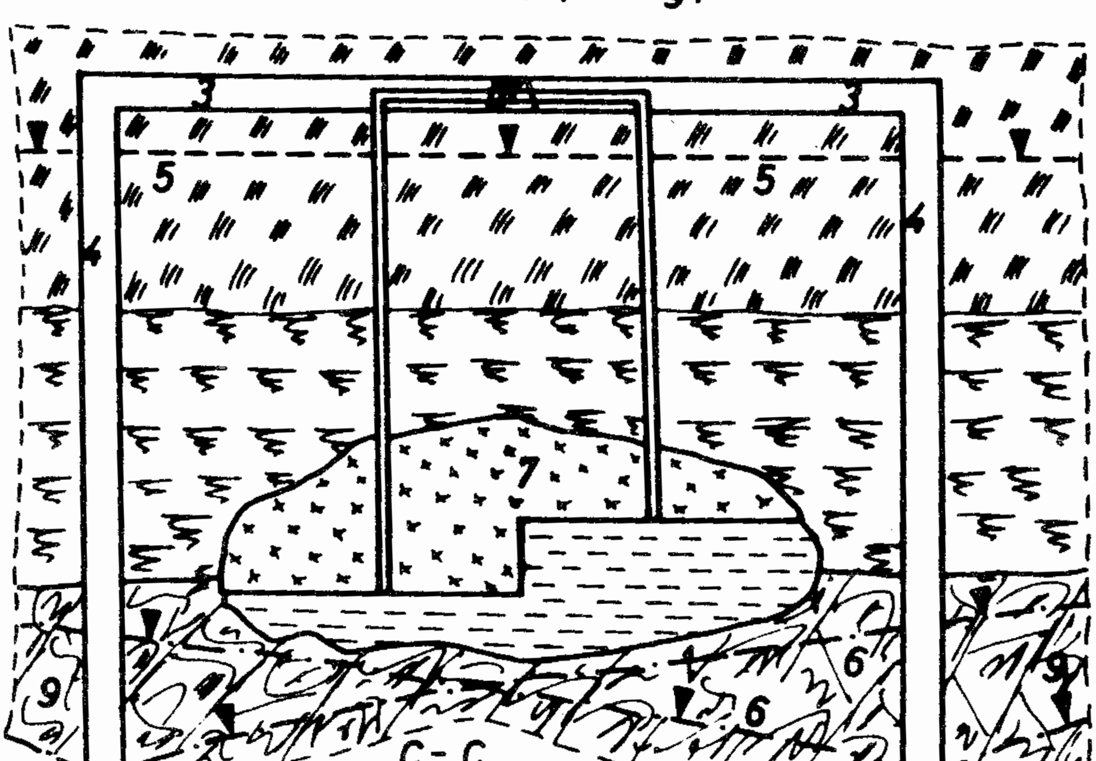

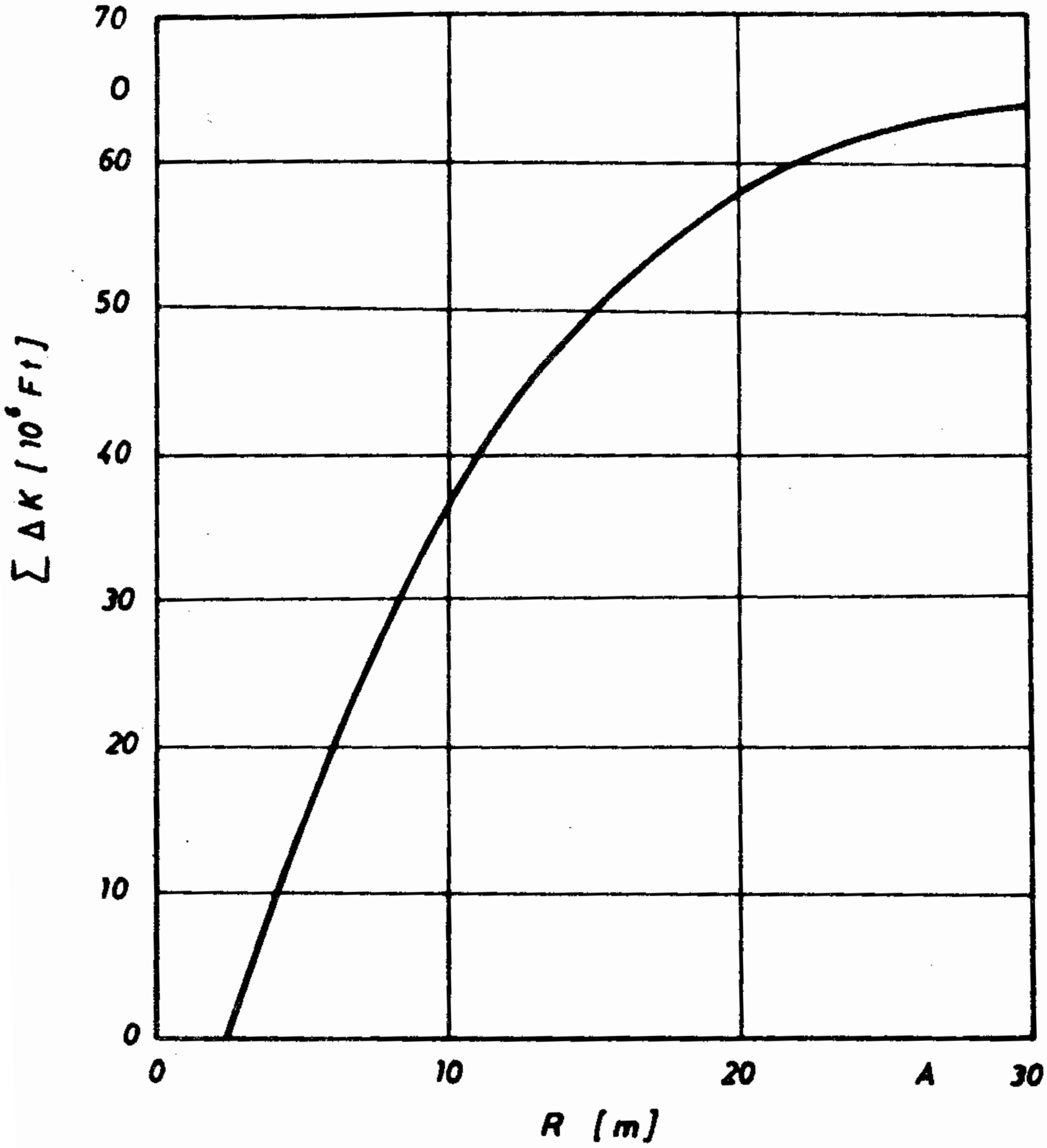

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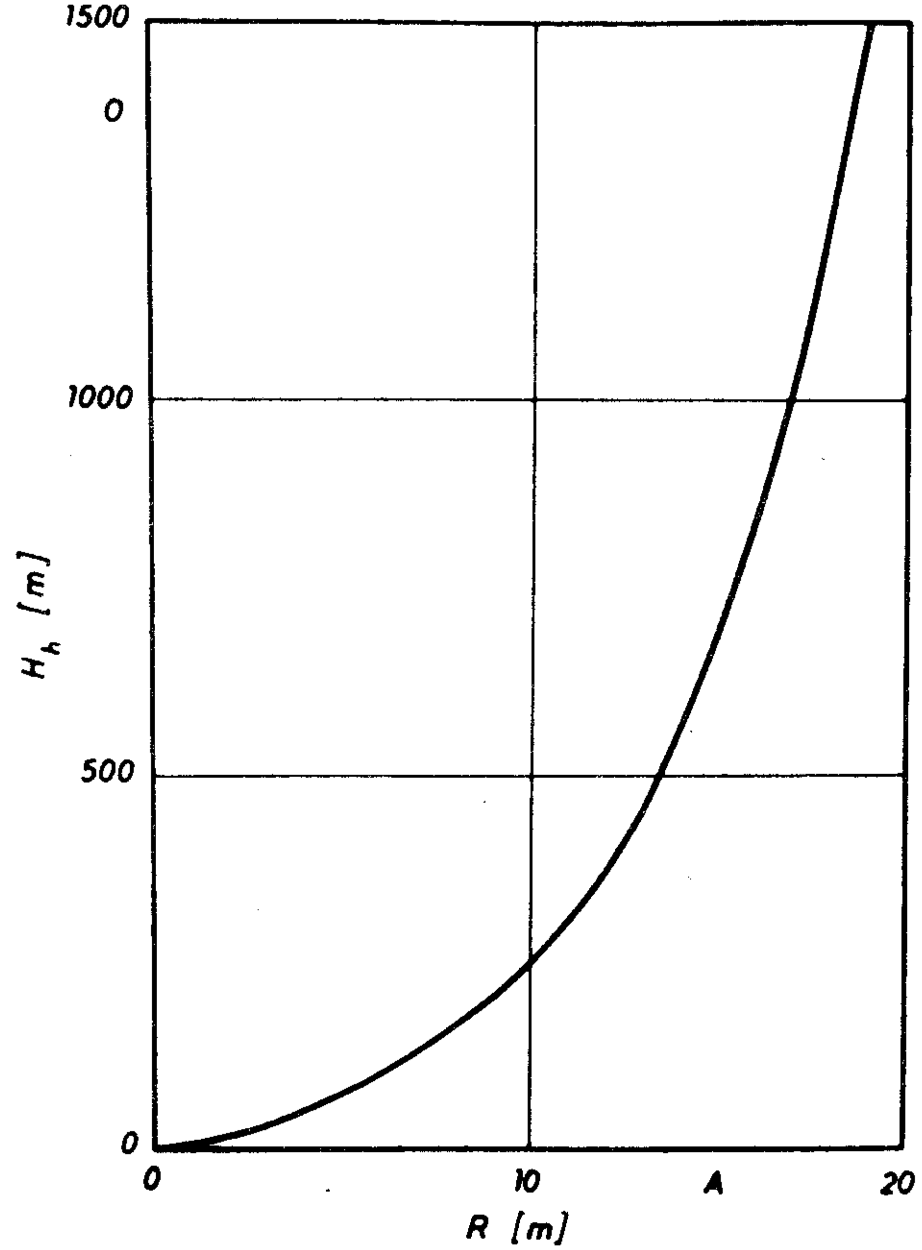

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