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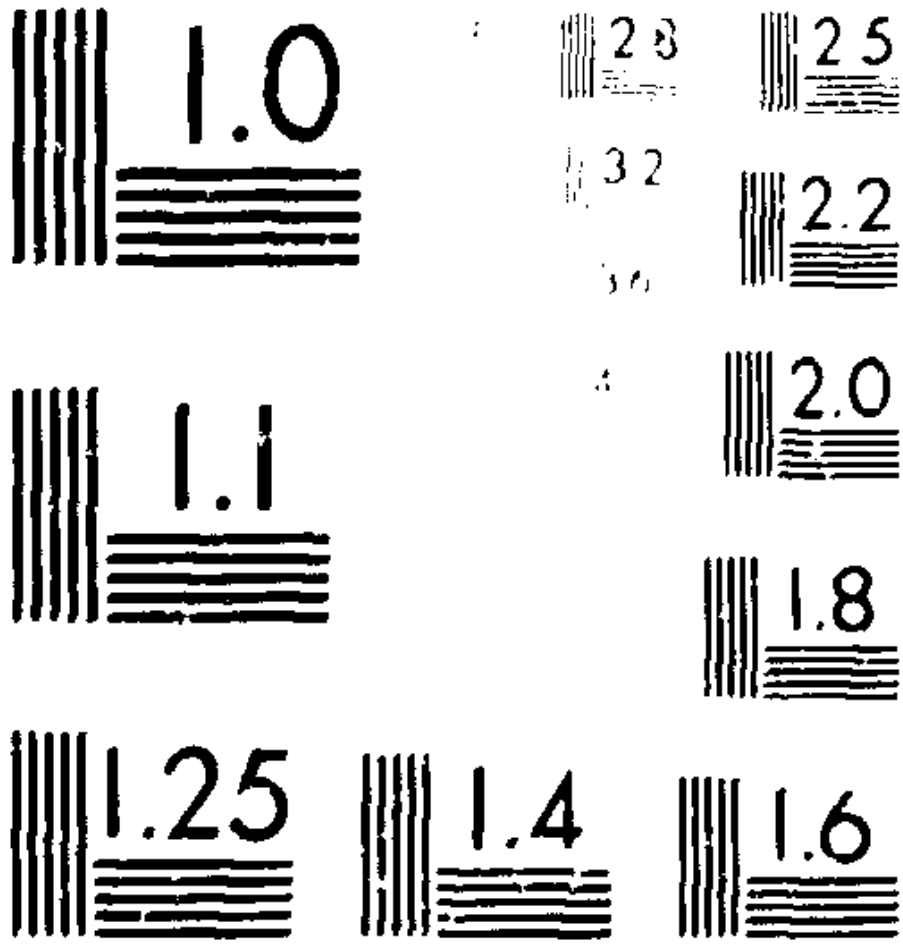

12022

Distr.
LIMITED

UNIDO/IO.518
15 November 1982

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

ENGLISH

SETTING UP A MECHANIZED SANDSTONE CUTTING PLANT FOR THE BUILDING INDUSTRY IN LESOTHO*

by

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V.82-33521

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Background History

It is interesting to note that the first official buildings of the Lesotho Kingdom under the rule of Moshoeshoe 1. around 1825 were constructed in sandstone and the proof lies on the summit of Thaba Bosiu, the historic stronghold of the Basotho nation. P1

It is a sad anomoly that with the passing of time and the introduction of more sophisticated building techniques in Southern Africa the potentially most lucrative natural building material in Lesotho has remained unexploited at an industrial level.

Since the early days of Thaba Bosiu the Basotho have built small dwellings from sandstone and examples of these may be seen in the construction of small huts and rondavels around the country. P2,3

The British annexed Basutoland in 1868, and the official buildings constructed immediately after that time favoured sandstone as a building material; to this day the Basotho consider the use of cut and dressed sandstone to be a sign of wealth and prestige. P4,5,6,7,8

July 1978, the United Nations sponsored a meeting of African experts on building materials, the venue being Addis Ababa in Ethiopa. Available and natural materials were considered and their impact on the building industries in African countries; however the use of stone was considered in general uncommon and yet sandstone is found everywhere in its natural form in Lesotho. (refer E/CN 14 HUS/22 Addis Ababa 17 -21 July 1978)

The Government of Lesotho in 1979 made the decision to build a new office complex to house the administrative departments of the various ministries. A site was chosen on the summit of Griffin Hill off Kingsway, the main highway through the centre of Maseru, and overlooking the monument to Moshoeshoe 1. and the plains of the Orange Free State.

In May 1980, at the express wish of the Honourable Prime Minister of Lesotho Dr. Leabua Jonathon, the Government Office Complex and future official buildings were to be designed in sandstone. The challenge was taken up by the Ministry of Works and after some research it became apparent that structural sandstone had not been used on official buildings for some considerable time. (other prestigious recent buildings had been faced with sandstone eg. Lesotho Hilton and the Victoria Hotel in the 1970s) P9

The challenge was further extended to the use of coursed sandstone as opposed to random bonded as the Architect Team considered this an important element within the overall design concept. The use of coursed sandstone dictates that the stones must be cut within a maximum tolerance in height of +- 5mm.to keep the course lines constant.

In January 1981 it became apparent that the private sector quarries were insufficiently organised to provide the required sandstone. A major project such as the Government Office Complex would require 2 - 3000 finished and dressed stones per week to form a rational building contract. The output of the quarries around Maseru extending to Roma was +- 200 stones per week. The Ministry of Works was accordingly authorised to open an experimental quarry which combined the labour resources available to quarry stone in the prescribed sizes for machine processing in quantities suitable for a viable building contract of considerable size. If the experimental quarry proved successful then sandstone in Lesotho could be considered an industrial commodcty. The background history having been considered and the problems carefully identified,the Ministry of Works ventured into quarrying and dressing sandstone with the following programme:-

1. The purchase of an existing labour intensive private quarry run on traditional lines of hand splitting and dressing stone to the required sizes. The purpose of this stage of the venture was to establish the output of a labour intensive quarry run on efficient basic techniques.
2. The establishment of a semi mechanised quarry to produce the neccessary stone at an industrial level.

Labour intensive quarrying.

In February 1981 the Ministry of Works successfully negotiated the purchase of an existing quarry approximately 8km. from Maseru. The quarry had been operated as a small family business and sold dressed sandstone to small building contractors. The output of +- 100 finished stones per week was way below capacity due to poor management and motivation. The following steps were taken by the Ministry of Works to upgrade the quarry:-

1. The quarry boundaries were clearly defined by a fence with vehicle access gates at the points of entry.
2. A tool store/nightwatchman's hut and a covered way were erected to facilitate the general maintenance of equipment.
3. The work force was increased to 40 - 50 and divided up into daily paid and piece workers. The daily paid provided the back-up for the piece workers in that they made the tools from steel reinforcement in small portable forges and maintained them while another team wedged out stone blocks and cut them into rough sizes for the daily paid piece workers to dress and finish. Women formed the main body of the piece workers and are paid by the month according to the number of finished stones produced. High protein soup is served daily to the quarry workers to promote fitness and stamina which is much appreciated by the women piece workers many of whom are suckling babies. P10-15
4. A schedule of tools and stores purchased at the start is attached at appendix 1.
5. A quarry foreman, much respected by the workforce, was employed to ensure the smooth running of the quarry. The quarry foreman daily checks the pieceworkers production for quality and marks the stone with a paint dot for stacking with the finished stock.

The change in management and motivation increased the output from +- 100 stones per week to +- 500. It is also gratifying to notice that other quarry owners in Lesotho are coming to the quarry to see how it works.

Mechanisation

The establishment of an efficient labour intensive quarry with an output of +- 500 finished stones per week gave the indication that to make sandstone an industrial building commodoty some form of mechanisation would be essential.

Enquiries were made throughout Southern Africa and it became apparent that there was no established sandstone industry of an industrial nature at all; the large marble and granite firms can produce the service on highly mechanised and sophisticated systems with imported machinery at high costs.

Further research was made into the possibility of custom built stone cutting machinery in Southern Africa. A firm with the most suitable qualifications and experience was approached in the Transvaal; however before designs were started the required machine performance was identified as follows:- P22 - 30

1. The presentation of manageable sizes of stone to a machine for cutting.
2. The actual cutting of stone into the required sizes for construction.
3. The ability of the machine to cut +- 4000 stones per week.

After considerable consultation the designers presented their solution as follows:-

1. Sandstone won from the quarry face in approximate sizes of 1200 long x 700 wide x 350 mm. high to be presented to the machine and loaded by crane onto a roller table feeding to a conveyor system to the main cutting blades.
2. The stone would pass through 5 cutting blades and be cut into 4 slabs each with 2 smooth sides.
3. The slabs would then be placed smooth side down and the conveyor/table reversed so that the four slabs pass through the blades in the opposite direction. There would now be 8 slabs of uniform section 150 x 150mm. and approximately 1200mm in length.
4. The 8 slabs then pass through 3 sets of smaller blades and each slab would be divided into 2 totally uniform blocks of stone of a predetermined length as required by the building designers.
5. The whole operation to take +- 15 minutes per cycle.

The initial concept design for the cutting machine may be seen at appendix 2.

The machine can be divided into two basic functions:

1. The stone cutting mechanisms.
2. The power unit.

1. The stone cutting mechanisms were required to produce finished stone at the rate of 4000 per week. The only cutting edge capable of producing this output proved to be a circular saw type blade with industrial diamonds set in a matrix. Specialists in the field of diamond edge industrial cutting informed us that sandstone was an ideal material to cut as the abrasive quality of the material tended to keep the diamonds exposed for continual cutting at speed in so far that a plentiful supply of water for cooling and cleansing was supplied to the blades while cutting.

It was calculated that approximately 45 litres/blade/minute would be required while the five main blades were cutting.

2. The power unit was selected on the following criteria:

Fuel energy source must be readily available and economic.

Maximum reliablity.

The availability of spare parts for maintenance.

The Rolls Royce C6 - 2000G diesel engine was chosen for the power unit.

The design of the two basic functions having been established further consideration was given to detail design and costings, and these are scheduled at appendices 3 & 9.

Final instructions were given to the machine engineers in April 1981,then manufacturing was started and delivery dates fixed for the end of May 1981.

See factory photograph of the completed machine at appendix 4.

The sequence of erecting the machines on prepared concrete foundations may be seen at photographs P16 - 21. P16 - 21

The operation and general running of the machines under the control of a competent engineer was also considered. It was decided that a local candidate would be identified for training on the machines in the course of their manufacture to have a 'grass roots' understanding of the mechanics. The principal of the Lerotholi Technical Institute in Maseru was approached and their mechanical trades department assisted in identifying a machinery operator with the following job description:

1. An operator to control and monitor a machine that cuts large blocks of sandstone (1200 x 700 x 350) into smaller sizes for building purposes.
2. He will be required by the analysis of stress gauges etc., from a console to control the speed of the block through the cutting discs to the end product.
3. When the discs are worn to predetermined limits he will replace them

and for this exercise it may be neccessary to provide him with an assistant but this will be determined at a later stage.

4. The machines are powered by a Rolls Royce C6 - 200OG diesel engine. A basic understanding of diesel engine mechanics and operation is neccessary in that the operator will be required to start, run, and close down the engine; to fuel lubricate and do general maintenance and small repairs. An engine analyser is being installed to give an early warning to the operator of serious mechanical and lubricating problems. The operator will not be expected to provide major mechanical maintenance to the engine, this will be done under a maintenance contract with a specialist.
5. The successful applicant will be employed on probation against a senior technical officer post with a provision for accelerated promotion should he proove himself. It will be a full time job and he will be required to spend 7 - 10 days in the factory during the manufacturing of the machines in the final stages.

Quarrying sandstone

The successful operation of the machinery depended on a quarry site with an adequate supply of suitable sandstone.
The following criteria were considered in the selection of the quarry site:

1. An adequate supply of useable sandstone.
2. Vehicular access from the machines to a good road.
3. A plentiful supply of water all the year.
4. Availability of labour.

Several sites were considered within the urban area of Maseru but these were rejected either because they lacked expansion potential due to surrounding development or there were complications in obtaining the use of the land.
A site at Lancers Gap was finally chosen (see map at appendix 5) which met all the selection criteria and samples of sandstone indicated the suitability of the quarry for building stone with an adequate supply of sandstone from Cave bed and Molteno beds of the Stormberg series overlying the Beaufort and Ecca beds. (see report at appendix 6)
It was neccessary to do certain work to the site before quarrying operations could begin:

1. Locate a site for the cutting machinery and prepare concrete machine beds. P16
2. Construction of a dam to ensure a continual supply of water in quantity. P18
3. The provision of an access road for the installation of the machines and the transportation of finished stones. P42
4. A quarry face for the production of bulk sandstone blocks to machine P34 - 36

The machinery site

Initial discussions with the machinery manufacturers indicated that a level area of approximately 8 metres square would be required. The final position indicated on the site plan at appendix 5 was chosen for the following reasons:

1. Proximity to the dam. P16
2. Adjacent to a track which could be developed into an access road. P17,42
3. No limiting influence on the quarrying of sandstone. P34

Construction of dam

A narrowing of the stream through a mini gorge at the edge of the proposed quarry site afforded an obvious choice for the position of the dam wall. P43 - 45
The flood level was considered adequate for a period of 6 months without rain. (see survey at appendix 7)
The dam was constructed by a local builder at a cost of M6 000:00 and was completed in approximately 6 weeks.

Access to machines

The existing track leading to the stream was upgraded by a labour intensive unit of the Ministry of Works. The work was completed in two weeks P40 - 42
at a cost of M3 515:00. (see schedule of costs at appendix 8)

Bulk stone quarry site

It was decided to start quarrying adjacent to the machines and near P34 - 39
to the stream bed as this would limit the manual transportation of bulk stone to the machines.
In the labour intensive quarries stratas of stone can be selected for wedging into appropriate slabs for splitting into rough sizes in preparation of the finished stone; this ad hoc selection of sandstone may be suitable for 'cottage industry' at the domestic building level but inhibiting at the commercial level in that the arbitary selection of sandstone to be quarried requires large tracks of land to be secured which in itself is wasteful often interfering with grazing and the growing of crops.
The quarrying of sandstone at the industrial/commercial level requires the maximum use of the stone within the industrial site with the minimum wastage employing techniques at the lowest cost.
The design of the sandstone cutting machine required that uniform slabs of sandstone of size 1200 x 700 x 350 be obtained for processing.
Considerable thought was given to quarrying techniques and it soon became apparent that only three methods could be considered for winning the stone from the quarry face.
1. Straight cutting.
2. Splitting.
3. A combination of cutting and splitting.
Experiments were carried out in splitting stone into the required sizes by drilling 38mm.diametre holes at 50mm. centres and then wedging to crack the stone into the required size. This method continually failed

as the corner into the stone face tended to shear diagonally giving what the quarry men describe as a toe to the face.

Experiments to blast the stone into precise sizes also failed as it was difficult to prevent fragmentation and irregular cracking of the sandstone face.

Methods of cutting by thermal lance and industrial diamond beaded wire were discounted due to expense and the purchasing and maintenance of imported machinery together with the complicated nature of their processes relevant to the skilled labour available.

Further research and experimentation showed that by drilling 38mm. diametre holes at 50mm. centres , the solids between the holes broke down under impact stress. Special tools were manufactured on site from worn out drill steels and the compressed air rotary drills were modified to give a hammer action without rotation and this was sufficient to break down the sandstone between the holes. It was now found that by horizontal wedging the blocks came out within a reasonable tolerance for machining.

In conclusion it is apparent that with an adequate home market and a healthy export potential into southern african countries a mechanised sandstone cutting industry appears to be a viable proposition, however care must be taken in assessing the output of machines. There is a tendency to accept the mechanical maximum output of the machines as an expected normal, discounting the human factor neccessary in the associated skilled and semi skilled trades relevant to quarrying and the finishing of sandstone. We have calculated that the planned capacity of the cutting machines is $\pm$ 4000 finished stones per week; however this is depependent on continuous running of the machines, 5 days a week and 5 hours a day. Over an approximate 3 months period since machine installation, the best returns for a week have been $\pm$ 2000 finished stones i.e. 50% of capacity, the shortfall being due to teething problems in the machines, time taken in training key personnel, and general confidence in the job. We have however shown that sandstone is a viable building material in Lesotho and on completion of the Government's major project, the Government Administrative Offices, the export potential will be examined and the possibility of opening other mechanised quarry sites pursued.

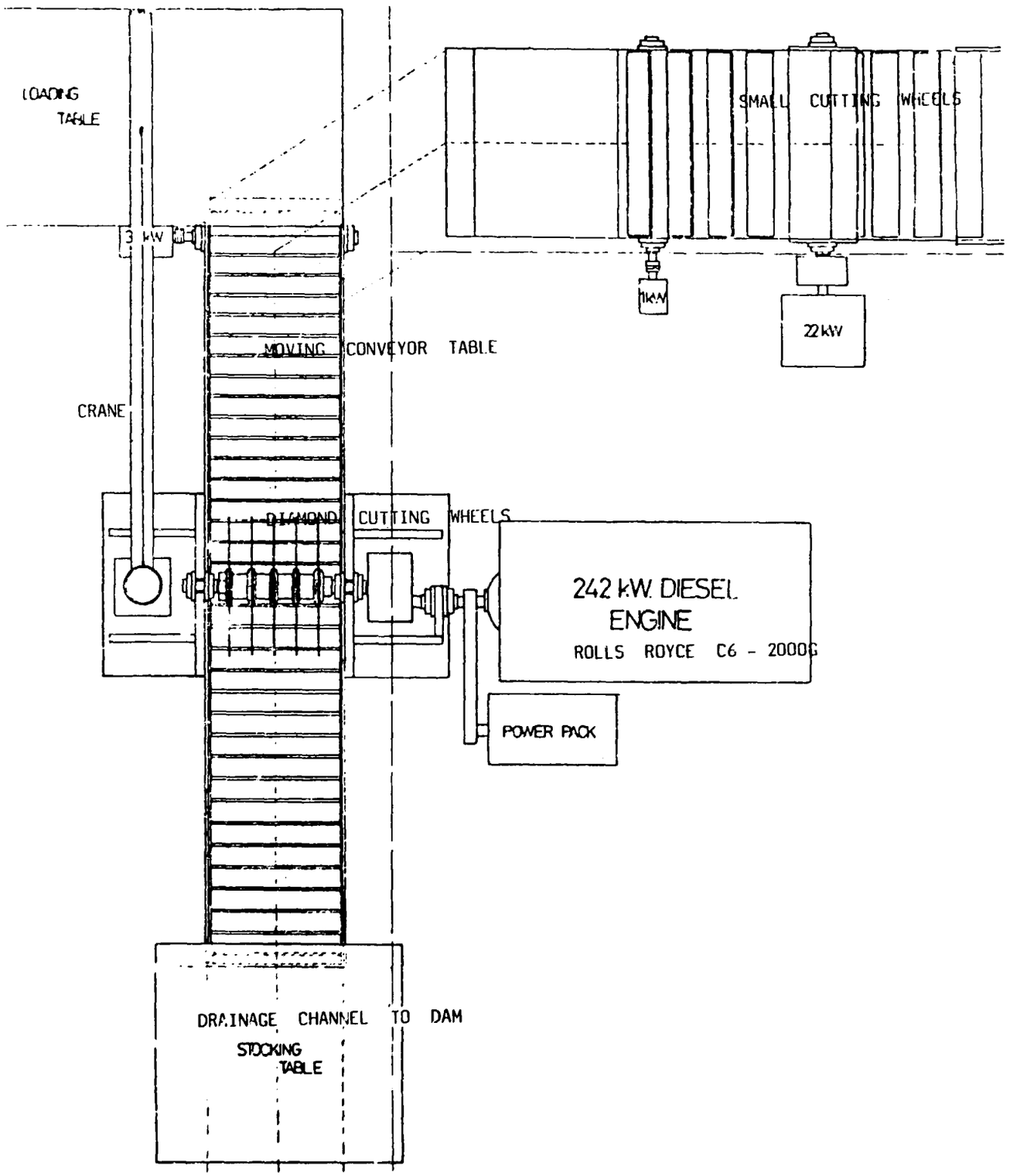
APPENDIX 1

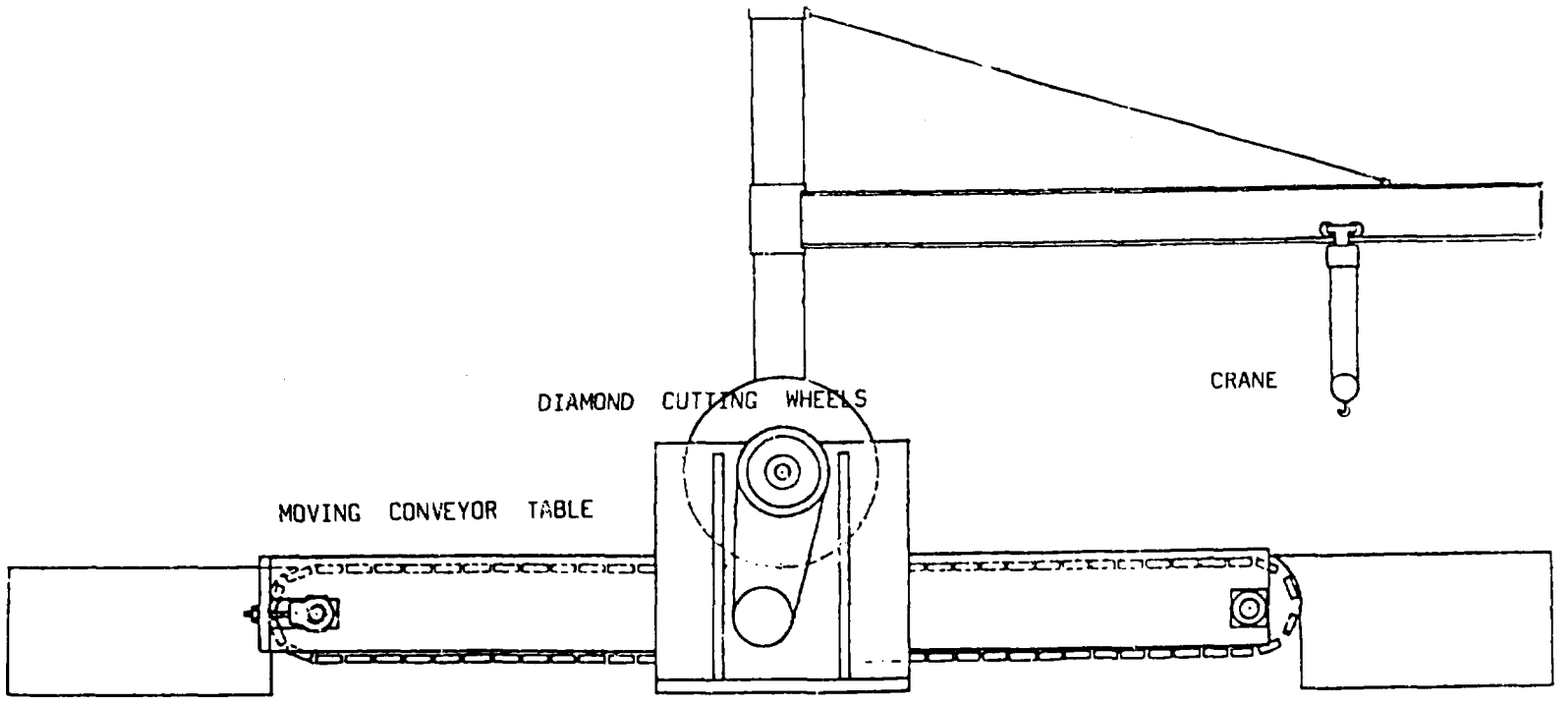
Description	Estimates of cost in Maloti	
	Unit rate	Total
3 portable forges	150	450
3 anvils	25	75
30 pitching tools	3	90
30 wood mallets	12	360
30 steel squares	7	210
30 tooth handles	7	210
40 steel wedges	2	80
60 steel punches	2	120
2 self powered jack hammers	1 500	3 000
2 stores (corrugated iron and gum poles)	500	1 000
1 covered working area	500	500
400 metres of security fencing	15/metre	6 000
wages float for 30 stone dressers		20 000
	Grand total	32 095

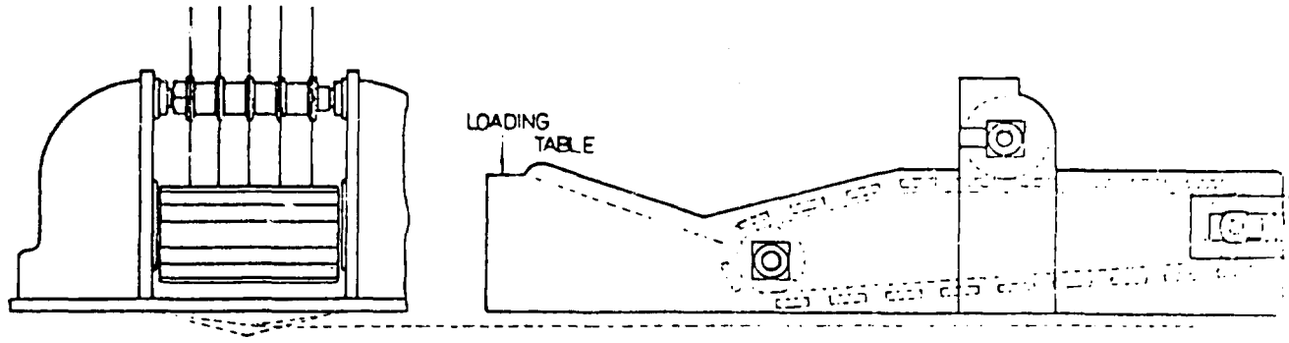
Note

No costs were estimated in respect of the use of the land.

APPENDIX 2


LOADING TABLE
3 kW
SMALL CUTTING WHEELS
1kW
22kW
MOVING CONVEYOR TABLE
CRANE
DIAMOND CUTTING WHEELS
242 k.W. DIESEL ENGINE
ROLLS ROYCE C6 - 200G
POWER PACK
DRAINAGE CHANNEL TO DAM
STOCKING TABLE





DIAGRAMATIC SECTIONS THROUGH CUTTING MACHINES

APPENDIX 3

Stone cutting machines - Summary of costings

The following are estimates of cost for a multi - blade sandstone cutting machine with an output of approximately 4000 stones per week based on an 8 hour day and a 5 day week.

Total cost of machines with 5 no.1 metre blades and 3 no. 500mm. blades was estimated as follows:-

Downpayment of 25% of total cost		M16 637:50
Balance		M49 912:50
Less 5% discount	M 2 495:62	
Total		M64 054:32

The machines will require the one metre blades changing approximately every week and the 500mm. blades every 2 - 3 weeks; thus there will be a requirement of two sets of spare blades to ensure continual smooth running.

Blades only have a limited life as they can only be retipped five times before they are redundant. The cost of retipping blades was estimated as follows:

1 set of 1 metre blades (5 blades)	M 8 000:00
1 set of 500mm. blades (3 blades)	M 840:00

The cost of the machine with installed blades plus two sets of spare blades was estimated as follows:

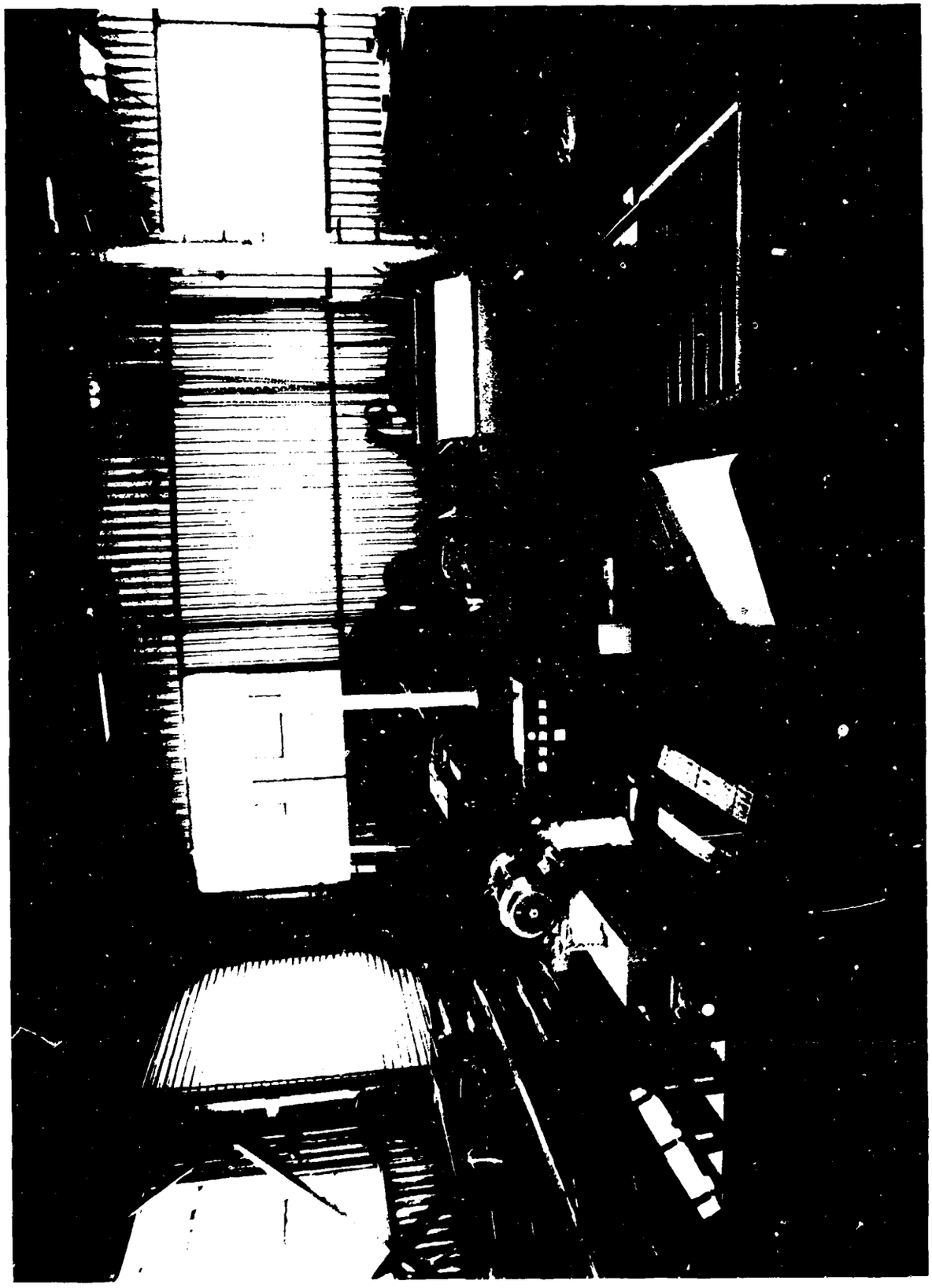
Machine plus installed blades	M64 054:32
10 x 1 metre blades and 6 x 500mm. blades	M19 360:00
Total estimated cost of machine and blades	M83 414:32

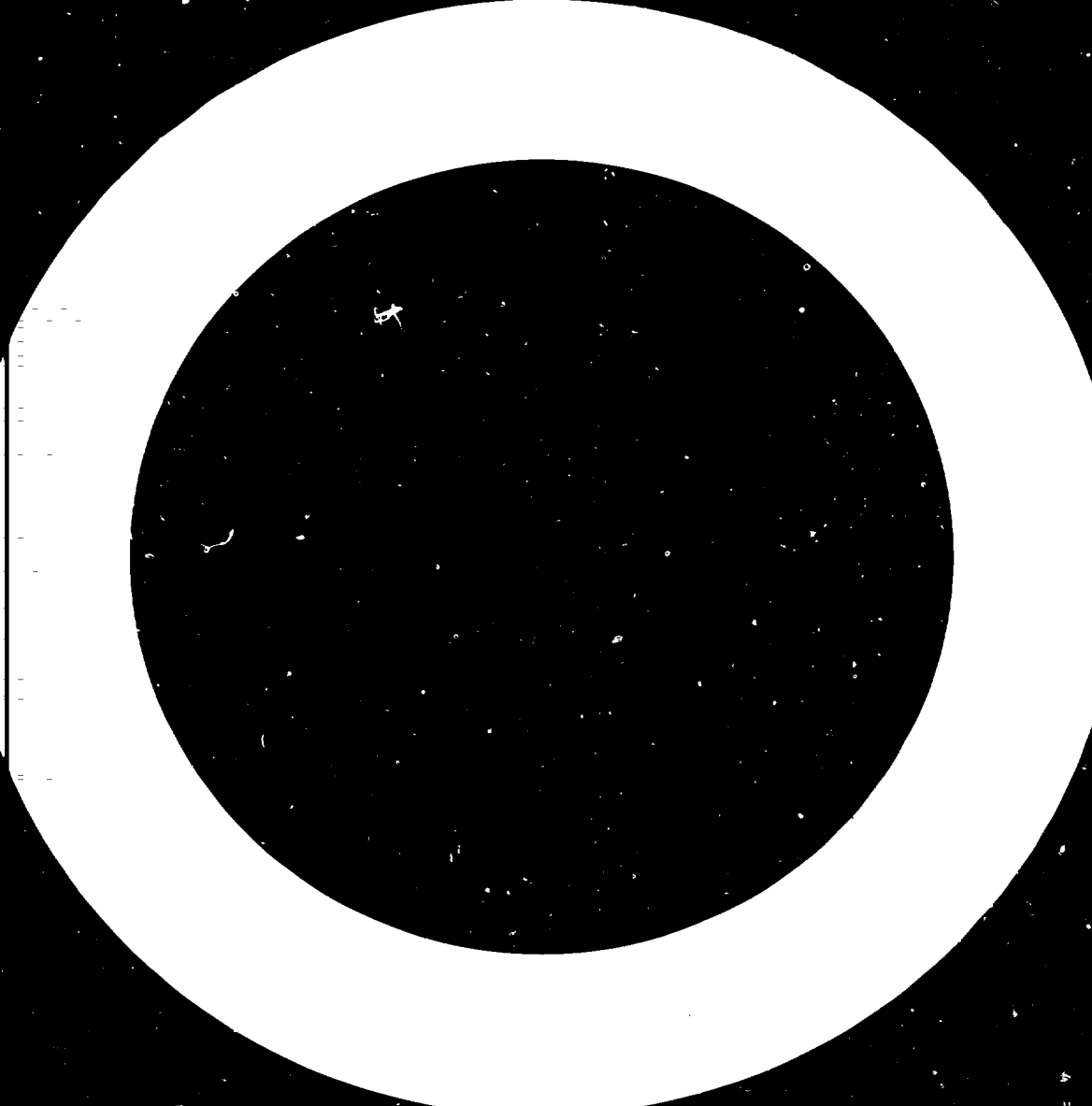
Other associated costs in setting up the machines were estimated as follows:

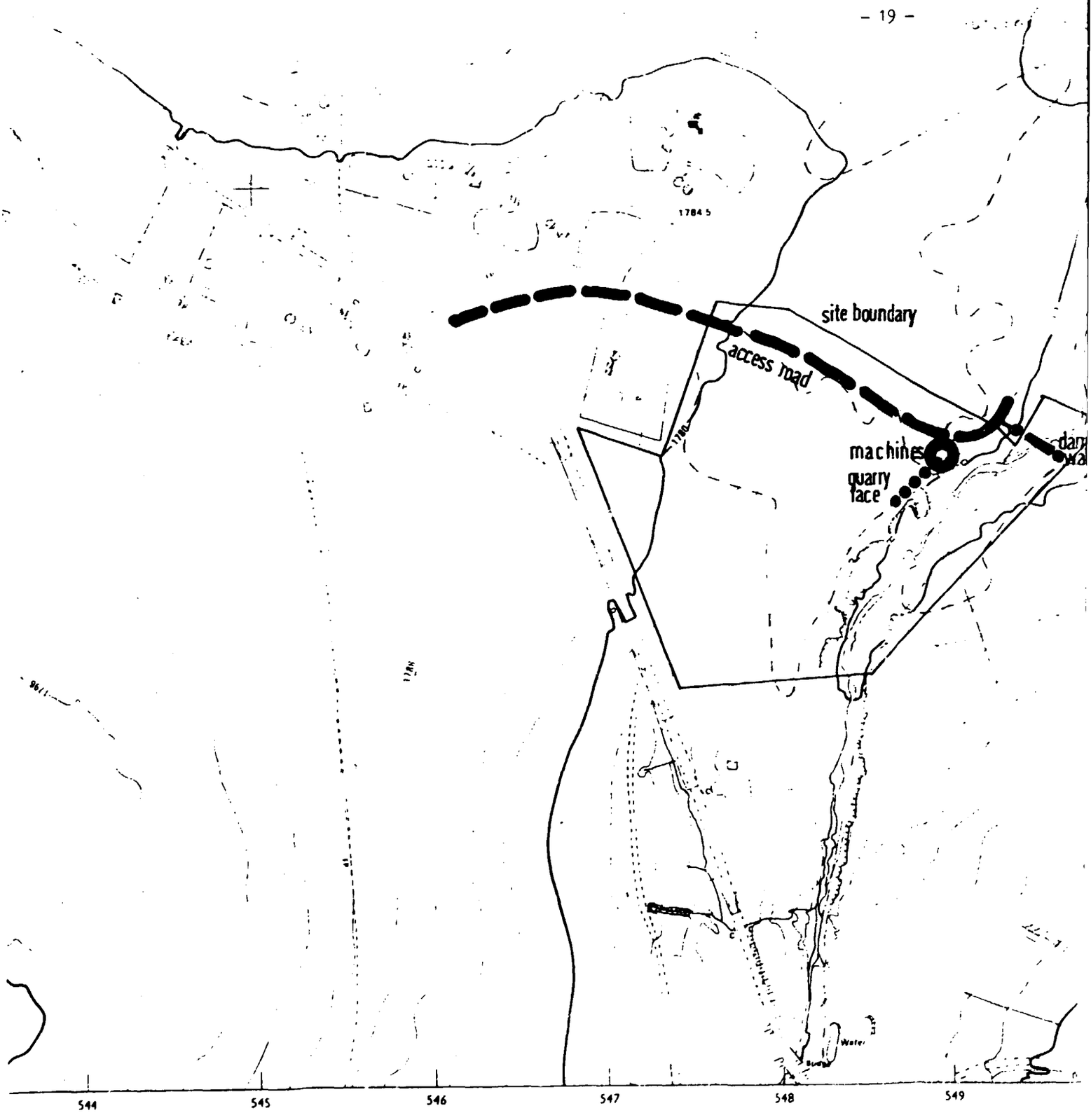
Erection of dam wall	M10 000:00
1 x 50mm. primatic water pump	M 900:00

Associated pipes and fittings	M	350:00
Concrete bases for cutting machines and pump	M	1 000:00
Erection of diesel storeage tanks	M	150:00
Total	M	12 400:00
Total for machines and associated fittings	M	95 814:32
Total including start up cost for labour intensive quarry as described in appendix 1.	M	127 909:32
	Say M	128 000:00

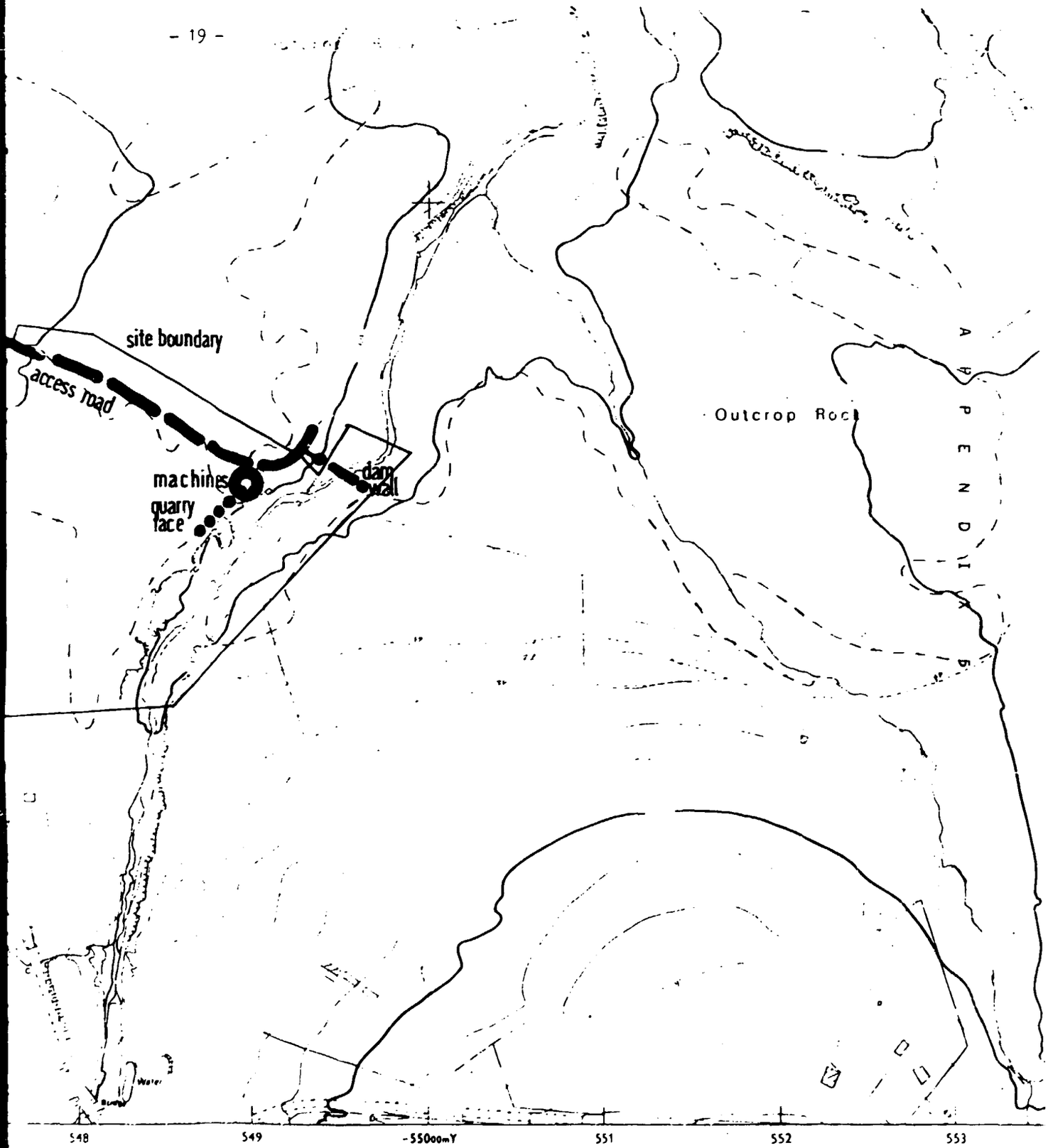
APPENDIX IV






site boundary
access road
machines
quarry face
1784.5
544
545
546
547
548
549
METRES 100 50 0 100
FEET 200 150 100 50 0 100 200 300

SECTION 1



SCALE 1:2500

50 0 100 200 300 400 METRES

FT 200 150 100 50 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 FEET

SECTION 2

APPENDIX 6

Report on the quarry sandstone prepared by the Ministry of Works Materials Testing Laboratory.

Occasionally the top 0.5 to 1.5m of the Cave sandstone has been metamorphosed to some extent (baked) by the heat of the over-lying lava flows.

Transition Beds

The Transition beds, underlies the massive Cave Sandstone and goes into a red colour. Overlying the Red Beds it is distinguished from them by a finer grain of sandstone beds. The Transition Beds contain alternating lenses of sandstone, clay-shales and mudstones.

The Transition Beds are absent in northern Lesotho and appears first in the Leribe district where the formation thickens towards the South.

Red Beds

The Red Beds overlay the Molteno Beds and is distinguished from the underlying beds by the red and purple colour of the clay-shales of which they are partly composed. This bed consists of moderately hard, fine to medium grained sandstones and hard mudstones with occasional clay-shales.

Molteno Beds

The Molteno Beds lie conformably on the Beaufort Beds and they are recognised by their white colour and the coarse grained structure. They consists of well cemented sandstones and grits with occasional clay-shales. This formation becomes thicker towards the south of Lesotho. The sandstones are frequently silica cemented and appear to have a low porosity.

The Beaufort Beds and the Ecca Beds are not exposed in Lesotho and are therefore not described here.

3. Other properties

X-ray analysis show that samples from the Beaufort series contain apart from quartz and feldspar minerals of illite, chlorite small amounts of Kaolinite plus traces of montmorillionite.

Compressive strength tests on intact rock specimens have shown strengths from 40 to 179 Mpa and tensile strengths from 3-7Mpa.

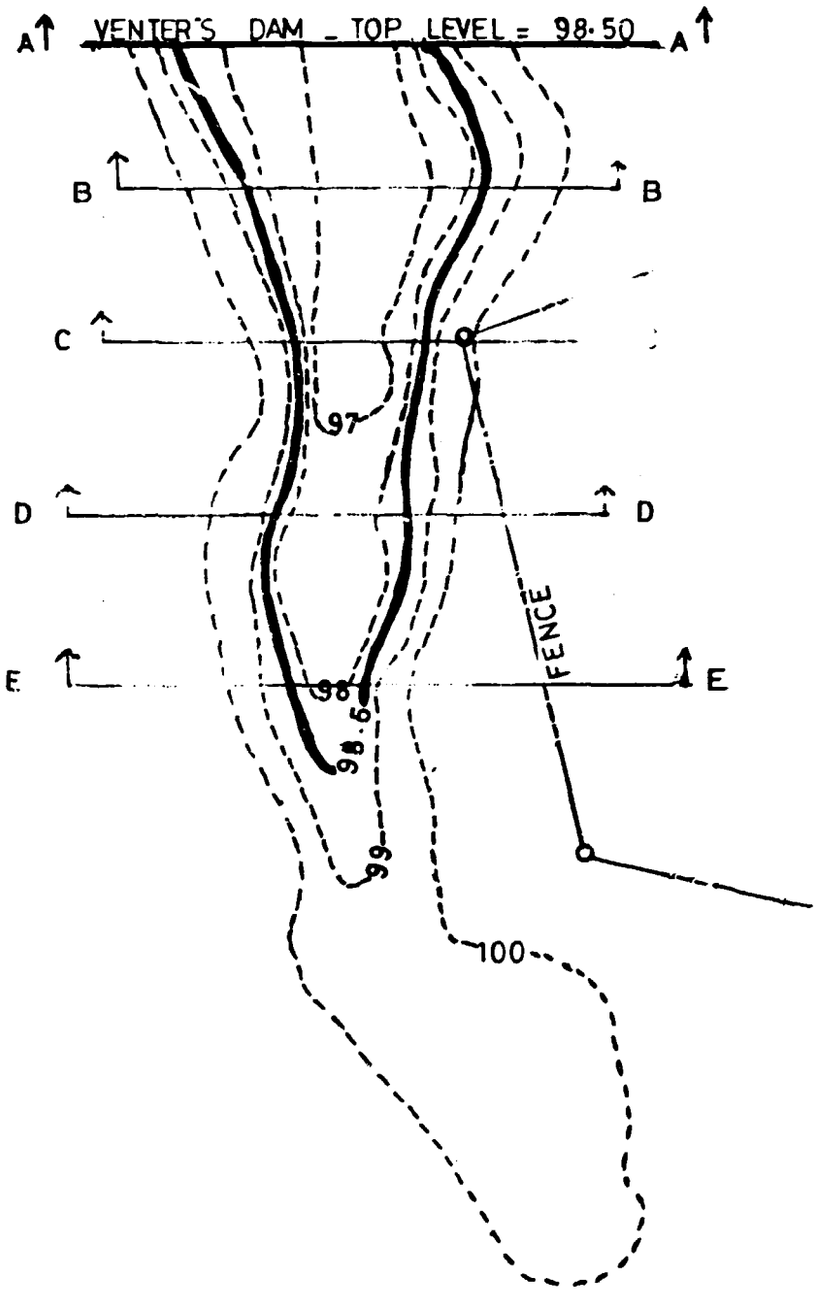
4. Comments

Sandstone has been successfully used in the building stone industry for centuries in Europe and for at least one

century in Southern Africa. Classical buildings in RSA cities amongst them Bloemfontein have sandstone as decoration block-work from Cave Beds, Red Beds and Molteno Beds beautifully set with granite and marble. Provided that a careful handling during the quarrying is done especially in the selection stage, sandstone rock will provide a very valuable building stone material.

Ministry of Works Material Testing Laboratory 1981

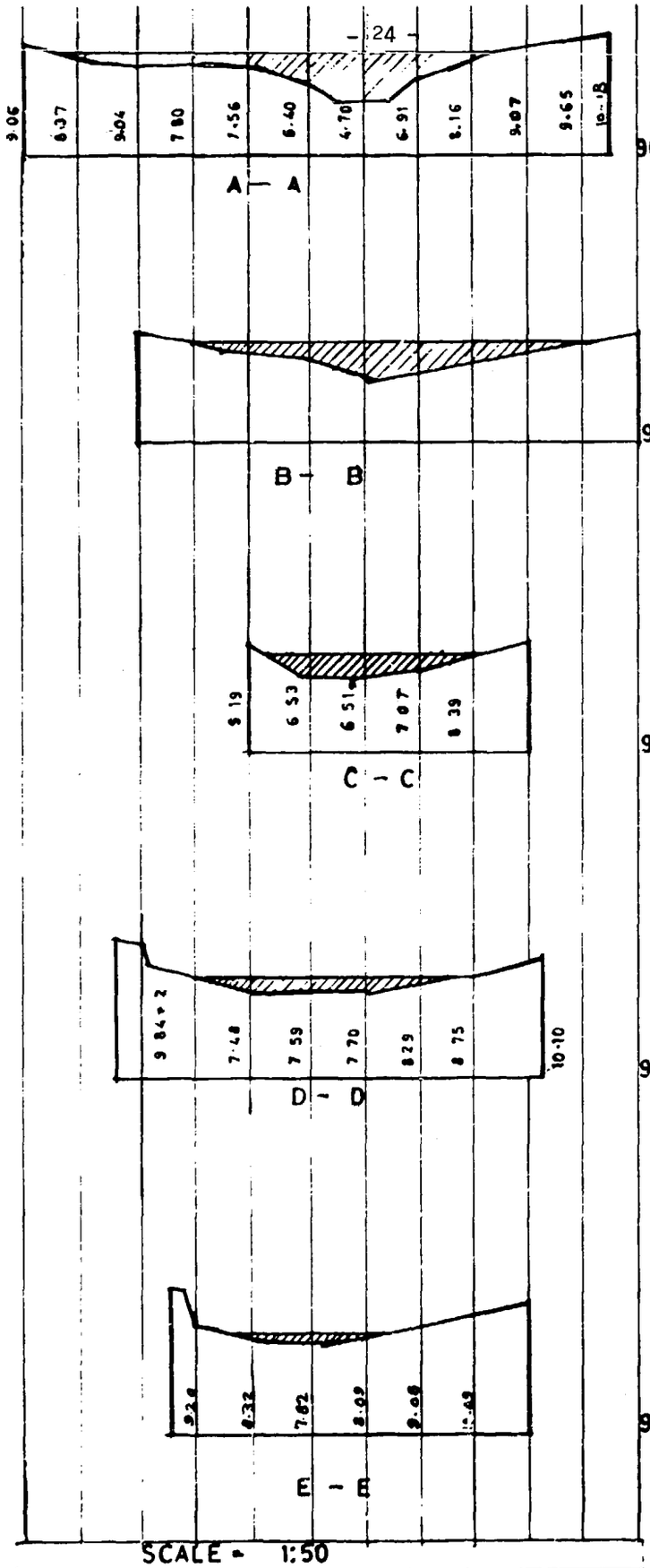
APPENDIX 7



SCALE - 1: 1000

APROXIMATE VOLUME = 2500m³

PLAN SHOWING APPROXIMATE SIZES OF WATER CONTAINMENT AREA, AT VARIOUS LEVELS. (Local Datum = 100.00.)



SCALE = 1:50

SECTION ON DAM AT WATER LEVEL 98.50

(LOCAL DATUM)

APPENDIX 8

Lancers Gap Quarry Access Road - Schedule of Costings

Description	Cost in Maloti
Supervision	
1 No. Technical Officer, 1/2 month @ M269/month	134:50
2No. Technical Assistants, 1/2 month each @ M119/month	119:00
Labour	
295 man days, casual labour @ M3:40/man day	1 003:00
44 man days, masons @ M4:48/man day	197:12
11 man days, operators @ M4:48/man day	49:28
24 man days, watchmen @ M4:68/man day	112:32
Plant	
8 1/2 tipper days (9 hours each) @ M12:54/hour	959:31
11 roller days (8 hours each) @ M4:12/hour	362:56
11 water bowser days at M57/month	31:35
3 vehicle days (estimated) @ M50/day	150:00
Equipment	
Use of tools, camp and storage facilities @ 10% of labour costs of M1 361:72	136:17
Materials	
12 metres of weldmesh @ M2:87/lin. metre	34:44
30 pockets of cement @ M3:00/pkt	90:00
Total	3 515:05

Note

All prices ruling at May 1981

APPENDIX 9

Estimated recurrent costs per month

Cutting machine

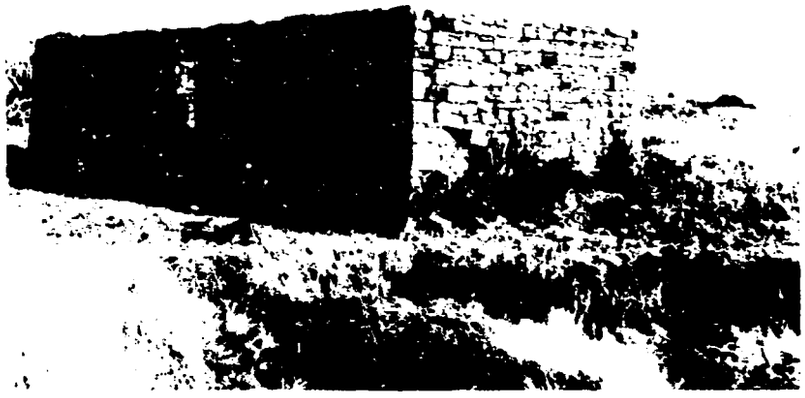
Description	Maloti/month
Diesel fuel	150
Retipping blades (max. output 2 500 stones per week, blade life 1.6 weeks, retipping cost M8000:00)	20 000
Labour	
Quarry master	500
Machine operator	350
Assistant machine operator	200
6 labourers @ M4/day	528
Transport	150
Total	21 878

Quarry

Description	Maloti/month
Diesel fuel	100
Hire of compressor M120/day	2 400
Hire of rotary drills 10 @ M5/day	1 000
Hire of steel sharpener @ M5/day	100
Labour	
Quarry foreman	160
4 bull facers @ M4/day	352
8 tool operators @ M4:50/day	792
8 labourers @ M4/day	704
Transport	150
Total	6 758

Estimated total recurrent cost per month M28 636:00 prices ruling at May 1981

P1



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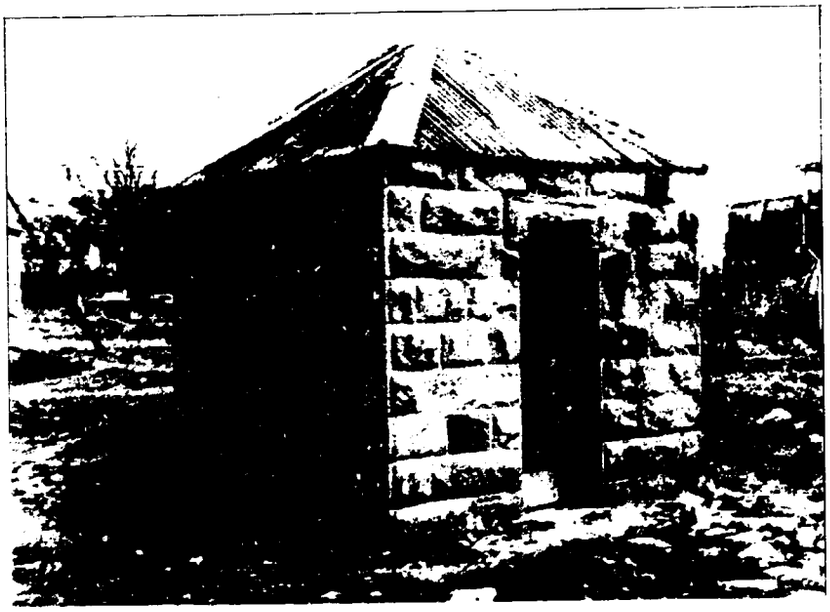

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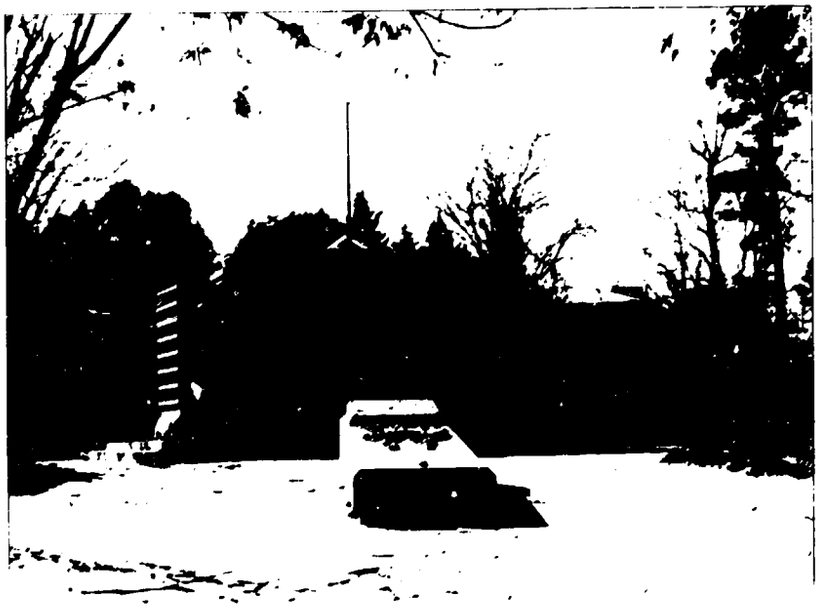

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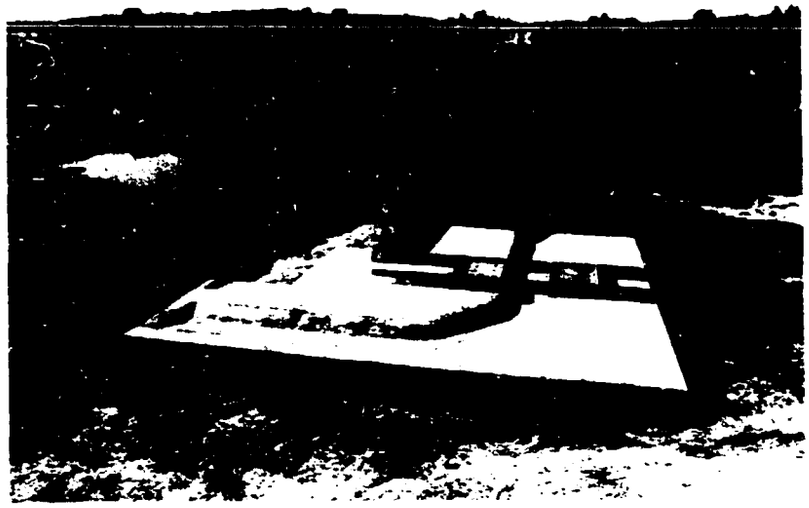

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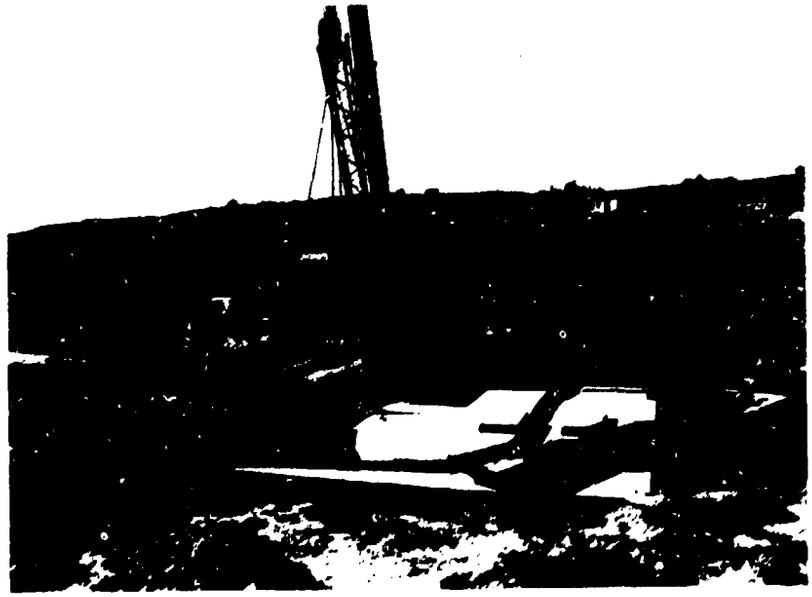
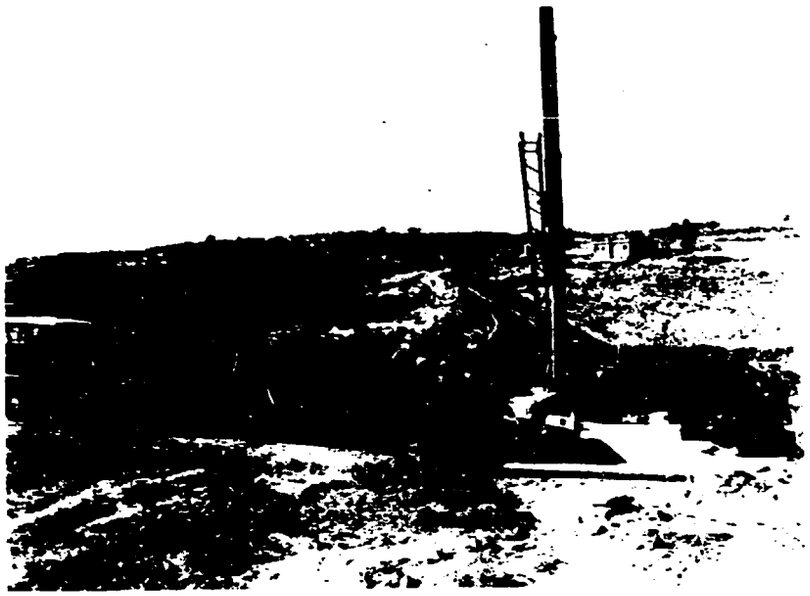
P18





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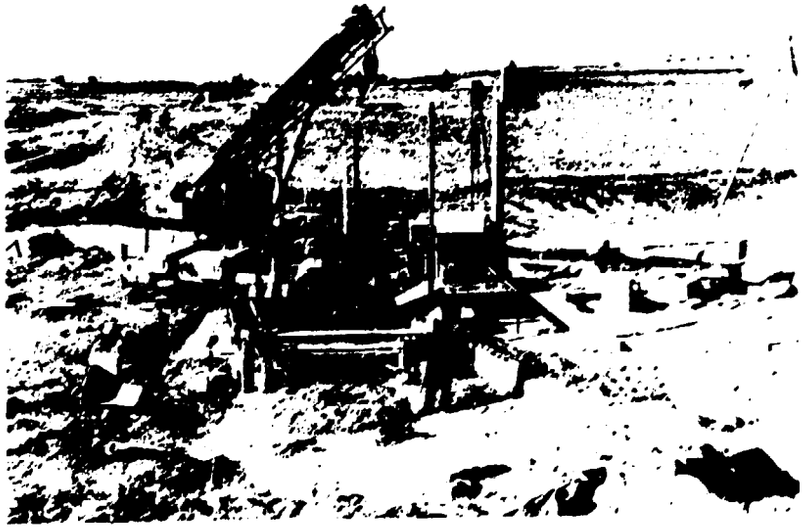

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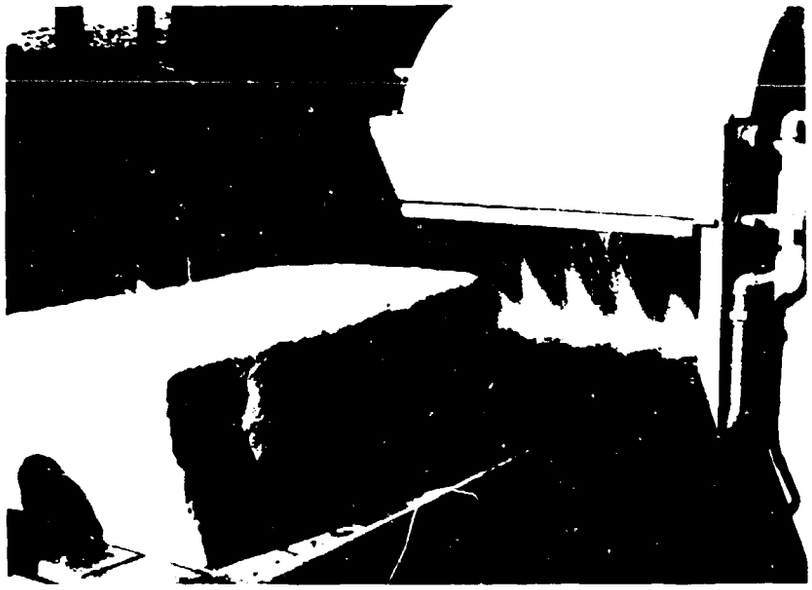

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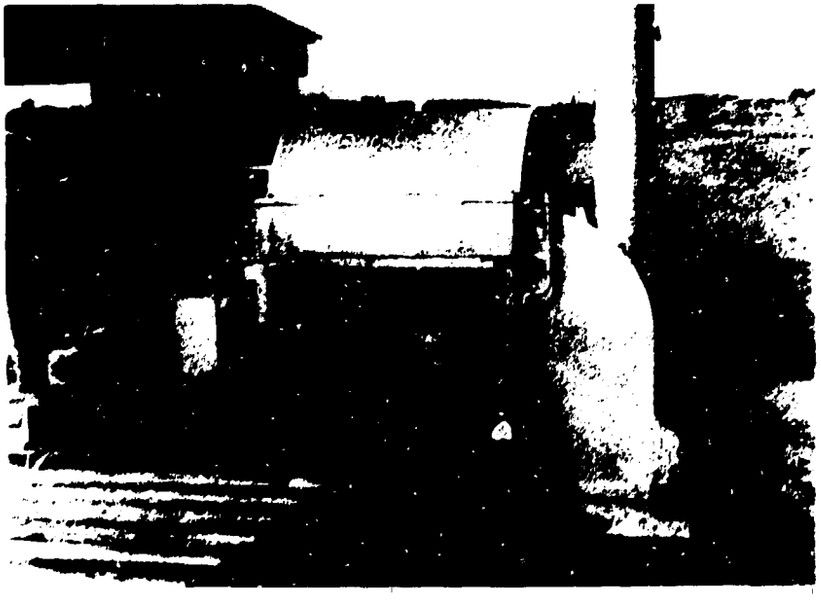

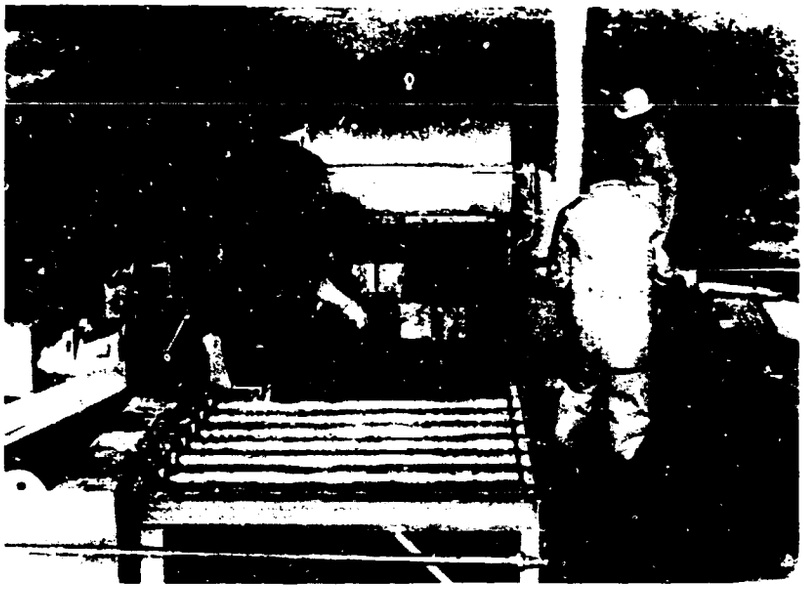

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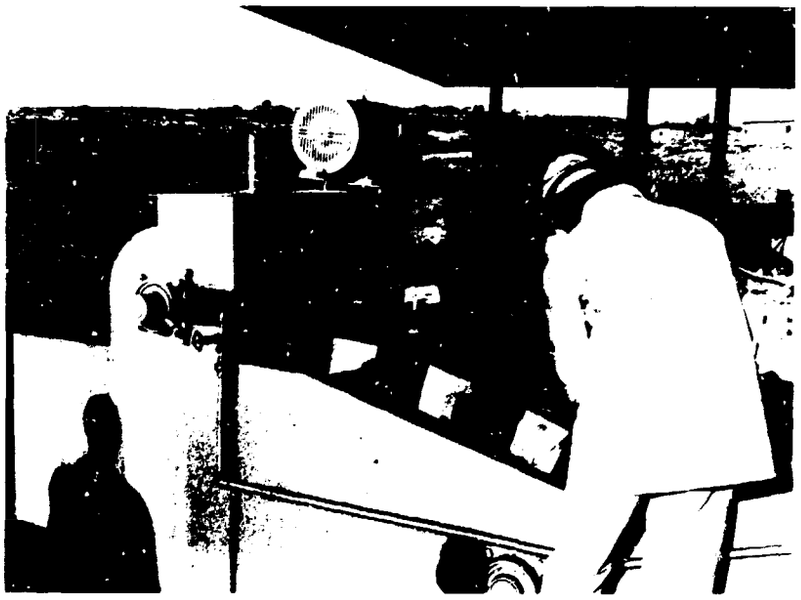

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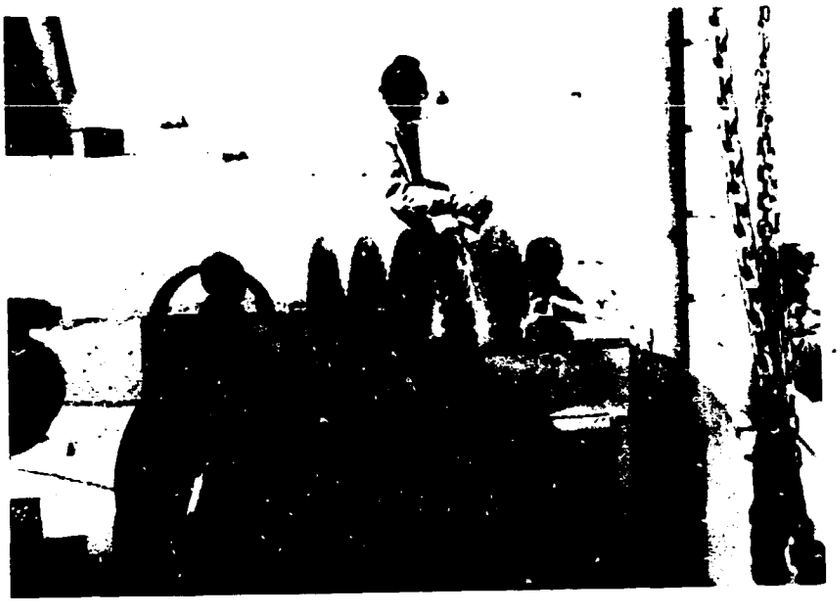

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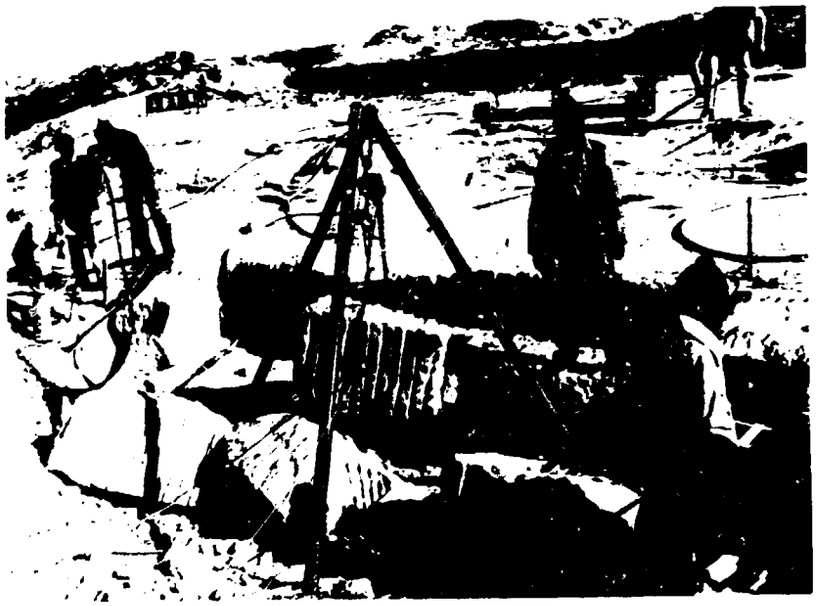

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