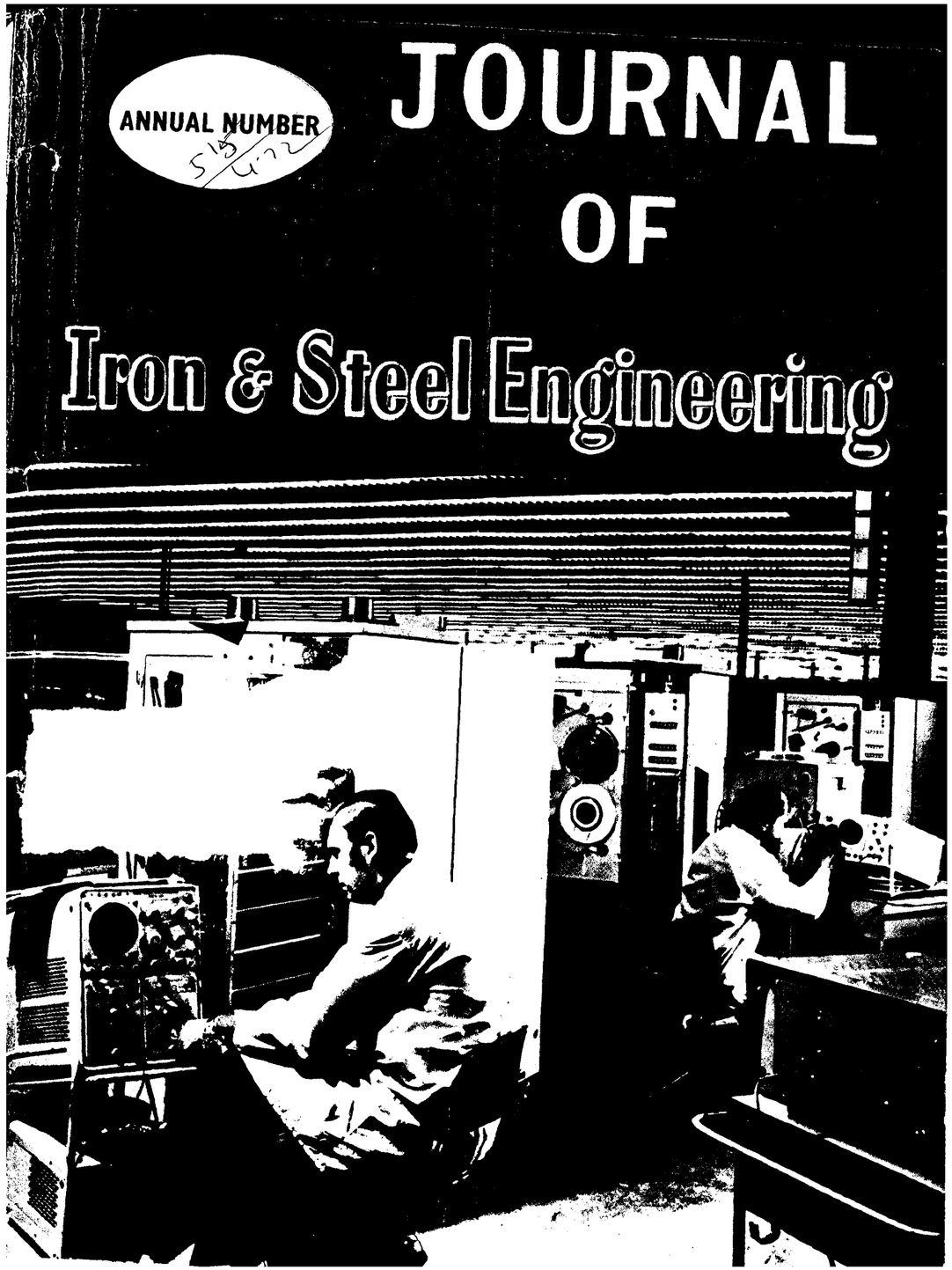
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Distance Measuring in Mine Surveying by means of Electromagnetic Waves

By HEINZ MEIXNER
Faculty for Mine Surveying, Department of Geotechnology and Mining, Mining Academy Freiberg

IMPORTANCE OF DISTANCE MEASURING FOR THE INFORMATION PROCESS IN MINE SURVEYING

IN the process of ascertaining, condensing, storing and output of information with regard to mining and in this connection the deposits, mountains, underground excavations and the surface over the mine, the determination of the spatial position of points, distances and areas plays a decisive part. As this is in principle traced back to the measuring of geometric quantities, such as angles and lengths, so that the technical progress is expressed last but not least by the methods of measuring angles, directions and lengths. In the field of length measuring (on which the following elaborations are based), a remarkable forward trend has become apparent, especially in the last two decades, so that also mine surveying was confronted with new aspects of arranging and carrying out the measurements.

The special features of applying known distance measuring methods consist in mine surveying in determining the lengths of relatively short distances above and below ground, which may be actinal, flat or vertical, depending on the set task. It becomes evident that also in future all direct and indirect distance measuring methods for mine surveying information acquisition, especially in connection with basic and supplementary measurements, operation control measurements, building measurements, depth measurements as well as the determination of mountain and soil movements will remain important, but those methods will play a particular part which contribute towards rationalization of mine surveying information and data collection (continuity) with the aim of a far-reaching automation (measured value determination and recording).

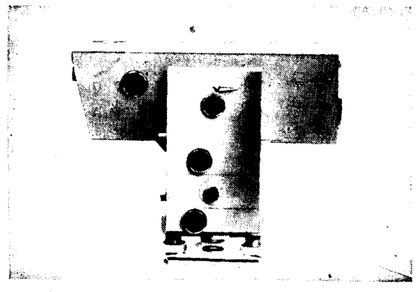

Fig. 1. Electro-optical telemeter EOK 2000 of VEB Carl Zeiss JENA

Fig. 2. Geodimeter NASM 4 B in open cast measurements

SPECIAL FEATURES OF DISTANCE MEASURING IN MINING WITH ELECTROMAGNETIC WAVES PRINCIPLE

Distance measuring with the aid of waves of the electromagnetic spectrum belongs to the group of indirect distance measuring methods, as the distance is determined by the transit time measuring of a high-frequency pulse (radar, shoran, hiran) or by phase angle measuring of continuous waves ; methods for the determination of the pulse transit time are impractical for mine surveying purposes, because of the necessity of high transmitting powers and the insufficient absolute accuracy provided. The methods of phase angle determination with continuous waves are divided into methods without modulation (interference comparator) and into methods with modulation of the carrier

waves ; with the latter, variable as well as fixed frequencies are modulated. The methods of modulated carrier waves are realized by microwave equipment or electro-optical instruments. Both groups are suitable for use in mining as the following essential prerequisites are met:

Adequate relative distance measuring accuracy over practically any distance,

independence from ambient influences, or the possibility of their elimination,

attaining a high labour productivity.

CALCULATION OF DISTANCE

Based on the well-knowa time/speed equation in physics and under due consideration of the refractive index n of air against vacuum, the required distance s'' between main and counter station (or between transmitting and receiving equipment and reflector), one obtains from the general distance equation

$$s'' = \frac{c_0}{2nf}\left(N + \frac{\omega}{2\pi}\right) \qquad (1)$$

wherein

c_0 = 299 792.5 ± 0.4 km/s the propagation speed in vacuum (according to the IUGG recommendation of 1957),

f = the modulation frequency,

N = the number of whole modulation wavelengths between transmitter and receiver,

ω = the measured phase difference between transmitted wave and the wave received after reflection.

N is usually determined either by frequency variation (phase zero control) or by using several fixed modulation frequencies f_i.

GEODETIC REDUCTIONS

The oblique distances s'' must be subsequently reduced to the chord of the reference surface (sphere). This altitude reduction is made according to the known equation

$$s' = \left[\frac{(s''+\angle h)\ (s''-\angle h)}{\left(1+\frac{H_1}{R}\right)\left(1+\frac{H_2}{R}\right)}\right]^{\frac{1}{2}} \qquad (2)$$

or according to the series development approximately according to

$$s' = s'' \frac{\angle h^2}{2s''} - s'' \frac{H_1+H_2}{2R} - \frac{\angle h^4}{8s''^3} \qquad (2a)$$

Therein $\angle h$ is the altitude difference between the two stations, H_1 and H_2 the station altitudes and R the curvature radius of the reference surface.

In order to complete the geodetic reduction, the chord must still be transferred to the circular arc of the mathematical reference surface

$$s \approx s' + \frac{s'^3}{24R^2} \qquad (3)$$

The flattening of the distances, which is usually carried out according to the GAUSS conformal mapping with the known formulae of KRUGER, shall be mentioned incidentally only.

In view of the above-mentioned geodetic reductions of electromagnetically measured distances, the following peculiarities use to happen in mining.

The relatively short distances result in a simplification of terms (2a) and (3) (see for instance [1] and [2]).

The dependence of the distance accuracy of the distance inclination, which can be noted from equation (2a) presupposes, especially in the case of the frequently occurring inclined sight distances for instance in open cast mining, a greater care in the altitude determination of the instrument stations [3].

ON THE DETERMINATION OF THE REFRACTIVE INDEX

As transpires from equation (1), the basic equation of electric distance measuring, the calculation of distance s'' is effected with the aid of the propagation speed of electromagnetic waves in vacuum which, as a universal constant applies to the entire range of the electromagnetic spectrum. The propagation speed c in the atmospheric medium is obtained, under due consideration of the MAXWELL equations, from

$$c = \frac{c_0}{n'} \qquad (4)$$

wherein for light or microwaves, according to

$$n = \sqrt{\varepsilon\mu} \qquad (4a)$$

the refractive index depends on the dielectrtc constants and the permeability constants.

According to a recommendation of the XIIth General Meeting of the IUGG in 1960, the refractive index is determined in electric distance measurements at the time of the measurements for light as carrier wave, according to the formulae of EDLEN or BARRELL/SEARS [5], which are identical for practical purposes, and for microwaves (λ = 0.03 to 1,00 m) as carrier waves, according to the following formula of ESSEN/FROOME (6):

$$n_L = 1 + \frac{n_{gr}-1}{1+\alpha t}\cdot\frac{p}{760} - \frac{5.56\ 10^{-8}}{1+\alpha t}e \qquad (5)$$

wherein

$$(n_{gr}-1)\ 10^7 = 2876{,}0409 + 3\ \frac{16{,}2876}{\lambda^2} + 5\ \frac{0.13638}{\lambda^4}$$

$$(n_M-1)10^6 = \frac{103.49}{1+\alpha t}(p-e) + \frac{86.26}{1+\alpha t}\left(1+\frac{5748}{1+\alpha t}\right)e \qquad (6)$$

Therein are:

n_L = group refractive index for light under the prevailing atmospheric conditions,

n_{gr} = group refractive index for light under normal conditions,

n_M = group refractive index for microwaves,

α = expansion coefficient of gases,

p = atmospheric pressure in Torr,

t = atmospheric temperature in °C,

e = partial pressure of the atmospheric steam in Torr,

λ = group wavelengths of light.

In practice, therefore, the determination of the refractive index is traced back to the determination of the atmospheric pressure, air temperature and steam pressure along the measuring line. When studying the errors using terms (1), (5) and (6), the result is obtained that, when presuming the same distance measuring accuracy and when using light and microwaves, approximately the same accuracy demands are made on temperature and atmospheric pressure measuring, the determination of the steam pressure, however, has to be in microwave distance measuring by more than two powers of ten more accurate than in electrooptical distance measuring (Table 1, p. 6). When finally taking into consideration that the steam pressure influence in electro-optical distance measuring compared to the temperature and atmospheric pressure influence is negligible, but is much more important in microwave distance measuring, it becomes already at this stage obvious that electro-optical distance measuring instruments are superior in practical use, as far as measuring accuracy is concerned.

Furthermore, the influence of errors in ascertaining the refractive index is considerable, especially in distance measuring with microwaves, because the required meteorological data are usually measured and averaged only at the end points of the distance and therefore do not always represent the actual conditions along the line.

EFFECTS OF AMBIENT INFLUENCES ON DISTANCE MEASURING WITH ELECTROMAGNETIC WAVES

When measuring relatively short distances, which are characteristic for mine surveying above ground and especially below ground, the electro-optical method is in principle superior to the microwave measuring one as, due to the excellent beaming capacity of the light, no disturbing effects need to be feared, caused by local reflections (soil reflection, reflections on obstacles [1], [4]). Therefore, the measuring accuracy of electro-optical distance measuring equipment is higher from the very beginning than that of microwave instruments ; although the disadvantage of stronger attenuation in case of rain and fog, which occurs already with the reduction in the lengths of microwaves and especially light waves has to be accepted. For special tasks in mining, such as depth measuring, in upcast shafts, electro-optical distance measuring instruments are therefore not suitable. An essential advantage of electro-optical distance measuring instruments for use in mining, compared to microwave equipments, is the use of passive optical reflectors in place of expensive active reflectors (relay stations), required for microwave distance measuring. Finally, mention should be made of the fact that in the development of electro-optical distance measuring instruments, essential improvements of the light sources were obtained with

Table 1: Dependence of the relative distance measuring error ms/s on errors in ascertaining meteorological data

Carrier	Effect of a temperature field $m_t = \pm 1$ degree	Effect of an atmospheric pressure field $m_p = \pm 1$ Torr	Effect of a steam field pressure $m_e = \pm 1$ Torr	Overall influence $m_n / n = m_s / s$
Light waves	$\pm 1.0.10^{-6}$	$\pm 0.4.10^{-6}$	$\pm 0.05.10^{-6}$	$\pm 1.45.10^{-6}$
Microwaves	$\pm 1.4.10^{-6}$	$\pm 0.4.10^{-6}$	$\pm 6.2.10^{-6}$	$\pm 8.0.10^{-6}$

Table 2: Use of microwaves and electro-optical distance measuring instruments in mining

Type	Carrier modulator	Modulation frequencies [MHz]	Application field	Lengths of the measured distances [m]	Systematic error proportions	measuring accuracy (without systematic influences) [cm]	Literature
Tellurometer	Microwaves (10 cm)	9.0-10.0	Open cast	200-6000	at obstacle	± 2 to ± 6	[1]
MRA 1	quartz	(4 frequencies)	Below ground	140-1150	depending on distance	± 9	[2],]4]
PEM 2	Microwaves (3 cm) quartz	9.0-10.0 (4 frequ.)	Below ground	120-960	independent of distance	± 3 to ± 6	[2]
Geodimeter	Light	30.0-31.5	Open cast	< 5000	without	± 1.5	[5], [6]
NASM 4 B	Kerr cell	(3 frequencies)					
EOS	Light ultrasound	54 to 60 (4 frequ.)	Below ground	120-1450	without	± 0.6	[2], [7]

Table 3: Results of EOS Measurements Below Ground [2]

Distance No.	^{s}invar [m]	^{s}EOS [m]	ε [mm]	Distance No.	^{s}invar [m]	^{s}EOS [m]	ε [mm]	Distance No.	^{s}invar [m]	^{s}EOS [m]	ε [mm]
1	120,103	120,112	−9	12	,391	,392	−1	23	,835	,828	+7
2	,098	,095	+3	13	600,492	600,492	0	24	,822	,816	+6
3	,114	,113	+1	14	,532	,537	−5	25	1080,932	1080,926	+6
4	240,220	240,223	−3	15	,489	,493	−4	26	,932	,918	+5
5	,220	,224	−4	16	720,615	720,608	+7	27	1201,008	1200,998	+10
6	,218	,220	−2	17	,614	,607	+7	28	,006	1201,007	−1
7	360,303	360,298	+5	18	,611	,607	+4	29	1321,122	1321,110	+12
8	,342	,342	0	19	840,736	840,728	+8	30	,123	,118	+5
9	,294	,291	+3	20	,732	,724	+8	31	1441,226	1441,222	+4
10	480,404	480,402	+2	21	,733	,728	+5	32	,226	,223	+3
11	,431	,430	+1	22	960,835	960,828	+7				

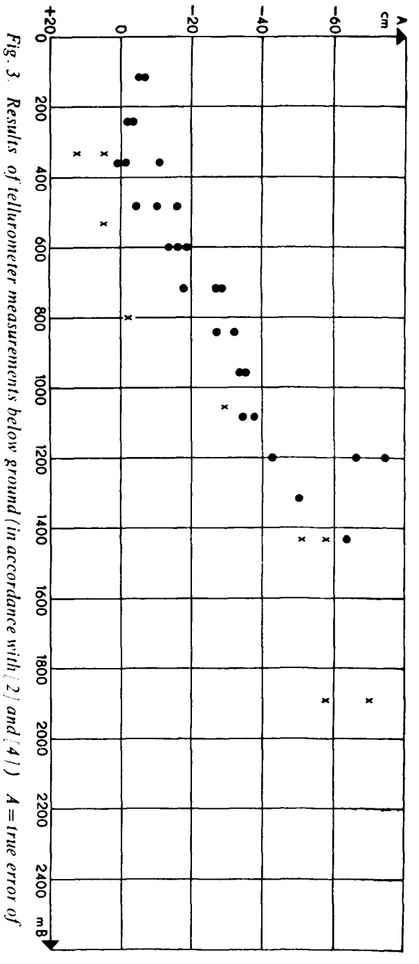

Fig. 3. Results of tellurometer measurements below ground (in accordance with [2] and [4]). A = true error of tellurometer measurements (MRA 1), B = distances below ground, 0 = cross section of the drift 2,5 × 2,5 m [2], X = cross section of the drift 5.2 × 3.8 m [4].

regard to measuring in daylight, as well as reducing dimensions and weights. The new *electro-optical telemeter* EOK 2000 of VEB Carl Zeiss JENA (Fig. 1, p. 3) meets on the whole all requirements made on a distance measuring instrument, which is to be used in mining [5].

SOME EXAMPLES OF THE USE OF ELECTRONIC DISTANCE MEASURING INSTRUMENTS IN MINING

For test measurements in mining in the GDR, microwaves and electro-optical distance measuring instruments, listed in Table 2 (p. 6), were used.

MEASURING IN OPEN CAST MINING MICROWAVE INSTRUMENTS [1]

The test measurements carried out in open cast mining, within the framework of a research project to the Mining Academy Freiberg to be carried out with the tellurometer MRA 1 in 1960 and 1961 proved that microwave instruments can in principle be used for a number of special tasks, such as longitudinal traverse surveys and distance triangulations. The advantage of the microwave distance measuring consists of its practical applicability at any time and under all weather conditions. Especially this aspect plays a great part in areas of open cast mining and in industrial areas, the atmosphere of which is enriched with condensation nuclei and has accordingly unfavourable optical viewing conditions. Considerable impediment was caused by pylons, electric railway wires and open cast equipment. By selecting suitable distances and screening of the indicator tube against magnetic fields, which are close to electric railway lines, it became possible to eliminate systematic influences to the largest possible extent.

Because of numerous possibilities for systematic influences and the necessity to include only suitable distances in the measurement, the comprehensive application of microwave instruments, even with shorter wavelengths, in open cast mining seems not very promising.

ELECTRO-OPTICAL INSTRUMENTS [5], [6]

For the metrological determination of the horizontal components of soil movements in open mine slopes, the use of electro-optical distance measuring instruments seemed an advantage, because from the beginning less systematic influences had to be reckoned with than with electromagnetic distance measuring. The test measurements were carried out by VEB Braunkohlenwerk Geiseltal within the frame-work of a research project from 1964 to 1966. The electro-optical distance measuring instrument NASM 4 B (Fig. 2 p. 3) was available. The measurments carried out on distances of 1 to 5 km length provided the following essential results:

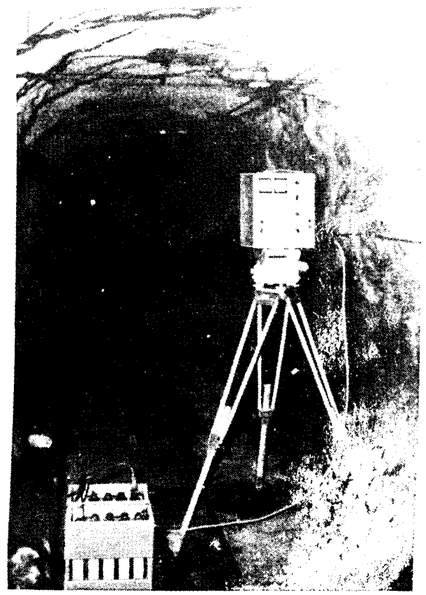

Fig. 4. EOS of VEB Carl Zeiss JENA in measurements below ground

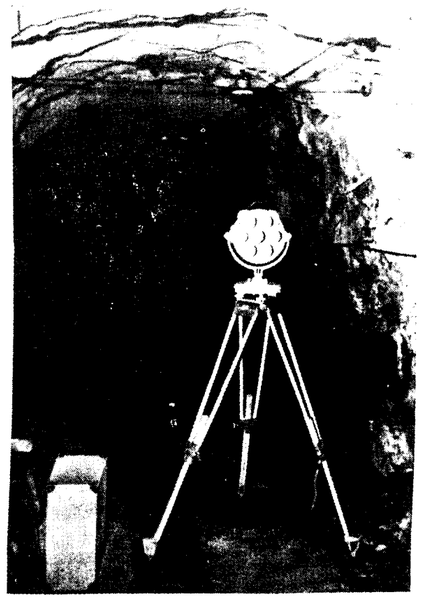

Fig. 5. 7-prism reflector of the EOS

Usually, the measurements became possible only with falling dusk. Under the existing ambient conditions, the use of an Hg maximum pressure lamp did not entail any advantages compared to the measurement with a normal bulb. Frequently occurring formations of smoke, haze and fog, as typical features in industrial areas, impeded temporarily the course of the geodimeter measurements. Special influences of physical nature to be feared in open cast mining on the propagation of light waves and thus on the distance measuring accuracy could not be observed.

MEASUREMENTS IN UNDERGROUND MINING

MICROWAVE INSTRUMENTS [2], [4]

Within the scope of research work carried out at the Mining Academy Freiberg, LIERSCH [4] proved that measurements below ground with the tellurometer MRA 1 can be carried out in cross-cuts of 4 x 5 m cross-section up to distances of 1800 m. Up to approximately 800 m distance, the occurring errors were of the same magnitude as above ground. At larger distances considerable errors occurred; at distance > 1800 m distance measurements could no longer be carried out.

The shaft depth measurements carried out with reflectors with the tellurometer MRA 1 on the pit bank and bottom landing yielded for depths of 140 m to 1150m compared to depth band measurements differences up to + 13 cm with an external accuracy of ± 9 cm.

SEIDLER [2] stressed the dependence of the range on the distance cross-section. With a smaller cross-section (2.5 x 2.5 m) the tellurometer failed already at distances > 1400 m. Fig. 3 leads to the conclusion that also the attainable accuracy depends on the cross-section.

Test measurements with the microwave instrument PEM 2 were carried out on comparable underground distances of 120 to 960 m lengths [2]. Distance-independent systematic deviations amounted in the two instruments used to (No. 4 and 6) - 4 or + 11 cm; these and the corresponding residual errors of ± 3 or ± 6 cm are more favourable than those obtained with the tellurometer MRA 1, but lead us to conclude that microwave instruments are not suitable for distance measuring below ground.

ELECTRO-OPTICAL INSTRUMENTS [2], [7]

The EOS (No. 191 385) of VEB Carl Zeiss JENA was tested by SEIDLER [2] below ground on comparative distances in a cross-cut of 2.5 x 2.5 m cross-section at the Freiberg lead ore pits and with invar wires to an accuracy of approximately 1 : 500 000. Figs. 4 and 5 (p. 8) illustrate the measuring situation. BOHM [7] has used the EOS (No. 191 394) successfully for main traversing in pit orientation.

Table 3 (p. 6) lists the results of comparative measurements below ground. As approximately "true" values were used the results of the invar wire measurements, so that in the mean error of the EOS measurements calculated from [ɛɛ] a proportion (although small) of the basis measurement is contained.

The tests with the EOS have shown that this electro-optical distance measuring instrument can be used for main traversing and precision measuring below ground. Atmospheric pressure and temperature curve in distances below ground follow certain laws and necessitate the determination of the meteorological data on the instrument as well as on the reflector station, required for the calculation of the refractive index.

CONCLUSIONS

For the measuring of relatively short distances in mines above and below ground, in connection with basic, supplementary and operation control measurements, electro-optical distance measuring instruments are by far superior to microwave instruments. The distance-measuring accuracy, the independence of ambient influences, the reduction of dimensions and weights, together with a simplification of the measuring process, as well as the possibility of an interchange with an automatically centered theodolite are development trends, which are reflected in both electro-optical distance measuring instruments of VEB Carl Zeiss JENA – the EOS and EOK 2000 –. Simultaneously, also the reasons are shown, which will lead to a wider use of the EOK 2000 in mining in the German Democratic Republic.

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VEB CARL ZEISS JENA AT THE 1972 LEIPZIG SPRING FAIR

By Dr. H. Schmieder

NOW as before it is of utmost importance for the scientifico-technical progress that highly precise and rationally operating instruments, instrument complexes and instrument systems are made available to research and production. Products of scientific instruments manufacture permit of extending the knowledge of man and of increasing the working productivity of science and industry. 125 years of successful work together with the creative power of the workers made VEB Carl Zeiss JENA an efficient centre of scientific instruments manufacture. Well-established and new instruments, exhibited at the 1972 Leipzig Spring fair are witnesses of our accomplishments and form a representatives survey of the export programme of VEB Carl Zeiss JENA.

The orientation of VEB Carl Zeiss JENA toward instrument systems as a means to rationalize complete metrological and technological processes is continued by the new design of the instrument system Industrial Photogrammetry. With the aid of this system it will be possible, to solve in a most economical way all measuring problems, especially those of complicated geometrical forms and of inaccessible n-objects. Referring to the E-System, the scientifico-technical progress of the production process of microelectronics and the close connection with the Soviet Union and the inherent economical advantages are demonstrated here for the first time.

Complex problem solutions, one of the economically most favourable variation in the field of physico-optical measuring instruments and microscopy are designed for chemistry, metallurgy and agriculture. The following problem solutions deserve special mention :

— absorption photometry
– spectrophotometry
— refractrometry/polarimetry
— REMAT process control
— transmitted-light microscopy
— incident-light microscopy
— interference microscopy
— polarization microscopy
— and — in co-operation with VEB Freiberger Prazisionsmechanik — x-ray microstructure analysis

The problem of waste water control and air pollution is especially taken into account.

Another instrument complex is that of industrial measuring instruments, where VEB Carl Zeiss JENA in conjunction with the associated firms VEB Feinmeβzeugfabrik Suhl and VEB Feinmeβ Dresden display a wide range of their production programme. With these products, the metal-working industry is offered the required measuring and testing instruments for an economical production.

For the economically very important problems of surveying, VEB Carl Zeiss JENA developed the instruments of the standardized series GEOmat.

Further instruments on exhibit are :

— the extended DOKUMATOR system
— structural units for numerically controlled machine tools magnetic tape stores for electronic data-processing equipment.

The exhibition programme is supplemented by a vast assortment of consumers' goods such as prism binoculars, sighting telescopes, theatre glasses, spectacle lenses and frames, compasses, photographic lenses

In the following, we wish to introduce the wide and versatile range of new and improved instruments of VEB Carl Zeiss JENA :

Fluorescence Microscope FLUOVAL

FLUOVAL is a universal microscope for carrying out all modern fluorescence methods and their combinations.

Due to its compact design, an easy, reliable and permanent adjustment, same as an almost complete screening against scattered light is achieved. The light exits in the base and at the front of the condenser may be concealed by diaphragms in such a way that, during observation, the user is protected from vagrant exciter light.

The exciter light source is a microscope lamp HBO 200, whose light path may be optionally switched over from incident light to transmitted light. Both optical paths are designed to employ the KOHLER method of illumination, both images of the field diaphragm may be exactly adjusted with each other. The swing-in type holders of the filter magazine accommodate a well-proved assortment of filters for ultraviolet, blue-violet, and blueviolet and blue excitation.

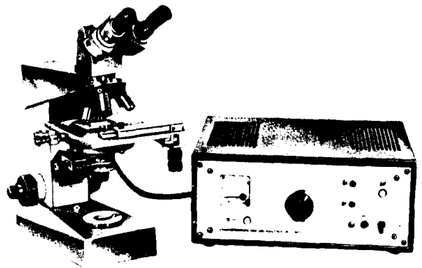


Fig. 1. Fluorescence Microscope FLUOVAL

The pertinent barrier filters are housed in a dial in the trinocular tube.

A projection lamp 6 V 15 W serves as a second light source to materialize combination methods.

The optical system of the illumination is made of a type of glass, which is extremely transmissive for the wavelengths of excitation radiation. The imaging optics consists of apochromats, plane compensation eyepieces and projection eyepieces with compensating effect for photomicrography.

When introducing a phase-contrast equipment 0.9/e, or a cardioid dark-field condenser in centrable substages, there will be possibilities to combine fluorescence excitation in incident light with phase contrast in transmitted light and with darkfield transmitted light, as well as for fluorescence excitation with the cardioid condenser, a technique, indispensible for serological fluorescence microscopy.

Heating and Cooling Stage—20...+ +80°C

The Heating and Cooling Stage —20.... +80°C is a supplementary unit for microscopes of the MIKROVAL-series, which are provided with interchangeable object stages. It is contained in the standard equipment AMPLIVAL therm and is intended for investigating the behaviour of microscopic objects in the temperature range —20.... +80°C and for determining the refractive index of transfparent media.

The mode of operation of the instrument is based on the PELTIER effect. Changing over from heating to cooling is performed by merely actuating the switch of the respective power supply line.

The object is moved by means of an object traverser, to which an object holder for object slides 76 mm x 26 mm, an object slide with thermocouple and, in addition, a moist chamber may be attached. The heating and cooling stage may also be centered and rotated (>70°).

With the aid of a cover, the object room can be isolated against the ambient temperature. It can also be flooded by gases, in order to prevent the steaming or the formation of frozen fog on the objects during the cooling process, or to be in a position to work in definite gas spheres.

When using object slides 76 mm x 26 mm, the setting accuracy of the temperature is ±0.2°C, whereas a still higher measuring accuracy is obtained with the object slide with thermocouple, which depends, however, on the indicating device employed. By the application of additional aids, a temperature constancy of ±0.03°C may be achieved.

Test substances with known melting points are available for checking and calibrating the temperature indicators.

Our range of Optical Circular Tables

The Optical Circular Tables OKT 500 and OKT 800 are shown for the first time at the 1972 Leipzig Spring Fair. They complement the series of non-swivelling optical circular tables, which now consist of the sizes OKT 315, OKT 500 and OKT 800.

Application : The optical circular tables are intended for use as supplementary units on boring, milling and grinding machines for producing angular divisions with a maximum error of 6". Junction dimensions and design render them particularly suitable for use on co-ordinate boring machines.

In conjunction with a power pack and with a stop with precision indicator or with a mirror or autocollimation telescope, the optical circular tables are employed as angle measuring instruments for testpieces up to 1000 kg.

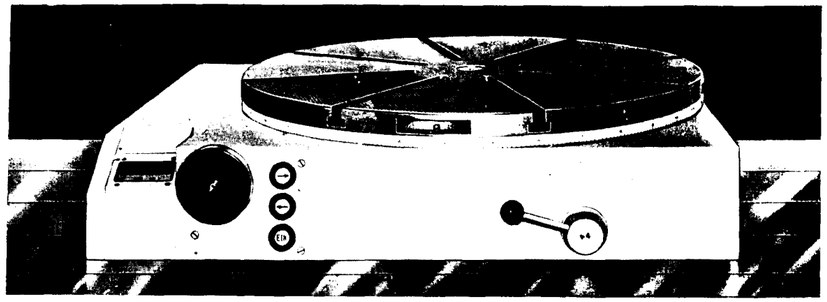


Fig. 2. Optical circular Table 800

Design features of the new models :

The OKT 500 with a diameter of the stage plate of 500 mm is provided with a handwheel for precision drive, a single-lever clamp and with a lever for disengaging the worm of the precision drive. Rapid displacement of the stage plate through a large angle can be carried out by hand, after having disengaged the worm.

The OKT 800 with a diameter of the stage plate of 800 mm is provided with a single-lever clamp, a disengageable handwheel for the precision drive, and with a motor with push-button control for clockwise and anti-clockwise rotation (4 r. p. m.) for the rapid displacement of the stage plate. Both models have the standardized projection screen for the quasi-digital indication of the angular position of the stage plate.

The stage plate is furthermore provided with 6 or 8 T-slots and, in centre, with a cylindrical bore which also holds the optical centering mark.

The handwheel affords reproducible angle setting of the stage plate to an accuracy of 1" to be made.

A coarse orientation scale at the periphery of the stage plate and a graduated glass circle in conjunction with the optical micrometer for the quasidigital reading of the angle in degrees, minutes and seconds on the projection screen permits the reading of stage plate's exact angular position.

The single-lever clamp arrests the stage plate in the nominal position, without changing the angle or the height position of the stage. The clamping pressure is produced by BELLEVILLE springs.

When setting the nominal angle, time is saved by the moveable zero index, a double line with the function of a catch fork on the projection screen. The minutes and seconds of the next angular position can be preselected, even during the machining of the present workpiece. The housing of the stage, same as the exterior electrical components are spray-water-protected.

SPECIAL FEATURES COMPARED WITH COMPETITIVE INSTRUMENTS

The planeness of the stage plate, its axial runout and its parallelism relative to the locating surface of the stage (of technical data) correspond to the high angle-setting accuracy of the OKT 500 and 800. Once an angle is set, it remains unchanged even at high machining powers in vertical and horizontal direction.

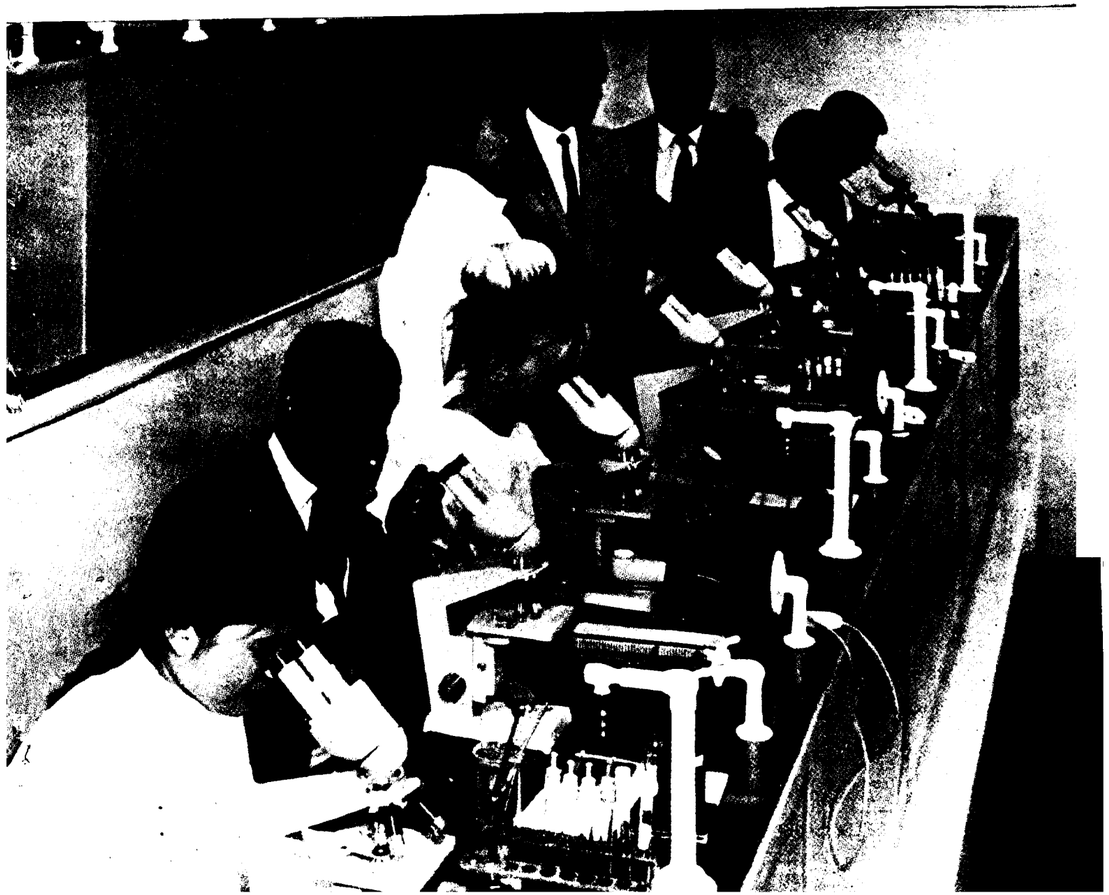
The angle values 1°, 1′, 1″ are quasidigitally indicated on the projection screen, i. e. they are largely free from subjective reading errors.

Centering of the optical circular tables relative to the working spindle of the machine tools has been made possible not only mechanically, but also optically by means of a centering mark.

TECHNICAL DATA	OKT 500	OKT 800
Stage plate dia.	500 mm	800 mm
Outer dimensions	636x500x165	970x800x220
Overall weight	152 kg	500 kg
Loadability, vertical	500 kg	1000 kg
Loadability, horizontal	300 kg	500 kg
Flatness of the concave stage plate	$\prec 3\mu$m	$\prec 5\mu$m
Axial runout of the stage plate	$\leq 3\mu$m	$\prec 5\mu$m

TECHNICAL DATA	OKT 500	OKT 800
Maximum non-parallelism between stage plate and bearing surface of the stage	$\leq 6\mu$m	$\prec 12\mu$m
Scales read to	1° 1′ 1″	1° 1′ 1″
Maximum error between two optional angle positions	$\prec 6''$	$\prec 6''$
Reversal error	$\prec 2''$	$\prec 2''$
Standard deviation	$\prec 0.8''$	$\leq 0.8''$
Mains connections	110 V, 127 V, 220 V, 240 V; 50-60 Hz	110 V, 127 V, 220 V, 240 V; 50-60 Hz

Students of the Friedrich-Schiller-University Working with microscopes of the Microval range made by VEB Carl Zeiss JENA.



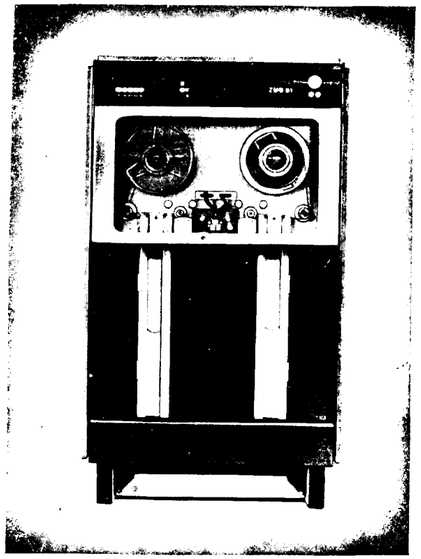


Fig. 3. Magnetic Tape Store ZMB 61

The Magnetic Tape Store ZMB 61

A new type of magnetic tape stores for electronic data processing equipment is introduced.

With this instrument, the speed of the tape was increased from 1.5 m/s to 2 m/s and thus the data transmission frequency raised from 64.000 to 96.000 characters per second. Same as the ZMB 51, also the ZMB 61 comes up to all international standards for digital magnetic tape recording. The ZMB 61 represents an adaptation of the ZMB 51 to the Soviet data processing equipment MINSK-32. It is interchangeable with the Soviet tape store NML-67 regarding the size of the data carrier as well as regards the junction conditions to the control units.

High-Voltage Spark Pulse Generator HFI 1

The High-Voltage Spark Pulse Generator HFI 1 is an excitation instrument for the spectroanalytical investigation of metals. It has been developed in close co-operation with the Technisch-Physikalische Werkstatten, Thalheim. As a spark generator with 12 KV

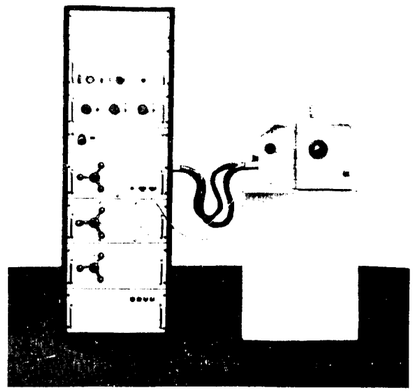


Fig. 4. High-Voltage Spark-Pulse Generator HFI 1

discharge voltage, it is mainly used in spectrographic metal laboratories for exact quantitative analyses. On account of its well reproducible discharge character, it is employed in particular in conjunction with direct-recording spectrometers, where the spectrally dispersed light emission is directly measured by electronic radiation detectors.

The spark frequency of the HFI 1 is electronically controlled in accordance with a patented wiring principle. As each spark has died away after about 0.1 ms, it will be possible (with the three phase mains), to increase the spark frequency from the 100 Hz to the 200 Hz or 300 Hz rythm. The effective light emission is increased to the same extent, and the reproducibility of the measuring values improved by the factor 2, compared with the hitherto usual disharge rate in the 100 Hz rythm. This effect may be easily proved by means of a direct-reading spectrometer, f. i. by the DSA 240.

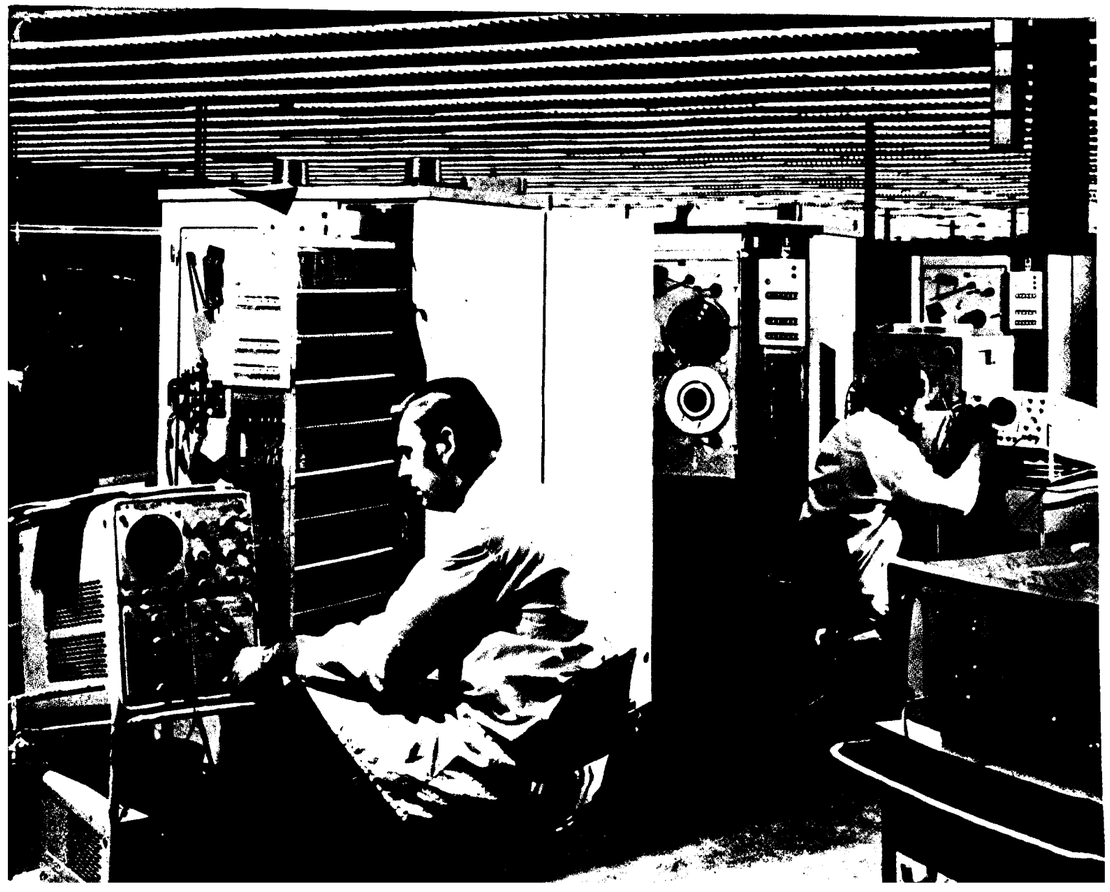
The instrument consists of six plug-in units, which are accommodated, one above the other, in a rugged sheet steel housing and which are electrically connected by multipolar plug receptacles. This design feature guarantees a good supervision of the instrument and a good servicing. All operating and control elements are attached to the front side. It is worth mentioning that the effective discharge current is measured by means of a thermo-transformer. This measurement is made in two ranges, independent of the high-voltage and pulse character of the discharge, in such a manner

that a proportional interconnection exists with the average light emisssion.

The mechanically controlled and non-screened Spark Generator HFO 2, supplied so far, is replaced by the radio-shielded High-Voltage Generator HFI 1. As regards the capacity of the light emission and the reproducibility, the HFI 1 is much better than the predecessor.

In addition to the direct spectroscopy, the HFI 1 can be employed to advantage as a modern exciting instrument also for plate-specific spectrographic methods, if mainly exact quantitative analyses of metals are to be carried out.

Adjustment of magnetic tape stores in an assembling hall.



Precision Diffraction Gratings

On the occasion of the 1972 Leipzig Spring Fair, JENA displays an assortment of precision diffraction gratings from their production programme from 1 to 2 m.

The standard assortment comprises plane gratings with 1300, 650, 325, 162 and 80 grooves per mm in seven different sizes between 30 x 30 mm^2 and 120 x 100 m^2 and for various wavelength ranges.

As a means of spectral dispersion, diffraction gratings represent very important components for physico-optical analysis instruments. In addition to dispersion

prisms, JENA employs increasingly precision diffraction gratings in their own production of spectral instruments, especially for spectrographs, monochromators, spectrophotometers, spectrocolorimeters in the ultraviolet, visible and infrared spectral region.

Diffraction gratings consist of a very large number of parallel grooves per length unit, applied to a reflecting metal layer on a glass support with plane or concave-ground surface.

Aluminium is preferably used as reflecting material, as it is distinguished by uniformly good reflection properties over a large spectral range.

The problems of the production of grating lie in the extremely high requirements to be satisfied by the accuracy of the distance between the individual grooves and of the profile of the grooves, and in the quality of the reflecting surface. Irregularities in the order of 1.10^{-5} may already cause undesired secondary phenomena in the grating spectrum.

The machines for producing original gratings and a copying method, where equivalent copies of the gratings are obtained, have been developed by the JENA Optical Works.

Method and Accuracy of Differential Rectification with the Topocart—Orthophot—Orograph

After having resumed the series production of the instrument combination Topocart-Orthophot-Orograph in 1970, numerous authorities in many countries had quite some valuable experience regarding accuracy, working methods, application ranges and economical applicability of this instrument combination for the production of orthophotographic maps. In addition, comprehensive statistical material on their accuracy was obtained by testing each serial instrument according to the ISP-recommended standard tests, prior to their delivery to the customers.

The following conclusions can be drawn from these data :

The on-line system design of the instrument combination has stood the test. It requires only a minimum of operational expenditure and greatly excludes errors of operation.

With a resolving power of 50 lines/mm, the orthogonal projection yields an outstanding quality of the orthophotographs.

The slit width of 4 mm can be regarded as standard slit width. After having checked hundreds of orthophotographs for "step formation" or "jumps", it may be assumed that the influence of the slope on the quality of the orthophotographs is so insignificant that the provision of special equipment for compensating the slope can be dispensed with.

The mean co-ordinate error of the orthophotographs is approximately $m_{x,y} = \pm 0.1$ to 0.2 mm, i. e., in the order of magnitude of the drawing accuracy.

Of great benefit is that, with the magnification range extending from the mean picture scale to the rectification scale 0.8 to 4.2, work can be done in almost all instances without subsequent photographic enlarging or reduction of the orthophotographs being necessary.

The variable speed control during the scanning of the profile by the factor 1 : 3 results in a time saving of 20 to 50% as compared with the fixed scanning speed.

The possibility of supplementing the dropped lines on the drawing table by stereomapping increases the accuracy and improves the interpretability of the dropped lines.

The accuracy of the contour lines, derived from dropped lines, amounts to $m_h = \pm 0.2$ to $0.4\%_0$ of the flying altitude h_g. The plotting capacity amounts to one to three stereomodels per shift.

ASCORECORD - 3 DP

In 1964, the co-ordinate measuring instrument ASCORECORD was introduced to the public for the first time on the occasion of international congresses in Hamburg and Lisbon. As a consequent further development of the co-ordinate measuring instrument Komess 3030, which was equipped with an electronic system for data determination and recording, it attracted the attention of experts over there. The instrument, which originally was built for astronomical purposes in little quantities only, found a larger circle of interested persons in the photogrammetric field, in test laboratories of precision engineering and electronics. In continuous further development, adapted to

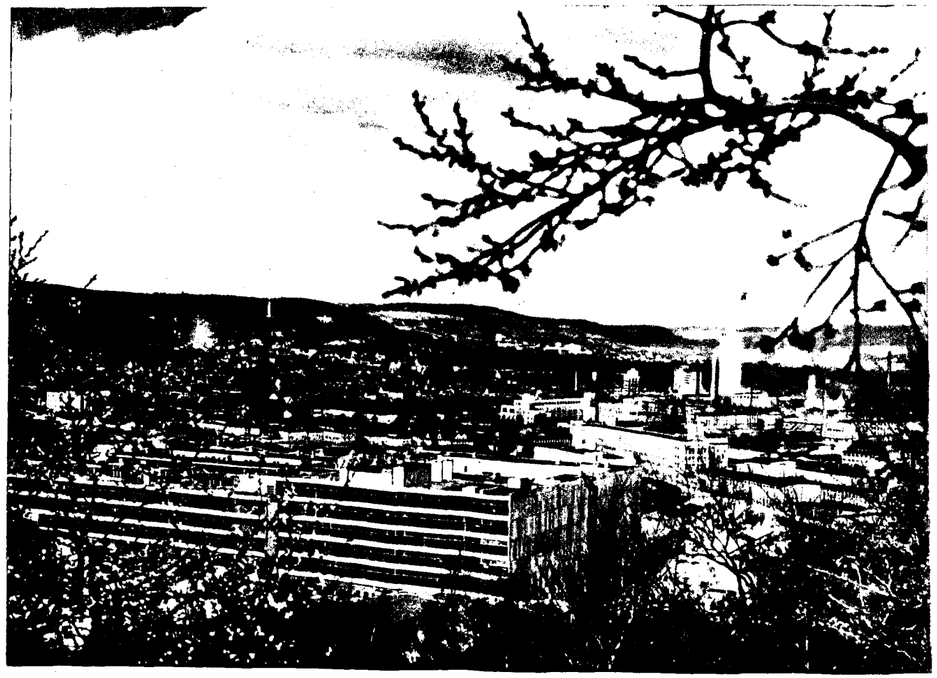
the requirements of the new users, the efficiency of the ASCORECORD was permanently improved. The standard instrument, which made use of the well-established ABBE comparator principle for two co-ordinates in order to achieve maximum accuracy, was optimized in design, same as the electronic units. At the beginning, the discrete transistor diode technique in conjunction with the relay technique was applied, but soon, a new electronic unit of smaller dimensions and higher reliability followed, which consisted of integrated circuits. In this way the service life of the instrument could be considerably increased, in particular when being in continuous operation in industry.

At the 1972 Leipzig Spring Fair, a new generation of the ASCORECORD is on exhibit which, while maintaining all prevailing advantages of the instrument, guarantees a further essential increase of the working productivity. This is achieved by coupling the ASCORECORD standard instrument with the small-type control computer KRS 4100 by means of the adaption member BITALUX.

The ASCORECORD 3 DP (data processor) is now in on-line operation with the small-type control computer, so that the further evaluation of the measuring results is considerably accelerated.

The photoelectric transmitter of the standard instrument supplies the information on the distance covered via the adaption member BITALUX to the memory of the computer, where all information on the ASCORECORD's instrument constants are to be found. Depending on the computer programme, the first reduction of the measuring values may be carried out already in the course of the measurements, so that a corrected measuring record can be written by the teleprinter. The complete reduction of the measuring values is effected at the end of the measuring set, in correspondence with the special user-oriented software.

It is assumed that the evaluation time amounts only to a fraction of the measuring time, so that the result of the measuring task may be ascertained very quickly.



In the foreground new buildings of the VEB Carl Zeiss JENA in the Valley of Lichtenhain ; in the background the South Works and in the centre of the town the Main Works.

The DOKUMATOR Microfilm Recorder DA 7

With their Microfilm Recorder DA 7, a new camera for the photographic recording of originals up to format AO is produced. It corresponds in all aspects to the requirements of modern microfilm engineering.

The DA 7 is an instrument with a table designed as a luminous box. The contact surface for the originals can be illuminated either by incident or by transmitted light. After a thorough investigation regarding its necessity, the possibility of using mixed light was dispensed with.

to each other by means of a special filter. The exposure time of the camera is constant.

The flat position of the film during exposure is ensured by a suction effect in conjunction with a pressure plate. After each exposure, the film is automatically advanced by the standardized step of 52 mm.

The operation of the recorder is largely automated. Depending on the confectioning of the film, different programmes can be set. Exposure of film strips with about 15 pictures (which can be subsequently developed in the Microfilm Developing Instrument DE 3), is possible, same as the microfilming of 30 and 50 m film

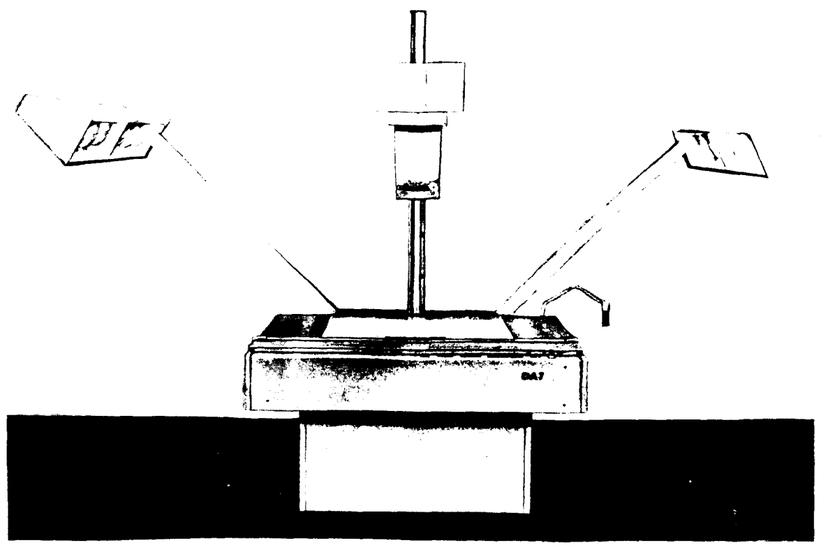


Fig. 5. DOKUMATOR Microfilm Recorder DA 7

The sensitivity of an unknown emulsion has at first to be determined by taking test photographs under varying setting conditions of the nominal value The fluctuations, caused by the reflection or by the transparency of the originals, are automatically compensated by a power switch with silicon-controlled rectifier in such a way that the density of the film is always correct. Thus, the sensitivity of the film and of the photoelectric detector are almost ideally attuned

contained in daylight loading spools or in cassettes. Any optional microfilm materials of any optional sensitivity may be employed.

The DA 7 can be set in steps to full-size photographs, or continuously from size A 4 to A O.

The special lens system, which has a very high power of resolution and which, due to a special-tpye

filter, eliminates greatly the distortion, is automatically critically depicted for all formats.

The Microfilm Developing Instrument DE 3

The Microfilm Developing Instrument DE 3 is a new design within the system of DOKUMATOR microfilm equipment. It is a valuable supplement to the microfilm Recorder DA 7, as it will be possible with its aid, to develop, fix wash and dry the 35 mm wide microfilm strips which may be provided with up to 15 individual pictures. The working method employed is that of the modern fixation development A thermostat, incorporated in the instrument, as well as a circulating pump take care that optimum conditions pervail in the fixation developer.

With the aid of a film-spooling device, the film strip comes from the film-strip cassette (accessory of the Microfilm Recorder DA 7) and is directly introduced into a spool, immersing in the fixation development bath. It must be stressed in particular that this process may be performed at daylight, or under ordinary room-illumination conditions. Washing and wetting facilities and a drying shaft are in the same instrument. Another advantage is a very simplified manipulation, so that the Microfilm Developing Instrument DE 3 represents a genuine enrichment of the DOKUMATOR microfilm system

Further particulars from :
VEB Carl Zeiss JENA
69, JENA · Carl-Zeiss-Straβe-1
DDR

New Pneumatic Tools of KRUPP Make

Krupp Maschinenfabriken in Essen are now offering a complete line of pneumatic tools, ranging from vane-type grinders and drills, sanders and impact wrenches to sheet-metal shears, nibblers and special-design tools for grinding, brushing, milling, polishing and cutting-off operations. All in all, this program comprises 190 different types of hand-held tools. It further includes pneumatic chippers, riveters, sand rammers, coal pickers, concrete breakers and rock drills.

PNEUMATIC STONEWORKING HAMMER

Two new pneumatic tools were added to the program recently, one of which is the stoneworking hammer 366 operating at an air pressure of 145 psig. This handy tool weighing only 750 g enables the stonecutter to chisel out recessed or elevated lettering, to carve out figurines or to perform other dressing work easily and quickly. Its air consumption is only 9 cu. ft per minute. With a stroke of 32 mm, the 20-mm diameter piston delivers 3500 blows per minute. The air inlet has a 1/4 inch female thread for connecting a 10 mm I. D. air hose. The chuck is designed for a tool shank size of 10.3 x 36 mm.

PNEUMATIC VIBRATORY GRINDER

The second new addition is the pneumatic vibratory surface grinder 532, also designed for an air pressure of 145 psig. Combining high speed (12,000 RPM) with low weight (1.9 kg), this tool may be used in the metal-working and automotive industry to facilitate the removal of old paint coatings, the grinding of primed surfaces, and other roughening, smoothing or polishing work, whether dry or wet. It is equally efficient for work on steel, aluminium, wood, plastics, etc. The grinder plate measures 180 x 100 mm and requires abrasive paper in the size of 235 x 100 mm. Air consumption is only 10.5 cu. ft. per minute.

A notable feature of this tool is its low vibration and silent running. Thanks to its symmetrical handle, this single-hand tool is equally suitable for both right and left-handers and can be safely used in all environments, even in rooms exposed to explosion hazards The air inlet has a 3/8 inch male thread for connecting a 10 mm I. D. air hose.

* * *

Continuous Casting at high speed

In the autumn of 1972 the Kawasaki Steel Corporation will be taking into operation a new strand casting plant in their Mizushima Works. The new plant, in which the Kawasaki Steel Corporation invested roughly 25 million DM, is being built by the Japanese licensee of DEMAG AG, Hitachi Zosen, Osaka.

The 2-strand machine is designed for a slab thickness range of 180 - 305 mm and a width range of 850-1,900 mm.

The strand caster will cast 275 tonnes of molten steel into slabs for sheet and heavy plate at high speed. For the first time in the history of Mannesmann/Demag the principle of progressive straightening is being employed for an arc-type caster with large initial radius. The design features ensure minimum change-over and repair times. All plant components, including ladle slewing tower, permit fully-continuous operation. The nominal capacity of the plant is 1.2 million tonnes a year.

Performance of the Geodetic Beacon Lamp TSG 200

By WIELAND FEIST

THE demand for the provision of a higher-performance beacon lamp as part of the equipment of the Universal Theodolite Theo 002, which ensured centering of the emerging bundle of light rays on the center of the luminous station that was free from systematic errors and also possessed a long range was the incentive for the design of the new Geodetic Beacon Lamp TSG 200.

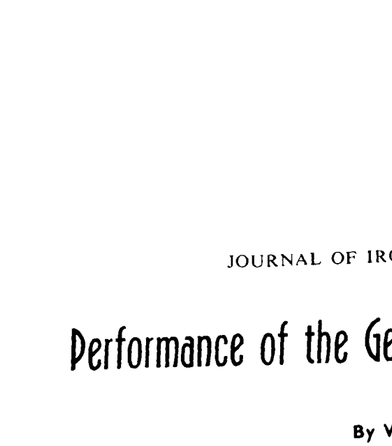


Fig. 1. TSG 200 in the tribrach 175

E. Grodel reported on the significance of the TSG 200 for the Theo 002 equipment in Reference [1], while K. Schmidt provided a comprehensive description of the instrument in Reference [2]. In the following, these works are supplemented by a few comprehensive investigations on the performance of the new Geodetic beacon lamp.

THEORETICAL STUDIES OF THE PERFORMANCE OF THE TSG 200

The range for first-order triangulations lies between 20 and 50 km, depending on the problems encountered in various countries. These long ranges and atmospheric influences make corporal targets so poor in contrast that the observer cannot resolve them with the telescopes employed in the sighting instruments used for first-order triangulation. That is why targets have to be signaled by luminous target marks. This makes it possible to make observation in the evening as well as during the daytime. The observer places the point of light marked by the beacon lamp on the horizon in his telescope's field of view and centers its crosshair on the midpoint of this point of light. The

Fig. 2. TSG 200 in the tribrach 60 on a tripod

point of light must be of a certain size and shape and possess the requiste brightness and distribution of the latter. Furthermore, it occupies a certain defined position in space and apparently embodies the center of the distant station.

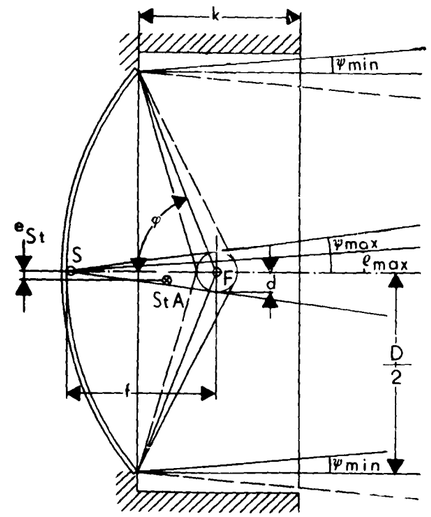


Fig. 3. Sketch of the beacon lamp. S = vertex, F = focal point, f = focal length, d = radius of filament, D = aperture of the mirror, SF = beacon lamp axis, StA = vertical axis, ω = aperture angle, K = length of housing, Ψ_{max} = maximum scattering angle, Ψ_{min} = minimum scattering angle, ζ_{max} = angle of avertence, e_{St} = eccentricity of the vertical axis relative to the beacon lamp axis

The size of the point of light is governed not only by the diameter of the lamp's parabolic mirror that is needed to provide the lamp with the necessary range for a tolerable power consumption by the lamp, but also by the mean distances employed and the resolving power of the telescopes in theodolites employed for first order triangulation and astronomical-geodetic work. In order to utilize the accuracy of sighting of these telescopes, the diameter of the parabolic mirror must be so chosen as to appear at an angle 1" to 2" for ordinary ranges.

For technical reasons, the light point is not the same as the target point, the center of the luminous station. In the following discussion, ∠e denotes the eccentricity in the lamp between the vertical axis of the TSG 200 and the axis of the emitted bundle of light rays, while E° is the eccentricity between the TSG 200 vertical axis and the center of the ground point at the target station, which may be determined with the aid of geodetic methods of measurement. The eccentricity ∠e, termed the centering accuracy of the TSG 200, may be composed of the following primary and secondary error components:

a) Imaging and zonal errors of the parabolic mirror
b) Lack of parallelism between the axis of the beacon lamp's parabolic mirror and that of the housing
c) Lateral displacement of the housing axis away from the beacon lamp's axis
d) The mirror's vertex is not situated in the axis of rotation of the beacon lamp
e) Eccentricity between the beacon lamp's axis of rotation and the axis of the lamp
f) Effect of avertence error

The sum total of all the components of centering error must be so low that the resultant systematic directional error is less than the accuracy of measurement.

The range of a geodetic beacon lamp is the second parameter for the performance of such an instrument. According to Reference [3], the range is the distance over which the threshold of visual acuity is reached under prevailing conditions of observation and at the prevailing transmissivity of the atmosphere.

The luminous flux emitted by the beacon lamp at luminous station toward the station of the observer is partially scattered and absorbed in the atmosphere. The transmissivity of the atmosphere is governed by these scattering and absorption losses, and is marked by the transmittance **q** of the range of visibility.

The meteorological daytime visibility s is, according to Reference [3], the horizontal distance in kilometers at which dark objects or landmarks that subtend a large enough vision angle, exhibit so little contrast against the sky owing to the turbidity of the air as to merge into the background, i. e. they are at the threshold of visual acuity. In meteorology, the visibility based on the contrast threshold of 0.02, is called the normal visibility N_1.

When the range of a beacon lamp is referred to in general terms, we must also state the normal visibility,

i. e. the meteorological visibility, on which this range is based.

CENTERING ACCURACY OF THE TSG 200

The shape, size, and brightness distribution of the point of light are governed by the diameter and quality of the parabolic mirror. The parabolic mirror has a diameter of D = 200 mm, and a natural scattering angle is $\psi' = 10'$. More than 90% of the light reflected by the mirror is thrown in the direction determined by the scattering angle. Optical tests made of the mirror's surface indicate that it is free from zones or portions of zones that scatter light to one side, its distribution of luminous intensity is uniform radially about the axis of the mirror.

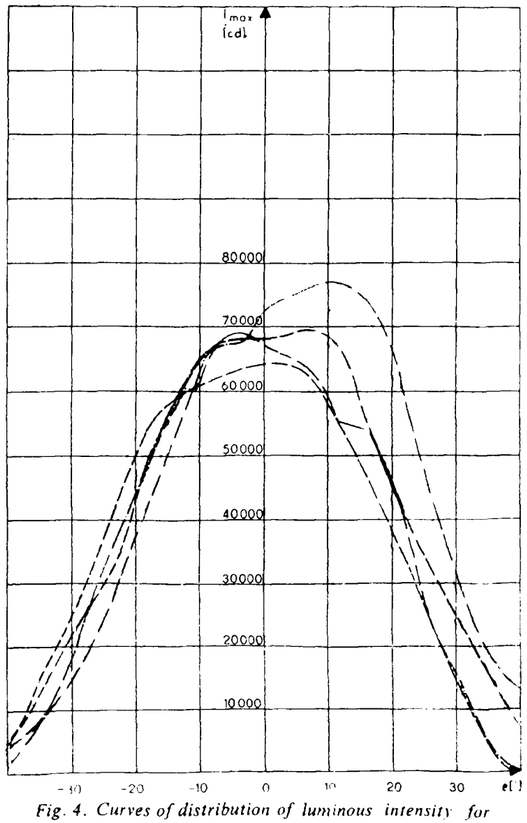


Fig. 4. Curves of distribution of luminous intensity for Instrument No. 1 (red) and for Instrument No. 2 (blue)

This eliminates the serious primary eccentricity errors e_s from TSG 200, which are due to zonal errors and produce uncontrollable systematic directional errors in the closure of triangulation. These zonal errors are very often found in ordinary searchlights, which are expected to emit as much high-intensity luminous flux as possible in a given direction, though the distribution of luminous intensity in the emerging beam does not have to meet any requirements. These eccentricity errors due to zonal errors may amount to as much as several centimeters. It is to be assumed that searchlights of that sort have in the past been employed as geodetic beacon lamps in many instances of national land surveys.

The TSG 200 has no such zonal errors. It provides an exact image of the lamp's filament and its luminous intensity is uniformly and symmetrically distributed about the axis of the beam.

The surface of the lamp's filament, which is of regular shape, uniform luminosity, and centered relative to the axis of the parabolic mirror, ensures that the point of light is visible in the same shape, with the same brightness, and with the same distribution of brightness over the entire angle of avertence. The errors of adjustment mentioned in Sect. 5b), c), d), and e) give rise to second-order centering errors. In order to reduce the sum total effect of these errors to a minimum and to ensure this minimum effect even after the lamp has been replaced, the lamp is mounted and centered in a special pre-centered base so that the center of the luminous element is no farther than some ± 0.1 mm from the longitudinal axis of this base. This centering of the lamp guarantees that the optical axis of the beacon lamp can be reproducibly maintained with an accuracy of ± 0.1 mm laterally and vertically even after replacement of the lamp. The sum total centering error of the TSG 200 is very small, amounting to:

$$\angle e = e_s + e_p + e_k + e_{v\,max} + e_a + e_{st}.$$

$$\angle e \approx 2\ \text{mm}$$

where:

e_s = effect of errors in the mirror's zones and portions of zones

e_p = effect of a lateral displacement of the mirror's axis with respect to the housing's axis

e_k = effect of the avertence of the mirror's axis relative to the housing's axis

$e_{v\,max}$ = effect of the avertence error $P_{mxa} = 15'$

e_a = position of the vertical axis and the axis of tilt with respect to the axis of the mirror

e_{st} = displacement of the vertical axis with respect

to the mirror's axis at right angles to the direction of the mirror's axis

The accuracy of alignment of the TSG 200, adjusted to a scattering angle ψ of 1° is about 6′. A telescopic sight with a magnification of 16 x that can be mounted on the beacon lamp housing is used to align the TSG 200 laterally and vertically with the observation station. The image of the filament is transmitted to the telescopic sight through a special prism to guarantee that the axis of the beacon lamp is parallel to the sighting axis of the telescopic sight. This makes it possible to che ckthe position of the sighting axis of the telescopic sight with respect to the direction of the beacon lamp's axis, or else the observer sets the sighting point exactly at the center of the lamp filament. This preven tscentering errors or loss of range from occurring when the lamp is faultily aligned.

RANGE OF THE TSG 200

The following factors govern the range of the TSG 200:

1) The transmissivity of the atmosphere

2) The luminous intensity of the lamp

3) The practical threshold of visual acuity with and without telescopic observation.

The transmissivity of the atmosphere is a component of the observational conditions that can not be affected technically. The turbidity of the atmosphere governs not only the transmittance of light, but the quality of the point of light as well. The greater the turbidity, the blurrier do outlines become and the stronger the fluctuations of the point of light. There

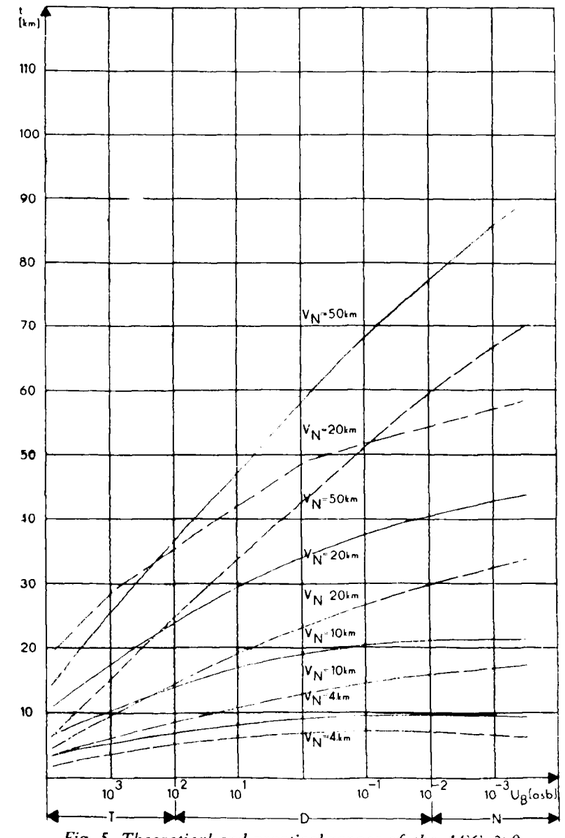


Fig. 5. Theoretical and practical ranges of the TSG 200 for observations made with the naked eye, as functions of M_β, the luminous density of the surroundings; T = day, D = twilight, N = night; —— theoretical range; - - - - theoretical range at a reduction of luminous intensity of 40 % after the threshold value of the eye deteriorated by the factor 10; -.-.- practically attainable range

are fixed limits that restrict the demand for maximum range of a geodetic beacon lamp. What we have to do is to estimate these limits and to achieve the range that is required for geodetic observations economically with a minimum consumption of electric energy. The third component that affects the dimensioning of a geodetic beacon lamp is the threshold of visual acuity with and without telescopic observation. What we aim at most of all is utilizing the times of day when the atmosphere is least turbulent for triangulations of maximum accuracy. But this implies that observations have to be begun in daylight .

Then the following factor enters into play: that the brightness of the point of light is often sufficient for measurement, but that supplementary brightness is required to locate this minute point of light in the field of view. This is emphasized by Wolinski in his paper [4] Quick location of terrestrial targets is required, however, for rapid measurements. All of these considerations entered into the design of the new geodetic beacon lamp.

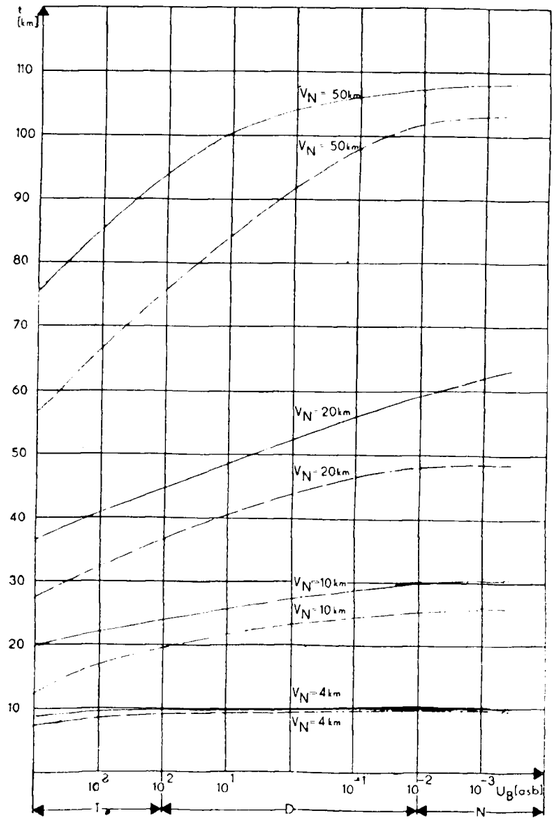


Fig. 6. Range of the TSG 200 as a function of $M\beta$, the luminous density of the surroundings for telescopic observation without any allowance for over magnification; T = day, D = twilight, N = night; range t under normal conditions, range t at a reduction of the luminous intensity of 40 %, after the threshold value deteriorated by the factor 10

The decisive factor determining the size of the TSG 200 is its luminous intensity. This was:

$J_{max} = 3 . 10^4$ cd to $1 . 10^5$ cd.

in the sample instruments we tested.

The intensity depends on the luminance of the lamp, i. e. the partial luminous flux $d\phi$, utilized by the parabolic mirror and radiated in the scattering angle. An important factor in the TSG 200 is the fact that this luminous intensity J_{max} drops no more than 20% from its maximum value at $\zeta \pm 0'$ throughout the range of the angle of avertence, $\zeta_{max} = \pm 15'$. Thus the TSG 200 maintains its efficiency at the maximum angle of avertence and is visible at full power from any observation station situated within the region ζ_{max} (Figs. 4 and 5).

Reference [3] states that the theoretical range t of the TSG 200 can be calculated from the range equation:

$$J = 10^6 . E_p' . t^2 . q^t$$

where

J is the luminous intensity, q is the transmittance of the atmosphere, and E_p' is the eye's contrast threshold. The solid-line curves in Figs. 6-8 give the results, based on various meteorological visual ranges. The dashed curves in these figures show how the range changes when assume that the eye's threshold value is raised by a factor of 10 and the luminous intensity of the TSG 200 drops 40%. This yields the following conclusions:

If the beacon lamp's luminous intensity is diminished or the eye's threshold value is raised, the range changes by some 10% to 25% on the basis of the given assumptions, primarily in the regions of good visibility. The visibility conditions then exert a stronger influence on range changes. Poor visibility can not be compensated for by using lamps of higher luminous intensity nor by increasing the magnification of the telescope. Increasing of the telescope's magnification may produce an increase in range, if visibility is good. In these regions of good visibility, reductions in the luminous intensity of the lamp produce perceptible losses of range, especially in observation with the naked eye, though this is not so marked in telescopic observation. On the other hand, the stated decreases in luminous intensity no longer play any part when the meteorological range of visibility N_v = 10 km. At low meteorological visibility range, the blurring of the point of light is another factor hampering rapid location by the observer. The contrast required for sighting on the target is lost. Test measurements made to determine the range indicated that the ranges attainable in practice with the TSG 200 very largely coincided with the theoretical ranges computed from the parameters of the TSG 200.

SUMMARIZING REPORT ON THE PERFORMANCE OF THE TSG 200

Tests and experimental measurements have shown that this new geodetic beacon lamp possesses high centering accuracy and long range. The design and construction, precise manufacture and adjustment, all guarantee perfect centering of the beam of light emitted by the beacon lamp with respect to the instrument's vertical axis, even after replacement of the lamp. There are no first-order centering errors, while the second-order centering errors are so small as to produce no systematic directional errors.

These same factors give the new geodetic beacon lamp high parallelism of the emergent light beam and a very long range, totalling about twice the meteorological visibility rang. Depending on meteorological conditions, ranges exceeding 100 km can be achieved with the TSG 200, even though the lamp employed as the light source consumes no more than 5 watts, and the operating voltage is 6 volts.

Thus we now have an efficient geodetic beacon lamp for establishing triangulation nets of the highest

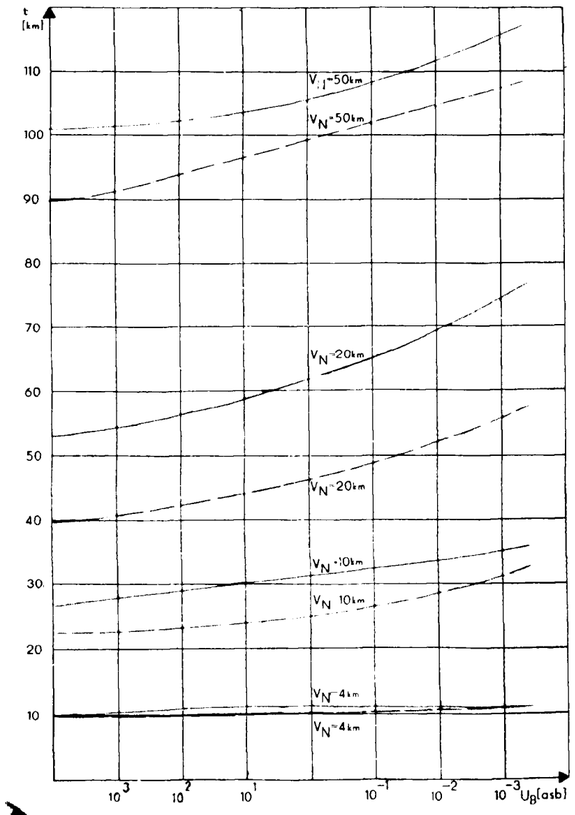


Fig. 7. Range of the TSG 200 as a function of $M\beta$, the luminous density of the surroundings for telescopic observation; —— range t under normal conditions, - - - range t at a reduction of the luminous intensity of 40% after the threshold value of the eye deteriorated by the factor 10

accuracy, a lamp that guarantees high accuracy of observation free from systematic errors and provides maximum utilization of days suitable for observation with low power consumption. Hence the new geodetic beacon lamp involves a major rationalization of triangulation operations.

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Further particulars from :

VEB Carl Zeiss JENA

Carl Zeiss Str-1

69, Jena, DDR

Twin Strand Model "S" Billet Casting Machine finds favour with India

Concast AG, Zurich, are pleased to announce that the Government of India, after careful consideration of the economic and efficiency characteristics of various types of continuous casting machines available in the international market, have granted permission to five steelworks to install a twin strand model "S" billet casting machine each :

M/s. Rathi Alloys & Steel Ltd., New Delhi, India.

M/s. Steel Complex Ltd., Calicut (Kerala) India.

Andhra Steel Corp. Ltd., Calcutta, India.

Electrosteel Castings Ltd., Calcutta, India.

Modi Steels, Modi Nagar (UP), India.

The decision of the Government of India in favour of these machines was based on their low capital and operating costs, short construction period, and high yield.

The setting up of these plants, popularly known as "Mini Steel Plants", in India, is expected to relieve the steel shortage prevalent in that country to a noticeable extent.

The machines will be engineered by Distington Engineering Company (British Steel Corporation), England, and under joint direction of Concast and Distington manufactured partly in England and partly in India

The Government of India is vigorously considering the installation of additional plants of similar type to make the country self-sufficient as far as possible in the production of semi-finished steel.

* * *

Two Goliath cranes for Sumitomo ready

Two 300-ton Goliath cranes have been completed for the Oppama Shipyard of the Sumitomo Shipbuilding & Machinery Co. Ltd.

Each having a span of 145 meters, a lift of 64 meters and a main trolley hoisting speed of 6.5 meters per minute, the cranes will be used for erecting hull blocks at the shipyard's 500,000-DWT building dock which is 560 meters long and 80 meters wide.

They are the fourth and fifth Goliath cranes manufactured by IHI after the 200-ton crane for IHI's Kure Shipyard and two 200-ton cranes for Nippon Kokan KK's Tsu Shipyard.

CERAMIC FIBRE LINING FOR 800-TON CAPACITY FURNACE

Year-long comparison with conventional lining

By An Engineering Correspondent

A ceramic fibre lining has replaced a conventional lining in a Swedish stress-relieving furnace with a length of 13,5 m and a maximum charge capacity of 800 tons. The furnace, owned by Uddcomb Sweden AB, Karlskrona, was designed and built by AB TABO-ugnar of Stockholm, to take pressure vessels and other large welded constructions for nuclear and petrochemical plants.

When the furnace was first erected in Degerfors in 1970, only the doors on both ends were lined with Triton Kaowool ceramic fibre, manufactured by *Morganite Ceramic Fibres* of Neston, England, and Liege, Belgium. The walls and roof were lined with 100 mm thick slabs of calcium silicate.

MOVED 600 KM BY BARGE AND RAIL

The furnace was constructed in a manner which would allow it to be dismantled and rebuilt in Karlskrona, some 600 km away. Triton Kaowool was chosen for the furnace doors to give a light but strong lining capable of withstanding frequent handling. The doors are made up in sections, some or all of which may be used to extend the furnace in order to accommodate vessels longer than 13,5 m. Triton Kaowool has a weight one-sixth that of insulating firebrick. It can be used at temperatures up to 1260 C and is highly resistant to thermal shock since all expansion of individual fibres is absorbed within the material. The operating temperature of the Swedish furnace is : 10 of 750 C.

Calcium silicate slabs were used for the walls and roof because they are cheaper than ceramic fibre.

OLD LININGS HAD CRACKED

In 1971, when the furnace was due to be moved to its new location after one year of operation, the calcium silicate slabs were so badly cracked that they had to be replaced. The ceramic fibre lining of the doors was completely un-affected, in spite of severe weather conditions when they were subjected to heavy falls of rain and snow. On the basis of the comparison between the two materials it was decided to use Triton Kaowool for lining the 13,5 m × 9,5 m walls and the 128 m² roof.

Triton Kaowool is produced in many forms, including blanket in various densities, bulk fibre for expansion joints, strip and a castable mix. The Swedish furnace was lined with a 19 mm layer of 128 kg m³ blanket over a base lining of 100 mm thick mineral wool.

FUEL SAVINGS OF 15%

Triton Kaowool is produced in various other densities (48, 64 and 96 kg m³) and in thicknesses of 6-50 mm. In its most dense form, its thermal conductivity is some 35% lower than that of insulating firebrick and its heat capacity is about one quarter that of firebrick. These properties, coupled with its excellent resistance to thermal shock, greatly reduce heating and cooling times and lead to fuel savings of up to 15%.

Being light in weight, ceramic fibre linings require only lightweight supporting structures and methods of fixing are quick, simple and efficient. Installation costs can be reduced by over 50% compared with firebrick. The blanket is impaled upon studs welded to the supporting structure and held in place by nuts and washers. The furnace can then be used immediately.

Further information from :

Morganite Ceramic Fibres Limited.
Neston, Wirral, Cheshire L64 3TR.
England.

J. D. Neuhaus of Witten-Heven — Manufacturers of AIR HOISTS

JUMBO —
A "TOM THUMB" WITH THE STRENGTH OF A GIANT

BUT Jumbo converts little power into much power; very much power. That is, if you are of the same opinion that one does need much power to lift a weight of about 7.5 tons, without any auxiliary means.

Here Jumbo represents the auxiliary means, which you or more probably your hands will need for lifting, lowering or pushing heavy weights.

The stuff – well - which you yourself do not need to possess any longer – just is nothing but power. Perhaps some weight, but that will suffice.

Sure, your hand, who is to lift a weight of 7.5 tons with the help of Jumbo, ought to weight at least 38.5 kgs. If you have not got a lean man of 77 lbs. in your workshops (which we presume you do not, from the fact that you are paying high wages), just give it to a stouter hand, then. It will be the lighter for him.

JDN—Jumbo a "Tom Thumb" with the strength of a giant
Lifting capacities of 5t and 20 tons

And Jumbo keeps calm, all the same whether you want it to lift a paper-bag full of peanuts, or a truck, or a mine locomotive or to shift the tracks of the latter aside. All this lies within its scope of not less and not more than 7.5 tons of weight.

One important thing still remains for you to know, namely the height or the distance of its lifting or shifting capacity: we supply the little but strong Jumbo for lifting heights of 20, 30, 40, 50 and also 60 centimeters. It is not with Jumbo to determine the point of time or the speed for locating a load, but it is entirely with the man handling it. Jumbo has got one disadvantage: it so seldom breaks down! Should this occur, however, a novice apprentice would be able to repare it. But this disadvantage hits whom if not us ourselves? To do away with it, we could give some good advice to the users of your Jumbo: they ought to lengthen the lever and try and lift 15 or 20 tons with it. Sure, it will break down then. But, you may take it for granted, never should we give any such advice to anyone!

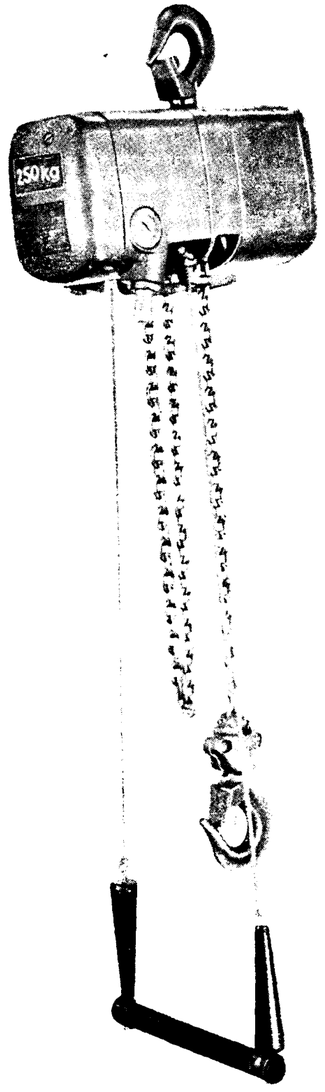
PNEUMATIC LIFTING BLOCK **QUIKKI**

The "quikki" is a Pneumatic Lifting Block with several out-standing features. It is exceptionally small and light, considering its power, and very quick action.

The "quikki" is available in two versions: with safe working loads of up to 250 kg. ($\frac{1}{4}$ ton) on a single chain fall or 500 kg. ($\frac{1}{2}$ ton) on a double chain fall. The Hoisting speed at full load is 24 metres per minute (78 ft min) on a single chain fall and 12 metres per minute (39 ft min) on a double chain fall.

The "quikki" can be equipped either with Push Button Control or cord control. With either of the control systems the Hoisting and lowering speed is infinitely variable. The Motor automatically stops when the lowest or highest hook position is reached.

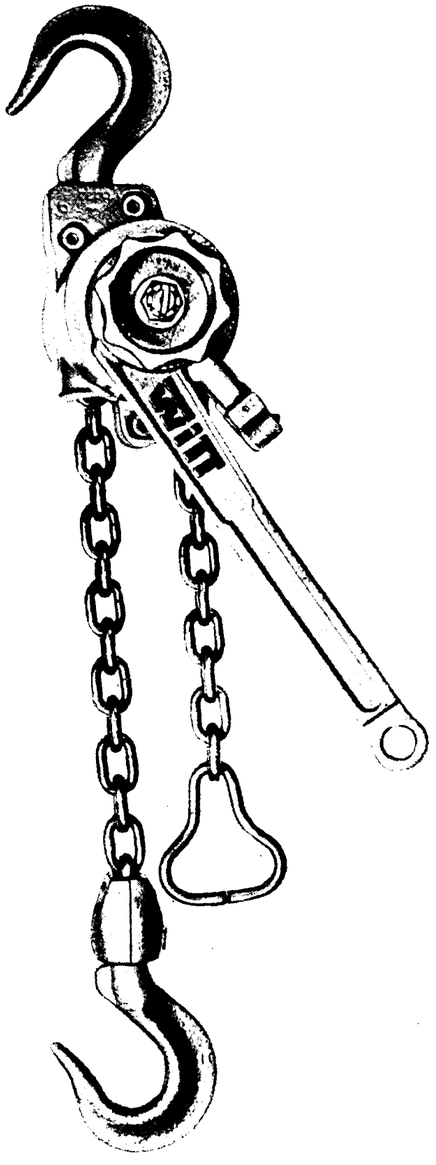
The "quikki" is ideal for high speed hoisting duties, and the compactness of the design, with



JDN Pneumatic Lifting Block "Quikki" Safe working load 250 kg. and 500 kg.

freedom from protruding controls or levers, gives it added advantages where working space is limited.

Finally the "quikki" is low in price.



JDN—Ratchet-type Hoist "Witt" Lifting capacities 1t, 2t and 5t

JDN-RATCHET-TYPE HOIST **WITT**

The " witt ", a newly designed hoisting, lifting and stretching gear of ours, is of extremely small and solid make, yet it is light and strong.

This was achieved by using only high-grade material for all parts without any exception, instead of the otherwise usual material. It, too, explains the easy handling of our " witt ".

The relatively small parts, yet efficient and powerful, do not at all exhibit any working resistance. You will therefore enjoy working with the " witt ".

The teeth of the sun-and-planet gear, precisely made of special steel, are constantly in double-mesh position. A fact, which in itself, guarantees a high working safety.

All rotating parts are provided with ball bearings or needle roller bearings. Another reason for its ease of operation.

The dust-tight sealing of all gear parts adds to its reliability and its durability.

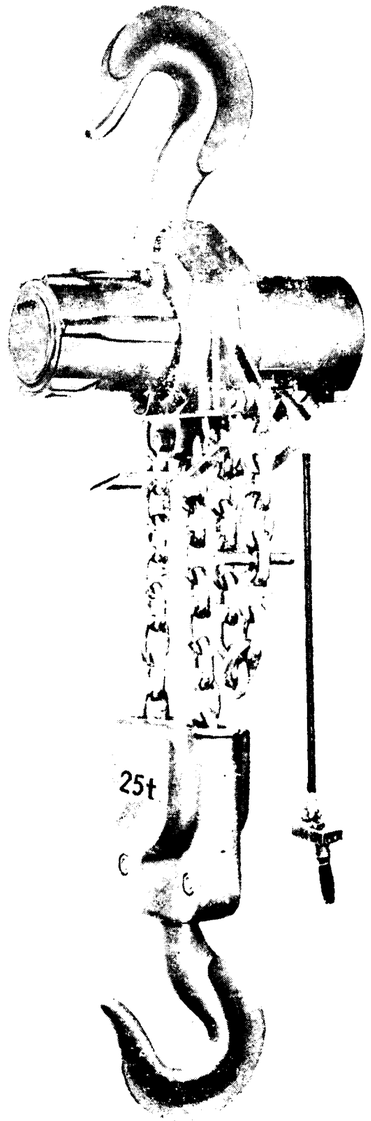
The load-pressure brake instantly holds the load in any position.

A chain dummy coupling provides the means for reeling the off-load chain to any desired position. This saves time.

Load hook and load chain are entirely made of heat treated alloy steel with a huge factor of safety.

The " witt " is available with and without an overload safety device.

In short, the " witt " (tractive force of 1, 2 and 5 tons is an extremely small, robust, reliable and handy implement ready to ease all lifting, hoisting and stretching operations.



JDN—Air Hoist Profi carrying capacity 25 tons
" The smallest 25t Hoist of the World "

JDN-AIR HOISTS **PROFI** THEIR VERSATILITY OF SERVICE IN INDUSTRIES

Chemistry :

placing of tanks, large-scale pipe relaying, mounting of nests of boiler tubes heat compensators, safe operation in rooms susceptible to explosion hazard.

Marine Engineering and on Ships :

raising of frames, installment of machines, fitting in the skin of vessels, removing cylinder heads, exchange of engine parts, removing hatch covers.

Further Ranges of Application :

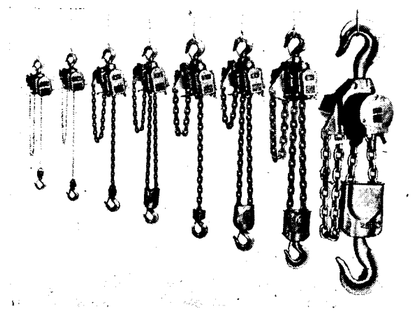
the automotive industry, storage yards and magazines, oil-storage depots, galvanic plants, paint shops, engineering, assembly lines, glassworks, sawmills, industry of explosives and pyrotechnics, inflammables, foundries, steelworks, refinery plants, paper mills, furniture works, etc.

JDN-Air Hoists incorporated into trolleys, reel-chain driven or travelling by compressed-air service, will solve any difficult lifting and transporting problem.

ADVANTAGE AND FEATURES OF JDN-AIR HOISTS **PROFI**

JDN are makers of Air Hoists with lifting capacities of from 0.25 up to 25 tons, thus covering innumerable application ranges. The working pressure amounts to a gauge pressure in atmospheres of 6 only, and two control systems are available for them. Heights of lift may be chosen as required.

JDN-Air Hoists may be incorporated into hand-power trolleys, into reel-chain trolleys, or into motor-driven trolleys. They are extremely robust, offer a reliable service and safety in every respect, by far beyond all existing standards. But these features might be expected from any excellent electrical hoist.



JDN—Air Hoists " Profi " carrying capacities 250 kg–25 tons

Electrical hoists, however, do not offer you the following facts: the lifting and lowering speeds of JDN-Air Hoists are infinitely variable. The duty cycle sequence and the duration of engagement per minute are of no consequence, because we guarantee a hundred per cent duty cycle.

Furthermore, JDN-Air Hoists have a smaller over-all height and-especially with high-powered hoists-they are a manifold lighter. They are not at all troubled by dust, smoke, vapour moisture and heat, and above all, they are explosion-proof by nature, i. e., they do not require any waste of explosion-proof appliances.

Further details from :

J. D. NEUHAUS Hebezeuge,
5810, Witten-Heven, (W. Germany)

German Participation in the 3rd Asian Trade Fair in New Delhi

German industry will exhibit its products mainly in the official pavilion of the Federal Republic of Germany under the co-ordination of Imag, International Trade Fair and Exhibition Service, Munich. This pavilion will host a wide range of products of German industry specially selected with the view of suiting in the concept of the growing industrialisation of India. One of the centres of the German participation will be the exhibition of Agrotechnical products which might be found a suitable instrument in the framework of India's Green Revolution.

18 West German companies will participate in the 3rd Asian International Trade Fair under the roof of the German pavilion. The German Ministry of Agriculture & Forests is going to have an Information Stand in the pavilion. Beside this 6 German firms are accommodated on 200 sq. metres open space.

Three-Roll Combination Piercing and Elongating Mill

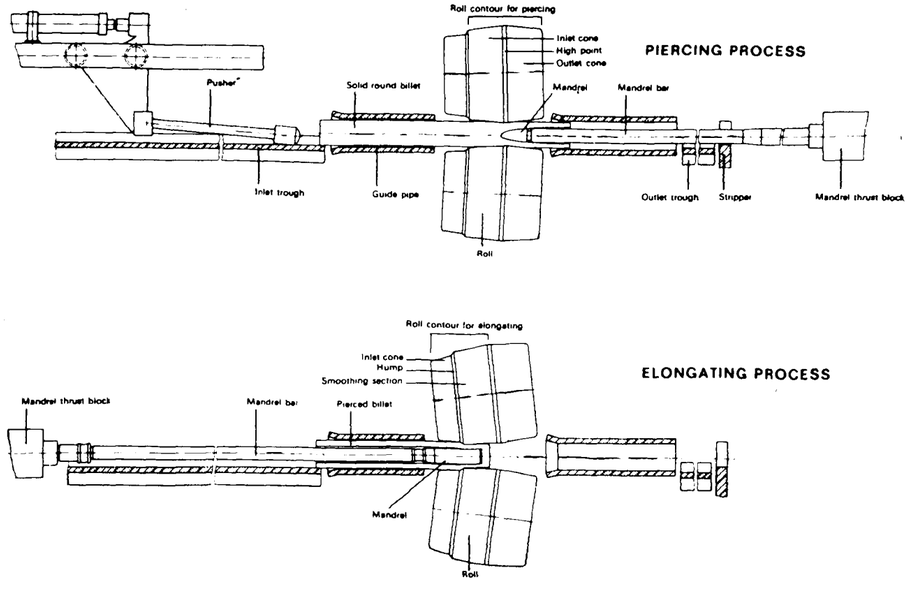
By A Special Correspondent

THREE-ROLL elongators, such as the Assel mill (see Meer Report 1192—"Assel Mills for the Manufacture of Thick-walled Tubes"), have been employed successfully for many years to process pierced billets. One of the principal reasons for their success is that they are able to produce the close tolerances required in particular in the manufacture of mechanical tubing for specific uses, such as ball and roller races, hydraulic cylinders, bushes etc.

The good experience with the three-roll arrangement led to experimentation to determine its suitability for the piercing of round steel billets. It was found to give very satisfactory results, and mills of this design have now been in use for a number of years. The very satisfactory results obtained—particularly as regards quality of the pierced billets—are attributable to the lack of shearing in the core of the billet due to the rolling forces producing a favourable stress distribution ahead of the piercing point.

In co-operation with the Stahl-, Draht-und Rohrenwerke (Steel, Wire and Tube Works) F. Meyer in Dinslaken, Mannesmann-Meer AG has now developed and built a three-roll mill whose noteworthy feature consists in its rolls, which can be swivelled, having both a contour for piercing and one for elongating, either of which contours can be selected as required by simply adjusting the rolls to the appropriate angle.

This mill is of particular interest for the manufacture of speciality tubing produced in small batches over a wide size range. As already indicated, the great advantage of the mill is that it can be employed for both the piercing and the elongating process without the necessity of having to change the rolls to suit the particular process (see conceptual diagrams). Instead of the costly changing of the rolls, these are merely adjusted to the required angles and to the correct distance apart. The only



Conceptual diagrams showing the two different processes (Photo: Mannesmann-Meer AG)

additional work involved is a few quickly performed preparatory jobs to make ready as appropriate the inlet and delivery side facilities.

For the piercing process, a pusher is provided at the inlet side of the mill, and a mandrel at the delivery side. The pusher advances the solid round billet through a guide pipe into the pass, and so towards the mandrel point. In the elongating process, on the other hand, the pierced billet—or 'bottle', so called because one end is closed—is pushed on and by the mandrel through the guide pipe and into the roll pass.

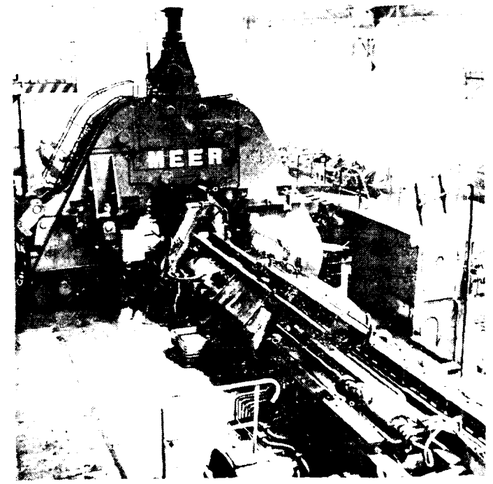
The rolls are so contoured that they have an inlet cone, a hump, a smoothing section, a so-called high point (a narrow section of contour at the thickest point of the roll), and an outlet cone. When the rolls are adjusted for piercing, the roll angle is such that the inlet cone and the hump do not come into play, and the cone which produces the smoothing effect during elongating assumes the function of a piercing roll inlet cone.

Sequence of Operation and Constituent Parts of the Mill

In the piercing process, the hot solid round billet is fed from the side into the inlet trough, and then advanced by the pusher through a guide pipe into the roll pass. The billet is then rolled over a mandrel, and thereby converted into a shell. Meanwhile, the pusher returns to its starting position, leaving the inlet trough clear for insertion of the next billet. At the end of the piercing process, the mandrel is retracted, and the shell ejected.

When the mill is being employed as an elongator, the bottle is placed into the inlet trough, the mandrel is introduced into the bottle, which is then pushed by the mandrel through the inlet guide pipe into the roll pass. When the bottle has passed through the mill, the mandrel rod returns to its starting position. The now elongated shell passes through a guide pipe at the delivery side, is drawn away from the mill by means of traction rolls, and subsequently ejected.

Facilities provided for adjusting the rolls serve for both the piercing and the elongating process, which processes, after being pre-selected from the control desk, are usually performed in an automatically controlled sequence of operations. Some of the numerous movements of the workpiece—i. e., solid



Inlet side of a three-roll combination piercing and elongating mill elongating pierced continuously cast billets.

(Photo: Mannesmann-Meer AG)

billet, bottle, and shell—and those of the operating items of equipment, such as pusher, elongating mandrel, piercing mandrel, and guide pipes, as well as of other facilities not mentioned here, are effected by pneumatic means, some by oil-hydraulic means, and some by employing such means in conjunction with gear units. Roll adjustment is accomplished by gear motors, and the mill is driven by two direct-current motors through a high-precision pinion stand with three output journals, which are connected by universal-joint spindles to the three roll necks.

In order to facilitate the fitting and removal of the rolls for size changing, the top of the stand is hinged and can be opened and closed hydraulically. The mill weighs about 210 tons and—including the inlet and outlet sections—is 32 m long. It can handle round billets ranging in diameter up to 200 mm.

SOME THOUGHTS ON NUCLEAR, MINERAL AND AGRO-INDUSTRIAL COMPLEX

BY V. ARAVAMUTHAN

Senior most Scientist and Head of the Division of Electrothermics and Electrometallurgy
Central Electrochemical Research institute, Karaikudi-3 S. Rly. Tamil Nadu.

ABSTRACT

Attractive procedures for the production of nuclear power are outlined. It is pointed out that greater returns from nuclear power can be had by employing it in industries which require large blocks of continuous cheap power such as (1) desalting of sea water to provide potable water and also water for agricultural and industrial purposes ; (2) electrolysis of aqueous solutions of sodium and potassium chlorides to obtain alkali metal hydroxides with chlorine as coproduct by utilising the purified chloride solutions left behind in the desalting of water ; (3) fused chloride electrolysis for the production of sodium, potassium, magnesium, calcium, sodium-potassium alloys etc., with chlorine as a coproduct by utilising the solid chlorides recovered from the solutions left behind in the desalting of sea water ; (4) electrolysis of water obtainad by desalting of sea water, to produce hydrogen and oxygen ; and (5) aqueous chloride electrolysis for the recovery of zinc, manganese, iron, lead, nickel, cobalt etc., from the purified chloride solutions obtained from primary and secondary sources. Important methods of utilising hydrogen, oxygen, chlorine, alkali metal hydroxides, sodium, potassium, calcium and manganesium metals are outlined with special reference to production of strategic metals, alloys and chemicals even from a variety of low grade raw materials such as low grade ores, chemical and metallurgical byproducts and also annual agricultural wastes. The possibilities of producing large quantities of well balanced human diet economically and obtaining greater returns from the soil are also discussed.

Generation of Power by Nuclear Fission Reactions

NUCLEAR REACTORS

THE greatest advantage of nuclear reactors is that the production of energy involves only a very small consumption of fuel. The three main units which comprise a reactor are fuel, moderator and coolant. The heat generated by the fission of fuel elements is absorbed by the gaseous or liquid coolant. In the heat exchanger the heat drawn off from the reactor converts water into steam and the coolant is circulated back to the reactor. The steam passes to a turbine which in turn drives electrical generating sets. A moderator is employed to slow down the fast fission neutrons in order to maintain the desired fission reaction. The moderator may absorb neutrons to a very small extent. Athough hydrogen is the best moderator of neutrons, it is not suitable because it absorbs slow neutrons appreciably. Heavy hydrogen (deuterium), graphite and beryllium are suitable moderators for a chain reaction. Of these three substances, graphite is most easily obtained in sufficient quantities and in sufficient purity. A developing chain reaction results in a constant increase in the number of dividing nuclei. To maintain a constant number of fissions in time, we must control the course of the reaction by regulating the number of fissions required or in other words by controlling the number of neutrons. This can be done by suitably introducing elements like cadmium and boron which effectively absorb excess very small neutrons thereby slowing down the reaction and if need be to stop the reactions altogether.

NUCLEAR FUELS

Materials such as U235, U233 and PU239 are known as fissile materials. U238 and Th232 from which fissile nuclei can be made by capture of neutrons are known as fertile materials.

Natural U238 contains 0.7% of fissionable U235. Of this only 44% of the fissionable atoms undergoes fission reaction and the remaining amount of fissionable atoms are retained in the spent fuel. Thus, in effect only 0.3% of the atoms present in natural uranium undergoes fission reactions. In graphite moderator type reactor employing natural uranium the amount of plutonium formed is less than the amount of U235 used up and eventually the reaction stops for lack of fissile material. In a power producing reactor of the gas-cooled type, the heat required to produce power is obtained by fission

This matter is based on the lecture delivered by the author in December 1971 at the Annual Meeting of the Karaikudi Local Section of tho Society for the Advancement of Electrochemical Science & Technology, India.

of U235 and also by the conversion of fertile U238 into fissionable plutonium. In breeder reactors employing U238, highly enriched in U235, in the absence of a moderator, the chances of parasitic or casual capture of neutrons is considerably reduced. Since the fast neutrons are used to produce fission, more neutrons are produced per neutron absorbed by the fissile material than is the case when slow neutrons are used. Hence more reactor fuel is produced than is consumed. In the breeding process, fissile and fertile materials are kept separated. The fuel U238, highly enriched in U235, is surrounded by a blanket of natural uranium. The neutrons released by fission in the fuel core are captured in the blanket with the production of plutonium. Finally, the blanket is removed and processed, the fissionable plutonium being extracted and used as fresh fuel. Owing to the absence of a moderator the core of a fast reactor is small and hence the heat produced per unit volume of the core is very much greater than other types. Liquid metals are generally used to remove this large amount of concentrated heat.

The gaseous diffusion method of separation of U235 from U238 depends on the fact that gaseous U235 has a smaller gas density than U238 and hence will diffuse more rapidly through a porous barrier. Uranium hexafluoride which is solid at the ordinary temperature but easily vapourisable is obtained from uranium dioxide. It is passed under pressure to one side of a porous filter. The diffusion side is maintained under vacuum to obtain U235 rich fraction. This fraction is collected and pumped through further filter. After several stages, the pure isotope U235 is obtained. Very costly gaseous diffusion process now used for the separation of U235 from natural uranium is being replaced by much cheaper centrifuge process. This method involves whirling. Uranium hexafluoride gas at such high centrifugal speed for the lighter and more fissionable isotopes separate out from the heavier uranium isotopes. Thus the concentration of U235 in natural uranium can be increased from 0.7% to any desired value for use as a fuel in breeder reactors. The enriched uranium in the form of a rod can be encased in niobium canisters surrounded by rods of natural uranium in order to get plutonium from U238. Control rods of high neutron capture properties are inserted in the core for regulating neutron flux at the required level. Liquid sodium when used as a coolant becomes radioactive and in order to cope with the radiation a double heat exchange system is employed whereby the coolant conveys heat to a second liquid sodium heat exchanger which is not exposed to the radiation and therefore can be circulated to the steam generating plant without hazard. Thus there is a primary sodium-sodium and a secondary sodium-water heat exchanger.

In the recovery of uranium and plutonium from the spent fuel elements, the spent fuel rods after removal from the reactor are stored in water for several weeks to allow decay of the more dangerously radioactive fission products. Solution in nitric acid followed by solvent extraction of the uranium and plutonium in dibutyl carbitol, allow of their separation from the fission products which remains in the aqueous phase. On reduction of plutonium with ferrous sulphate and treatment with dilute nitric acid, the plutonium is stripped from the organic phase leaving the uranium behind. The plutonium in the aqueous solution is concentrated by evaporation, converted into fluoride and in a manner similar to that used for uranium converted into metal by reduction with metallic calcium. The uranium in the organic phase is stripped with dilute acid and recovered as diuranate by precipitation with ammonia and then processed further.

Uranium oxide (UO_2), the carbide (UC), plutonium oxide (PuO_2) and the carbide (PuC) have high melting points and good creep properties and their physical stability under irradiation is much better than that of the metal. As fission product gases can be accommodated in the uranium oxide crystal structure to a larger extent without instantly swelling, much higher burn-ups are possible with this fuel than with uranium metal. Moreover, in water and gas-cooled systems, the uranium oxide fuel if exposed to the coolant, in the event of fracture of the fuel container, will have better corrosion resistance thus minimising the hazards of fuel element failure. In fast breeder reactor, mixtures of uranium oxide, plutonium oxide, ceramic fuel can be employed. However, these compounds are brittle and are susceptible to thermal shock. While uranium metal fuel elements can be fabricated through the conventional methods of melting, casting, rolling, or extrusions, uranium oxide has to be fabricated through ceramic fabrication processes to form sintered pellets. In addition, because of the poor thermal conductivity of uranium oxide, smaller fuel section have to be employed for efficient heat abstraction. These limitations to some extent can be overcome by incorporation of metals thus combining the excellent ductility and thermal conductivity of metals with the desirable heat characteristics of the oxide and carbides. Various combinations such as UO_2 Fe, PuO_2 Be, UG Zr and even U UC may become

important in the future development of atomic energy. Fuel developements for advanced fast reactor design would have to be based on mixed uranium-plutonium carbides which by virtue of their higher fissible atom density and higher thermal conductivity (compared to oxides) can offer higher heat rating and coolant temperatures. Mixtures of thorium oxide and uranium oxide and mixed thorium-uranium carbides must also be utilised in future.

THE FUEL CONTAINERS

The chemical reactivity of uranium is so great that the metal has to be clad in a case of more resistant metal which will not interfere too much with nuclear chain reaction by absorbing many neutrons. The metal cladding may be unbounded or bounded to the fuel element by brazing or rolling. The metal can or sheath must safely contain the fuel and dangerous radicactive fission products, be compatiable with both the fuel and the coolant, possess low neutron capture cross section and allow efficient transfer of heat to the coolant. In the case of gas cooled reactors operating at 450 C, magnesium alloy containing 1% aluminium and a small amount of beryllium is used as a sheathing material. Mangesium is used as a canning material and the coolant gas is carbon dioxide which operates at temperatures suitable for power production. The advantages of magnesium over aluminium are (1) magnesium has only a small tendency to absorb neutrons (the capture cross-section for thermal neutrons is only a quarter that of aluminium); (2) magnesium does not alloy with uranium whereas aluminium does; and (3) magnesium has better ductility and better machining properties in comparison with aluminium. Magnesium is advantageous to zirconium for the following reasons: it has far better resistance to carbon dioxide upto highest service temperatures envisaged and better thermal conductivity. Therefore, the effective cooling surface of a can can be greatly increased at small weight penalty by finning.

Gas-cooled reactors operating at 600 C would need beryllium as a sheathing material, as it possess good strength and thermal conductivity at elevated temperatures excellent corrosion resistance to carbon dioxide and very low neutron absorption cross-section. In water-cooled reactors operating only slightly above ambient temperature, the fuel element is uranium rod hermetically sealed in a tight fitting aluminium jacket. In the boiling water-reactors and the pressurised heavy-water cooled reactors, where the temperature of operation is about 300 C at 1000-1500 psi, the fuel is in the form of sintered uranium dioxide pellets loaded and sealed inside corrosion-resistant thin walled zirconium alloy tubings. In the fast breeder reactor employing enriched uranium metal as fuel, niobium is used as a sheathing material. In the fast-breeder reactor employing oxides, the mixed UO_2-PuO_2 ceramic fuel in 5 mm diameter are bonded into thin-walled 6 mm diameter stainless steel tubing to stand up to the rigours of liquid sodium cooling at 700 C. As a result of fast neutron damage, considerable void generation and swelling growth will occur in stainless steel unless the composition and fabrication are carefully controlled.

CHOICE OF COOLANT

The qualities required of a coolant are: (1) it should possess a high capacity for absorbing and conducting heat; (2) it must be stable under heat and radiation; (3) it should not develop dangerous radioactivity under neutron bombardment; (4) it should be cheap and available in plenty; and (5) it should have a small cross-section for neutron capture.

Air, although available in plenty, and practically at no cost, is undesirable as a coolant because it is not efficient in heat transfer and also it causes excessive oxidation of graphite moderator and with fuel canning material. Hydrogen causes embrittlement of structural materials and serious explosions would occur if leaks develop. Nitrogen has a large cross-section for neutron capture. Helium is excellent in every respect but for the cost. Carbon dioxide, although not quite as efficient as other gases in heat transfer, yet is used because of its cheapness, the safety and stability. Water is a cheap coolant. It is easily pumped and is also good moderator. However, it is corrosive to many metals at high temperatures and boils at a low temperature. Hence it must be used under high pressure in order to transfer useful heat to steam generators for electricity production. Liquid sodium and sodium-potassium alloys have low melting points, low capacity for absorbing of neutrons, stable at high temperatures, possess high thermal conductivity and good heat transfer properties and large amount of heat can be carried in a small volume. Pumping of molten sodium or sodium-potassium alloy can be done by electromagnetic pumps in which pumping power is obtained by introducing an electrical current in the metal as it passes in a pipe between the poles of an electromaguet. The force exerted on to metal conductor by the magnetic field causes flow to take place. Such a pump has no moving parts and no seals and thus requires very little maintenance. In reactors where enriched uranium sheathed in stainless steel is cooled by molten sodium, the graphite moderator is protected by zirconium metal against corrosion by sodium. Mercury, because of its large cross-section for neutron capture, is considered unsuitable as a coolant. Bismuth, although costly, has the advantage of possessing a much lower neutron cross-section than sodium and also the property of being able to dissolve uranium which is very important in fast breeder homogenous reactor.

TYPES OF REACTORS

A nuclear reactor is a device in which self-sustained fission chain reaction can occur in a controlled manner for generating electricity. During the process of nuclear fission a large amount of energy is released and neutrons are also emitted. These fission neutrons can produce more neutrons by introducing further splitting. When the ratio of the number of fissions in any one generation to the number of fissions in the immediately preceding generation is equal to unity, energy will be produced at a constant rate. Such a system is said to be critical. If the ratio is greater than unity the number of fissions and hence the energy released will increase with each succeeding generation and the reactor is said to be super critical. If the multiplication factor is less than unity, the chain reaction will die out ultimately and the system is called sub-critical.

Nuclear reactors are broadly divided into two types. The fast reactors are those in which fissions are introduced primarily by neutrons with an energy of the order of 100 Kev and above. The neutrons released in fission have a mean energy of about 2 Mev. In thermal reactors, fissions are induced by neutrons that have an average energy of about $kT = 0.025$ ev, for $T = 300$ K. The thermal reactors require a much smaller amount of fissionable material as compared to fast reactors.

When the neutron is passing through matter it is not necessary that fission should occur. Neutron may either be absorbed by the nuclei or may be scattered with or without change in energy. The scattering process is of extreme importance in a thermal reactor. The neutrons ejected during fission are highly energetic and in order to slow down they must be scattered by other nuclei. To reduce the energy of the neutron there must be a small atomic weight material in the reactor which is known as the moderator. The hydrogen nuclei in the water molecules, the deuterium nuclei in the heavy water molecules and the beryllium nuclei in beryllium oxide are responsible for slowing down neutrons.

The reactors in which fuel elements like enriched uranium metal, oxides and carbides of uranium and plutonium encased in metallic sheath and surrounded by liquid or gaseous cooling agents are classified as heterogenous reactors.

In the pressurised water reactor, heat is extracted from the fuel elements by pumping water under a pressure of 2000 psi. The superheated water at a temperature of 340 C is then pumped to a heat exchanger where the steam produced goes to turbines to generate electricity. The fuel consists of an alloy of uranium and zirconium enriched with U-235 clad in a zirconium sheath. In the boiling water reactor, heat exchangers are not necessary as the water boils in the reactor, thus generating steam which goes direct to the turbine. The fuel element is enriched uranium in the form of rods which are suspended in the water.

In the homogenous reactor, solid fuel elements are not used. Enriched uranium in the form of uranyl sulphate dissolved in water acts both as a coolant and moderator to slow down the neutron particles which maintain the fission reaction. The system is pressurised to prevent boiling, the hot solution being pumped through a heat exchanger where steam is generated. Accumulation of fusion products is dealt with by bleeding off a portion of the liquid and replacing by fresh fuel. The advantage of employing fuel element in solution as compared to a heterogenous system is that the limited life of solid fuel elements (owing to structural and physical change caused by radiation and the accumulation of fission products) is overcome and hence the expensive periodical shut downs for refuelling are avoided. Because of extremely low neutron capture characteristics, heavy water is an excellent moderator and coolant and can with advantage be used in the place of ordinary water, in nuclear reactors of advanced design.

A breeding reactor of a homogenous type can also have a core composed of U-235 in the form of uranium sulphate which is circulated through a heat exchanger. Surrounding the core is a slurry of Thorium-232 in which breeding will occur, the neutron from the core being captured to produce U-233. In this system both the radioactive waste products contained in uranium solution and the material bred in the thorium are removed continuously by circulating through processing plants.

By employing a circulating liquid fuel such as a mixture of molten salts, the high fabricating cost of solid fuels is avoided in the development of atomic power. Undesirable fission products are removed from the circulating fluid continuously. A minimum of reactive material could be employed since at any time the make-up fuel can be added easily. Nuclear radiations cannot damage the molten fluoride fuels structurally in contrast to solid fuel elements. The percentage of solid fuel actually burned in reactor is very limited owing to the fact that the solid fuel elements warp, crack and blister owing to intense radiation. Fused salts allow the reactor to be operated at lower pressures and higher temperatures and therefore they have got the advantage over water containing systems. Molten salts act as fuel solvent or coolant without troublesome gas mixture being formed and in this respect also they are superior to water cooled or water moderated reactors. Fused salts dissolve a very high percentage of materials which are fertile (in the sense that they could be made fissionable by neutron bombardment) or already fissionable and therefore they are superior compared to systems containing molten metals. It is possible to fuel with a solution of uranium tetrafluoride in a molten mixture of sodium and zirconium fluoride. A composition containing lithium, thorium, beryllium and uranium fluorides has been used successfully as a primary coolant and fuel.

Manufacture of some important fuels and cladding components

THORIUM, URANIUM AND VANADIUM OXIDE CONCENTRATES

Finely powdered monazite in 325 mesh is reacted (preferably in a ball mill since the abrasive effect of the balls accelerate reaction by destroying the hydroxide layer formed on the grains of the materials. Since the process combines decomposition with grinding it does not require the use of finely divided concentrate) with a 45% sodium hydroxide solution at 138 C (280 F) and filtered at 82 C to separate sodium phosphate together with excess sodium hydroxide. On concentration, sodium phosphate is precipitated out and sodium hydroxide is returned to the cycle together with fresh amounts of sodium hydroxide. The water insoluble compound consisting of thorium, uranium and rare earths is dissolved in 35% hydrochloric acid at 80 C and separated from any unreacted ore. The chloride solution is then treated with caustic soda to a pH of 5.8 in order to precipitate thorium and uranium. The mixed chloride solutions are used as the starting material for the production of misch metal.

Wherever apatite is present along with monazite the finely ground mineral is leached with 8N nitric acid at the boiling point for a few hours. Then the resulting monazite is processed as indicated earlier. Thorite is an alternative source of thorium in the form of silicate. Heating finely powdered thorite with 12N nitric acid at its boiling point for several hours and filtering furnishes pure thorium nitrate solution. On the addition of ammonia at pH 5.8 to 6, thorium hydroxide is precipitated out. The ammonium nitrate solution is then treated with some more ammonia and can be disposed off as a valuable fertilizer.

Although uranium is widely distributed in many minerals, yet it is present in most minerals in very small quantities such as in shales, lignites, marine phosphates, sea etc. However, very vast quantities of shale, lignite, marine phosphates are available and therefore at sometime or other these may be considered as important sources of uranium. Uranium present as an oxide in small amounts in association with pyrites can be extracted as dilute solution by bacterial leaching. Pyrites under the influence of sulphur oxidising bacteria is oxidised to acidic ferric sulphate which is a very effective lixiviant for uranium mineral. When the aqueous solution is neutralised with lime uranium is precipitated out along with iron. In the near future, uranium would continue to be extracted from carnotite and from pitch blende.

(To be continued)

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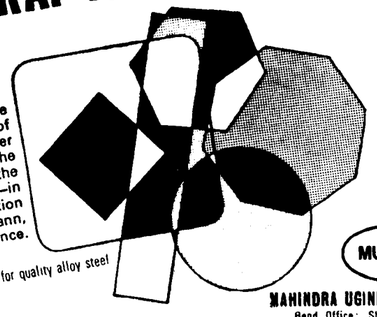

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