JADE TILE

FEASIBILITY STUDY

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1. INTRODUCTION

This report, prepared jointly by M.W. Waldner of Mohawk Oil Co. Ltd. and independent consultant E.M. Plank details the findings of a study conducted to determine the production and capital costs associated with an optimum system for manufacturing tiles and slabs from **British Columbia Nephrite Jade.** These products are to be made from lower grade, yet still attractive nephrite which hitherto had been unsaleable but represents a significant volume of reserves and production. The study, a plan of which is attached as **Appendix II,** and report were jointly funded by Mohawk Oil Co Ltd., the Department of Energy Mines and Resources of Canada and the Ministry of Energy, Mines and Petroleum Resources of British Columbia under the Canada/British Columbia Mineral Development Agreement.

The study encompassed international research into various cutting and grinding technologies available primarily in North America and Europe, including research into Mohawks' own exclusive manufacturing techniques. The research eventually led to the stone cutting industry in West Germany and Italy. The impetus for researching the tile manufacturing technologies came from the need to enhance the economics of mining and marketing nephrite jade and to reduce the cost of manufacturing jade tiles and slabs manufactured from the construction quality material.

The study findings are specific to production of tiles and slabs from a British Columbia Nephrite Jade. The physical and chemical characteristics of this jade precluded the direct application of a "standard" stone tile production system.

1.1 HISTORY

The Cry Lake Jade Mines Ltd. properties, now owned by Mohawk Oil Co. Ltd. are located in the Provencher Lakes - Kutcho Creek area of Northern British Columbia (see **Figure 1**). Mohawk has been mining nephrite jade as a primary product from this area since the mid 1970's. Although some production has been from alluvial boulders, the primary production has been mining in-situ lenses of jade. During the past 10 year period approximately 830 tons of jade has been shipped from the minesite via **"cat-train"** to the camp thence by air to Dease Lake and finally by truck to Southern B.C. Most B.C. Jade production finds its way, in raw form, to off-shore markets, primarily Taiwan. This off-shore market is mainly for carving and jewellery quality jade which accounts for approximately 25% of Mohawk's total production. The remaining 75% of production has generally been unsaleable or fetches prices below exploration, development and mining costs.

In 1982 Mohawk initiated investigations into developing a market for the non-carving and non-jewellery quality jade. Jade tiles were identified as the most attractive mechanism for marketing this **"lower grade"** jade. After researching manufacturing techniques a plant was established in southern California and 4x4 inch tiles were produced and sold beginning in 1983. The tile manufacturing process allowed the liberation of higher quality jade and simplified the jade grading process in addition to enhancing the value of the lower grade jade. A marketing campaign was organized for introduction of the jade tiles and **"JADE INTARSIA"** was established as the tile sector of Mohawk's jade business.

Manufacturing and distribution of the four inch square by one-eighth inch thick jade tiles has continued since 1983, albeit on a reduced scale during the past year. After an expenditure of approximately $1.5 million in the jade tile business and with three years marketing and manufacturing experience it became evident that the price of the tiles had to be reduced if the necessary sales volumes were to be achieved for a viable operation. The tiles currently sell for more than $150 per square foot, Designer Net. A target price of $100 or less per square foot has been set and this is only achievable if tile production costs can be drastically reduced. Market research also indicates that the sales volumes can be enhanced if a greater variety of products can be offered, including different size tiles, slabs, and blocks. Other uses for the lower grade jade have also been identified including table legs, desk sets, book-ends and other home, commercial, souvenir and gift items. However, the tile and slab manufacturing must be profitable if the remainder of the "value-added" part of the business and the bulk jade sales are to be economic, even though an economic analysis of the business would necessarily include all aspects from minesite to saleable products.

WEATHER CONDITIONS COMPARISON

	Annual Precipitation	F.F.D.*	C Mean Temp. Spr.	Sum.	Fall	Wint.
Terrace	109 cm (43")	151	6.3	15.5	6.7	-3.1
Prince Rupert	286 cm (113")	n/a		n/a		
Vancouver	110 cm (43")	198	9.6	16.9	10.7	4.0
Prince George	62 cm (25")	68		n/a		

*Frost Free Days

Source: Ministry of Agriculture
Climate of B.C.

FIGURE 1

1.2 TERMS OF REFERENCE

The study focus was to research available techniques and technologies for production of nephrite jade tiles and determine preferred manufacturing equipment and optimum plant design and location. The study included an analysis of Mohawk's current tile manufacturing plant and identification of production inefficiencies. Additionally, available alternate techniques and technologies were to be ascertained and evaluated. Plant Site Selection essentially focused on a northern or central B.C. plant location versus a southern (lower mainland) location. A foreign plant site was not considered although tariff considerations had previously dictated a United States plant location.

Previous production experience and marketing information assisted in determining the basic criteria for the tile specifications. These criteria were:

1. A 4x4 inch (approx 100 cm^2) jade tile was to retail for less than $11.00. This translates to a total manufacturer's cost of approximately $45.00 per square foot and a retail price of under $100 per square foot.

2. Minimum production rates of at least 1100 square feet per month were to be expected based upon a 40 hour work week.

3. The raw jade blocks could be considered to be in rough boulder form up to dimensions of 2x3x3 metres, but commonly less than 1 cubic metre.

4. All equipment must be CSA approved and compatible with all Canadian standards.

5. The plant was to have the capacity to produce slabs and bevelled 4x4 inch, 6x6 inch, 8x8 inch, 4x8 inch and 12x12 inch tiles with a minimum thickness of approximately 1/8 inch.

These criteria served as the bases for comparison of the various equipment types and techniques available. Production rates and costs were compared, plant expandability assessed, yield from raw jade boulders determined, and capital equipment costs identified. Assessment of individual equipment manufacture's after sales service was done including parts availability, training programs, actual user feedback and general industry stature and performance.

Plant Site Selection was based upon the premise that this native British Columbia mineral (Nephrite Jade) would be processed in the Province. This **"value added"** approach to the jade is a serious departure from the previous jade industry practice of exporting the material in the raw form for processing off-shore. The primary criteria in the Plant Site Selection were:

1. Raw material and finished product transportation costs.

2. Availability of an appropriate work force.

3. Availability and cost of water, electric power and to a lesser extent natural gas. (Serviced land).

4. Availability of level, well drained light industrial land which would support heavy production equipment without the need for expensive foundation preparation.

5. Proximity to domestic and foreign markets primarily the U.S., Asia and Europe. This includes estimated differences in marketing costs between locations.

6. Impact of weather conditions on the operation, especially impact and associated costs of operating a high water use plant in freezing conditions.

7. Availability and level of Federal, Provincial and Municipal Government assistance programs.

2. SUMMARY

This report describes the results of research into the feasibility of manufacturing 4x4 by 1/8 inch thick tiles from British Columbia Nephrite Jade. This study was jointly funded by Mohawk Oil Co. Ltd., and the Federal and Provincial Governments. The primary criteria for establishing the feasibility of the venture was that the tiles must retail for less than $100.00 Canadian per square foot. That would require total manufacturing costs to be approximately $45.00 per square foot or less.

The study included research into all possible relevant cutting, grinding and polishing technologies and techniques including the use of high pressure water, lasers, abrasive slurries, and diamond set or impregnated tools for cutting and/or grinding jade. The research included appraisal of Mohawk's own technology and techniques as well as identifying and assessing others. Six European manufacturers of stone working equipment were identified as possible suppliers of appropriate equipment which could economically produce jade tiles.

A preferred manufacturer of equipment and a tile manufacturing technique was identified and a plant site recommended. The best alternative is considered to be establishing a tile manufacturing plant in the Lower Mainland (probably the Surrey area) using equipment manufactured by Carl Meyer. This West German manufacturer completed tile manufacturing test work successfully and at the lowest cost; approximately $39.00 per square foot for 4x4 inch jade tiles.

3. NEPHRITE JADE CHARACTERISTICS

There are essentially two types of jade recognized in the world, an amphibole jade (Nephrite) and a pyroxene jade (Jadeite). The jade that is referred to in this report is **Nephrite Jade**. Nephrite Jade is essentially a rock composed of a matte of fibrous tremolite. Ideally, the composition of tremolite approaches $Ca_2\ Mg_5\ Si_8\ O_{22}\ (OH)_2$. However, because tremolite is an amphibole mineral in the continuous tremolite - ferroactinolite series the composition is variable. The variations in the colour of nephrite are primarily due to this compositional variation. There are often minor amounts of other minerals in Mohawk's Jade including uvarovite (chrome garnet) chromite, chlorite, talc and magnetite.

The unique physical and chemical characteristics of Nephrite Jade make it a very durable building material, but also a very difficult material to work. At a hardness of between 6 and 7 on the Mohs Hardness Scale, it is much harder than such materials as marble and onyx, at approximately hardness 3. Jade is about equivalent in hardness to the primary minerals which constitute granite but jade is much different texturally and compositionally. Granite is composed of three primary minerals and several minor accessory minerals all crystalline in nature. According to Leaming (1978), Nephrite Jade is essentially a monomincrallic rock characterized by a peculiar texture in which microfibrous tremolite occurs as twisted and felted bundles, tufts and sheaf-life aggregates in interlocking random orientation, whereas granite is an aggregate composed of large individual crystals. Jade has a very high compressive strength, in excess of 61,000 lbs/in^2 (Belyk et al 1973), which is greater than steel. Jade has a high density, about 3.0, equivalent to about 185 lbs/ft^3, or more than 5% greater than the density of granite.

4. CUTTING, GRINDING AND POLISHING PROCESSES

The physical characteristics of the jade affect how the material can be cut, ground and polished. Chemistry is not very important, since jade is generally inert, essentially unaffected by strong solvents, acids or bases. Therefore, the following physical characteristics appear to be critical for working jade:

Hardness	6 to 7
Compressive Strength	+61,000 lbs/in^2
Specific Gravity	approx. 3.0 (185 $lbs/ft.^3$)
Texture	microfibrous matte - random orientation

Certainly colour is a criteria from an aesthetic viewpoint as is the translucency and lustre. One of the reasons for specifying that the tiles must be thin is due to the translucency. However, this does not affect how the jade will grind, cut, or polish.

4.1 CUTTING PROCESSES

Cutting technologies and techniques investigated included:

1. High pressure water; 2. lasers; 3. sawing employing abrasive slurries; 4. Diamond set or impregnated saw blades of various configuations.

These systems were identified by researching industries which cut hard materials including metal, stone, wood, glass, and other minerals. Manufacturers are listed in **Appendix I.** High pressure water was generally ineffective; laser beams may have limited specific applications; sawing using abrasive slurries was generally unsuccessful; diamond set saws gave the most favourable overall results.

4.1.1 HIGH PRESSURE WATER

High pressure water cutting has met with some success when used on crystalline, natural material. Flow Systems of Kent, Washington has developed a system that is marketed by Admac, which is employed in cutting marble, granite and other materials.

Discussions with Rod Draughton and Jim White indicated that although their system could cut jade it would not be viable on a commercial basis. The system uses high pressure water with abrasives added to the water stream. Failure of the jade test cutting was attributed to the material's hardness, fibrous nature and random orientation of the fibres.

4.1.2 LASER

Test work has reportedly been carried out by Nana Corp. of Alaska and Battelle on Alaskan jade employing lasers. Personal communications (D. Anderson - Aug. '86) suggest that test cutting of jade using steady and intermittent lasers proved unsatisfactory. The cuts were uneven and tended to have the shape of an inverted V (ie: wider at the bottom of the cut). Also the depth of the cut was less than one inch and left a glassy, slag-like residue. Test work conducted for Mohawk by Cut-A-Die of Markham, Ontario met with some success. Flat jade slabs were successfully cut using a 600 watt CO^2 laser, a Royal Zenith - Coherent Everlase 525. This machine is computer controlled and fully automatic. Cut-A-Die does custom cutting and etching at a charge-out rate of $150.00 per hour. Custom laser cutting can also be done by Arvan of Vancouver, B.C. Cut-A-Die's laser cut through a 4"x4" - 1/8" thick tile making complex internal cuts at a cutting rate of 20 inches per minute using the continuous wave mode. The kerf loss was approximately 0.2mm. The edges of the cut were the roughness of 80 grit sandpaper and bleached (burned) white on the surface (no significant penetrative damage). There was no significant burning on the side that the beam entered and approximately .5mm of burn damage on exit side. The laser could have applications for etching and cutting slabs and tiles. This machine will perform internal (jigsaw) cuts or external cuts on flat surfaces. The laser tested would not cut uneven surfaces because the light ray must be focused and strike the surface to be cut at a constant distance from the light source. The depth of the cut is limited by the dispersion of the ray which occurs as the surface to be cut becomes further from the focal point of the beam as the cut deepens.

4.1.3 ABRASIVE SLURRIES

Breton s.p.a. of Italy manufactures a reciprocating perforated steel gang saw which employs an abrasive slurry as a cutting agent composed of lime, mineral cuttings and steel shot. A detailed description of the system follows under the test results from Breton's experiments, (see Sub Section 5.1). The system relies primarily on the abrasive slurry dislodging mineral crystals from the stone being cut and/or the material being softer than steel. This slurry of lime, steel slot and saw-cuttings is recirculated and thus the mineral cuttings also assist in the cutting process. The system failed to perform satisfactorily probably due to the hard, fibrous nature of the jade.

4.1.4 DIAMOND SAWS

There are essentially three styles of diamond saws that were investigated:

1. Disc (circular) saws of various diameters for blocking, slabbing, bucking and ripping.

2. Reciprocating saws primarily for blocking or slabbing.

3. Band saw primarily for blocking and slabbing.

Blades for all of the above saws are either continuous rim - diamond set or impregnated blades, or segmented - diamond set or impregnated blades. Diamond cutting technology is the most common in the stone and mineral cutting industry. Virtually every manufacturer of stone cutting equipment has at least one style of saw designed to accept diamond blades.

The principle behind diamond sawing technology is that diamonds, hardness 10, will cut the softer jade or granite which has a hardness of between 6 and 7. Other physical characteristics besides hardness do affect this mechanical sawing process, especially the texture of the material to be cut. The typical process for cutting granite involves the "plucking-out" of individual crystals, the cutting of a softer material by a harder material and the abrasive nature of the minerals that comprise the saw cuttings. The diamond cutting process for jade is based primarily upon the hardness difference between the cutting medium (diamond) and the jade. The saw blade must be able to sever the randomly oriented matte of fibrous nephrite rather than dislodge individual crystals. The cuttings are non-abrasive and tend to plug the cutting tool's surface inhibiting, rather than assisting, the cutting process. Commonly water jets are directed into the cut aimed at or near where the saw blade meets the jade. Most of the cutting systems, with the possible exception of the band saw rely on high speeds for the blades and high pressure between the saw blade and material being cut. The water acts as a coolant for the blade and flushes the cuttings out of the saw cut.

4.2 GRINDING AND POLISHING PROCESSES

The physical characteristics of the jade affect how the material is worked. All the grinding and polishing techniques involve working the jade with diamond tools and hard grit sanding discs or powder. The techniques are essentially one of two types:

1. Lapping using polishing/lapping grits.

2. Grinding and polishing using diamond tools and sandpaper type diamond grit.

The Mohawk System employs a lapping and polishing process which relies on addition of a grit slurry. The slurry floods the tile surface while a rotating plate spins on the tile surface and the table spins. The two stage lapping and polishing process uses two different grit sizes. The final polish is dependent upon time for each stage.

The commercial stone grinding and polishing machines made in Germany and Italy universally employ gradationally finer diamond set tools mounted in rotating heads, which grind and polish the tile surface. Generally an eight head grinder/polisher has been recommended for jade. This technique relies on a combination of head (tool) pressure on the tile surface, the rotation of the diamond set tool on the surface to be polished and on some machines the diamond set tool also oscillates.

5. TILE MANUFACTURING PLANTS

Many manufacturers of cutting, grinding and polishing equipment were contacted. There are several equipment manufacturers who produce complete, fully integrated equipment packages and many more manufacturers, primarily in Italy, who produce specialty equipment exclusively for one or perhaps two seqments of a multifaceted tile manufacturing system. With the exception of the high pressure water and laser cutting systems, only the integrated manufacturers were asked to perform tests for the manufacture of jade tiles and slabs. There were several reasons for this decision:

1. The major, integrated equipment manufactures could supply a properly engineered, and sized plant, whereas the manufacturers of specialized equipment did not have properly sized equipment for an integrated plant.

2. The specialized equipment manufacturers could not supply the expertise to design an entire plant.

3. After sales service from small, foreign equipment manufacturers was difficult to determine but expected to be poor in comparison to the larger firms.

4. The small companies generally could not offer installation and training assistance except at a high cost.

5. Only the larger equipment manufacturing companies could perform the test work required to determine if a certain piece of equipment or an overall plant design was viable.

From the short list of companies identified as possibly being able to perform the necessary tests and/or supply an integrated tile production line, six companies agreed to perform tests and/or specify a plant. Several tool manufacturers also agreed to perform tests, but eventually none of these companies were given jade directly from Mohawk for test work, although several contributed assistance on tool technology to the equipment manufacturers. All companies who performed test work agreed to perform the tests at no charge if Mohawk delivered the jade free of charge to their test facilities and did not require that the jade be returned. A complete list of all manufacturer's researched is detailed in **Appendix V**, along with brief descriptions of their businesses. The most important manufacturers names, addresses, phone and telex numbers and contact names are listed in **Appendix I.** The six manufacturers of equipment identified as best candidates for supplying appropriate integrated equipment included three Italian firms; Breton, Gregori and Pedrini and three German firms; Carl Meyer, Loffler and Hensel. Two of the Italian companies refused to take delivery of the jade after it was shipped and two German companies did preliminary bench scale testing agreeing to do full scale tests if their systems and systems designs looked viable after the preliminary trials, economic evaluations and comparisons. Two manufacturers performed full scale test on the jade. The results of the comparisons are illustrated on **Table I.** The equipment costs listed do not include such items as transportation, set-up costs, training, taxes etc., because such costs were not provided by all manufacturers. Irrespective of which company is chosen as preferred, these additional costs would be incurred.

TABLE I - PLANT COMPARISONS (1,000 FT^2/MO. - 4" X 4" TILES)

PLANT	COUNTRY OF ORIGIN	TILE SIZES PRODUCED 4x4	4x8	6x6	8x8	12x12	SLABS	TILE THICKNESS (4" x 4")	% YIELD FROM RAW BOULDERS	(*3) PRODUCTION COSTS PER FT^2	FACTORY SUPPORT & PARTS AVAILABLE	PLANT AREA (FT^2)	WATER REQUIREMENTS (LITRES/MO.)
BRETON	ITALY	x	x	x	x	x	x	3-5mm	30%	$32.40	FAIR	7,800	4.9 million
GREGORI	ITALY	x	x	x	x	x	x	3-5mm	Approx. 25%	$38.15	POOR	7,500	N/A (Est.approx. 5 million)
PEDRINI	ITALY	x	x	x	x	x	x	3-5mm	Approx. 25%	$35.15	POOR	7,400	N/A (Est. approx. 5 million)
CARL MEYER	W. GERMANY	x	x	x	x	x	x	3-5mm	50%	$22.55	GOOD	4,800	1.5 million
LOFFLER	W. GERMANY	x	x	x	x	x	x	3-5mm (Slabs min. 10mm)	22%	$34.25	FAIR TO GOOD	6,500	N/A (Est. approx. 3 million)
HENSEL	W. GERMANY	x	x	x	x	x	x	3-5mm	40%	$26.52	GOOD	5,200	2.9 million
MOHAWK (*1) (Current Plant)	U.S.A. & CAN.	x	x	x			?	3mm	27%	$97.68	FAIR	3,150	1 million
MOHAWK	U.S.A. & CAN.	x	x	x			x	3mm	35%	$57.95	FAIR	4,800	3 million

(*1) - Based on actual production of 225 ft^2 per month.

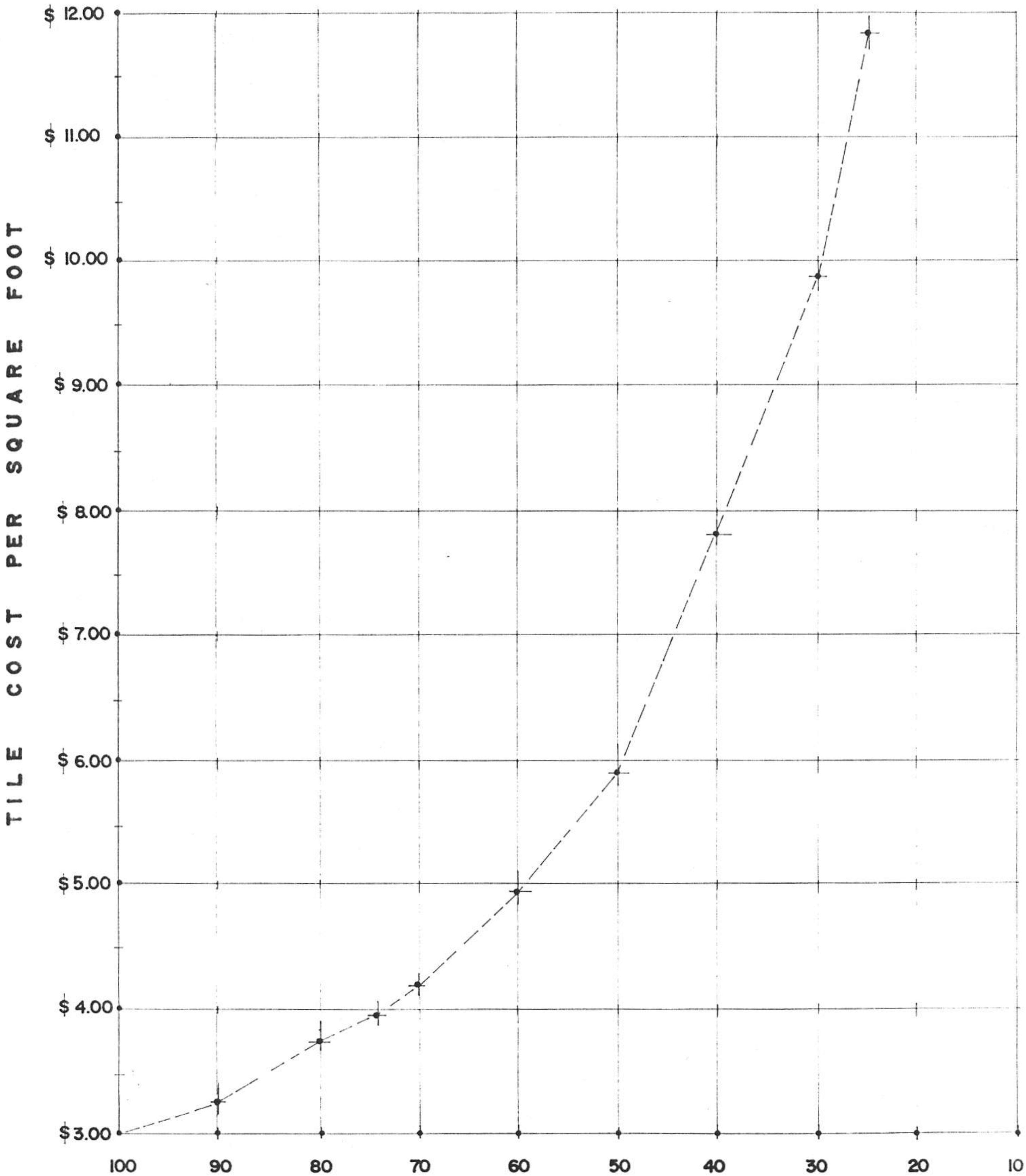
(*2) - Exclusive of freight, taxes, duty, set-up costs, etc. (Complete $CDN. - F.O.B. Origin)..

(*3) - Labour, tools, jade.

TABLE I (cont'd)

PLANT	POWER	NO. OF EMPLOYEES	PRODUCTION RATE (4"x4" TILES)	PLANT SET-UP & TRAINING PROGRAM	BACKING REQUIRED FOR PRODUCTION	TOOLS AVAILABLE	TEST WORK SUCCESS	(*2) EQUIPMENT COSTS	MISCELLANEOUS
BRETON	450 hp 650 kw	7	+2,000 ft^2	YES	YES	FAIR	PARTIAL	$773,300	- Requires boulders be encased in grout - Maximum width of slab 40"
GREGORI	740 hp 510 kw	7-8	Estimate 1,500-2,000 ft^2/Mo.	NO	YES	FAIR	NO	$674,600	- Slabs maximum width of 40" - High water consumption
PEDRINI	620 hp 430 kw	6		NO	YES	FAIR	NO	$910,750	- Slab maximum width 21" - Block saw step cuts, not single pass Allowing thinner blades
CARL MEYER	250 hp 200 kw	4-5	1,720 ft^2/Mo.	YES	NO	GOOD	YES	$742,000	- Can produce 62" wide slabs - Bandsaw operates with segments missing
LOFFLER	261 hp 210 kw	6	Approximately 1,500 ft^2/Mo.	YES	YES	FAIR	NO	$650,000	- Low pressure polisher - Slabs up to 108" wide by 10mm thick can be cut
HENSEL	250 hp 200 kw	5	1,650-1,850 ft^2/Mo.	YES	YES	GOOD	PARTIAL	$510,000	- Cut 18"x12" slab maximum
MOHAWK	65 hp 48 kw	5	225 ft^2/Mo.	N/A	NO	GOOD	YES	$216,550	- Slabs maximum width 21"
MOHAWK	200 hp 145 kw	14	1,125 ft^2/Mo.	N/A	NO	GOOD	YES	$461,550 (total including current plant capital)	

TILE COST VS. JADE RECOVERY - TABLE III



Jade cost = $ 1.50 per lb. Tile = 1/8" thick

5.1 BRETON s.p.a.

Breton's block sawing technology is a vertical, oscillating or reciprocating, multiblade gang saw using a lime slurry and steel shot as a cutting agent. Another possible saw type is a multiblade diamond disc saw. However, the disc saws oan only produce slabs less than one-half the blade diameter (cutting depth of blade) whereas the reciprocating saw, does not have the same limitations. The polishing technique is essentially the same as the others researched with the exception of Carl Meyer who uses a lower pressure process. A schematic of Breton's system is illustrated in **Figure 2** and described in detail below.

STEP 1

Place the jade boulders in a box-like form. Orient the boulders in the same direction, pack as tightly as possible and encase in a cement and sand (soft grout) jacket. Each block to be approximately 1000x2000x1000mm.

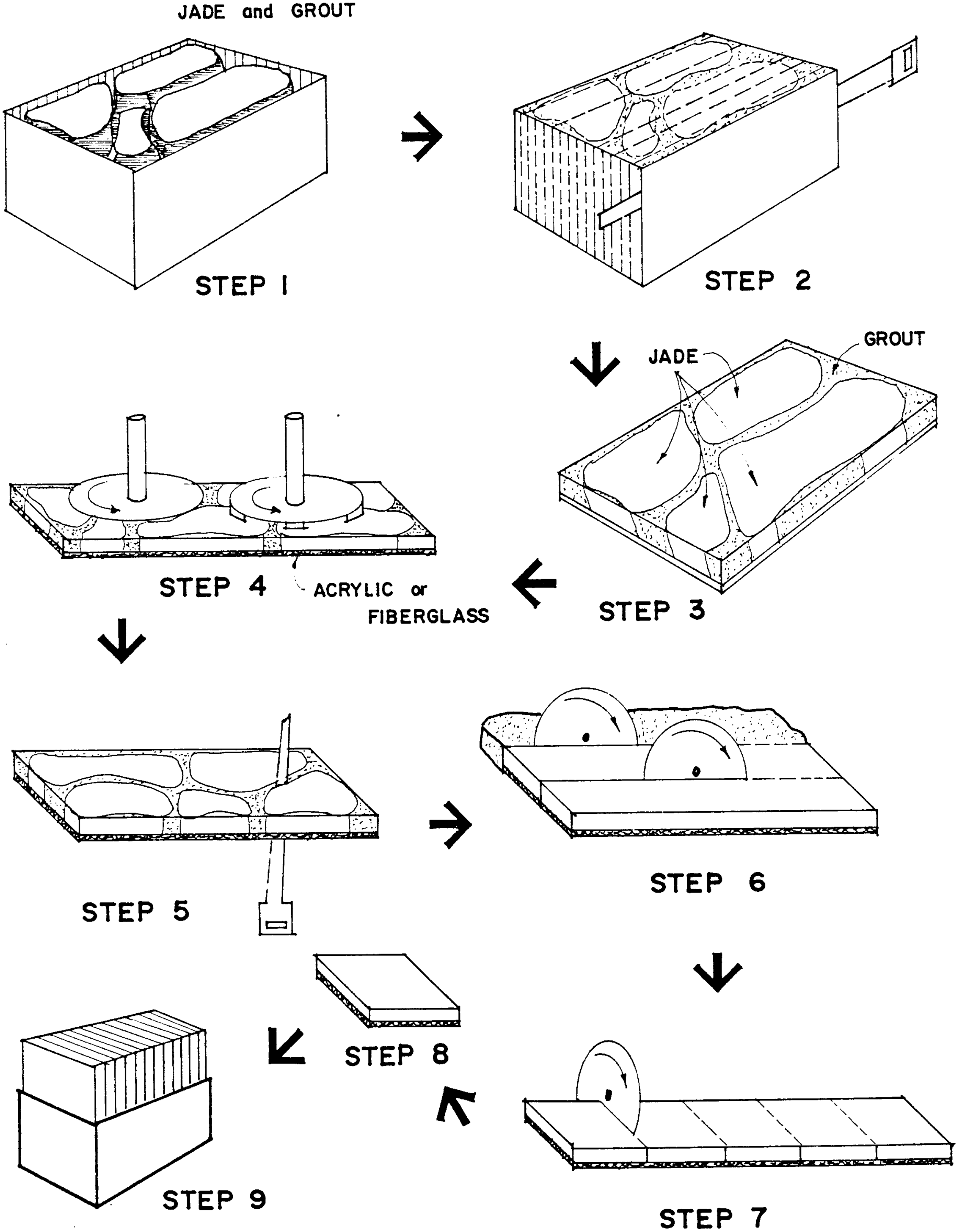
STEP 2

Load blocks under gang blocking saw and cut into slabs. A vertical reciprocating band, gang saw was tested. The steel perforated bands and a cutting slurry of steel shot and lime failed to cut the jade at an acceptable rate, the blades tended to break and the minimum slab thickness was 10mm. The other two saws tested were the oscillating Masterbreton HG and rectilinear Boxerbreton HSE.

A reciprocating, diamond seqmented blade, gang saw, the "Diabreton-HSW" had trouble with segments tearing off, and was considered unacceptable.

A large diameter diamond segmented circular (disc) saw performed, but there was some trouble with segments breaking off. It was found that the boulders still had to be encased in grout. The Ortobreton 4EG or 2EG with up to 8 vertical blades and one horizontal cut-off blade will cut up to 8 blocks automatically, in a step cutting sequence. This system, the most successful, uses approximately 425 l/min. of water and has a total of 182.5 h.p. (140 kw).

BRETON SYSTEM FIGURE 2



STEP 3

Apply acrylic sheet or chop fibreglass to the back of each slab of jade and cement aggregate.

STEP 4

Polish the slabs using a Levibreton KG 40/012. This polisher has 7 vertical spindle grinding heads for dressing (lapping) the slab and 2 heads for polishing. It can polish up to 200 ft^2 per hour. This machine uses 250 l/min. of water and has a total of 140 h.p. (105 kw).

STEP 5

A jig-saw is used (manual) to cut the polished jade slabs out from the jade and cement slabs. This involves cutting only the cement grout encasing the jade.

STEP 6

Strips are then cut from the rough shaped jade slabs using a Breton 190 ADR transversal rectifying saw. This saw will handle up to 7 blades but only 2 are required holding 350mm diameter diamond disc blades. This saw will cut strips up to 2000x400mm and slabs to 7mm thick. This saw has a total of 17.5 h.p. (13 kw) for the spindle motors, push motor and roller motor.

STEP 7

The tile cutting saw DXS/5 cuts the jade strips into tiles using a single diamond disc blade capable of squaring tiles with a maximum dimension of 600x300mm (24"x12"). The tiles are then transported by motorized roller conveyor to the chamfering machine.

STEP 8

The tile edges are chamfered and polished by a Chamfering Breton Model 1BS/28 having a total of 6 h.p.

STEP 9

The tiles are washed, dryed, inspected and packaged.

The Breton process has some flaws or difficulties in the primary (blocking) step where jade losses and tool failure could be high. The polisher relies on high pressures employing a multi-movement head to lap the slabs. This could cause breakage of thin slabs. The polishing process is more expensive than other methods because cement as well as jade is polished. Breton back-up and service is considered the best of the Italian firms researched. At a production rate of 1,000 ft^2 per month a total of seven people would be required to operate the plant. An addition of approximately two people could allow production to increase to more than 2,000 ft^2 of 4x4 inch tiles per month based on a 40 hour work week.

5.2 GREGORI s.p.a.

Gregori is an Italian manufacturer of a complete line of marble and granite slab and tile production equipment. Their primary block sawing technology employs multi-blade circular or disc saws. They do provide a fully designed plant including conveyors and other materials handling devices. Gregori declined to perform any test cutting after the jade arrived in Italy. A schematic diagram of their system is illustrated in **Figure 3** and described below.

STEP 1

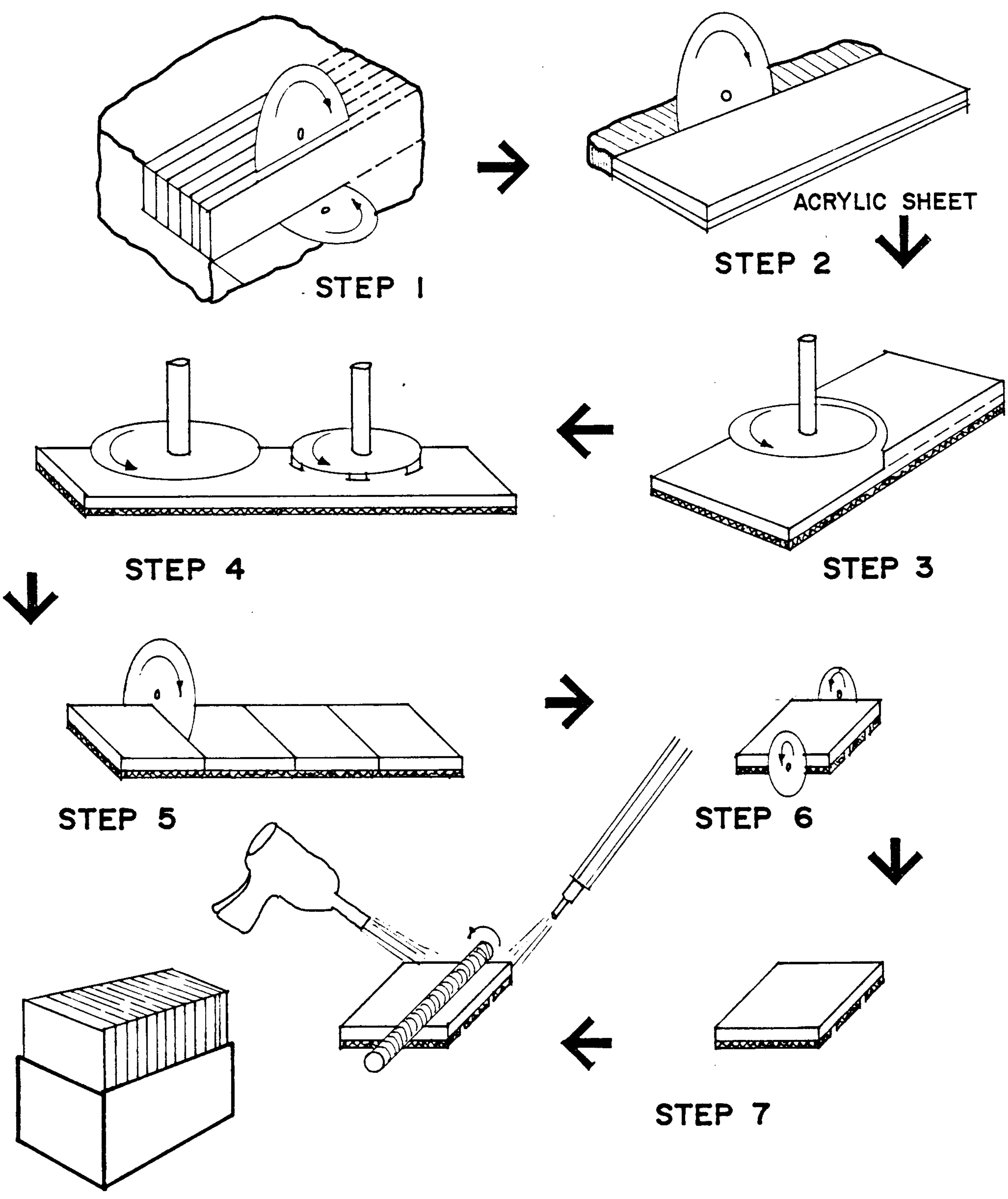
The blocks would have to be secured in a bed of quick drying grout in preparation for sawing using a circular (disc) blocking saw. This saw, a Bufalo-mg, is capable of carrying up to 19 vertical blades in diameters from 600 to 1200mm plus one horizontal, cut-off blade 350-600mm in diameter. This machine will cut slabs from blocks with a maximum dimension of 3500x1800x1800 mm. Minimum thickness of slabs is estimated to be 8mm. This saw has a standard voltage of 380 volts. Total power requirement is 250 h.p. (184 kw). This step requires a carriage for the raw blocks. The cut slabs are transported by bridge crane or some similar device to a deposit area.

STEP 2

The slabs are picked up with an arm crane and stacked on a tilting device which is capable of feeding the Ghepard, automatic squaring sawing machine. This machine squares the two opposite sides of a slab and cuts the slab into strips if tiles are required, to the desired dimension (ie: 4", 6" or 12" wide). A 500mm blade is normally used in this machine. Standard voltage is 380 volts. Power draw is 24 h.p. (16.6 kw).

The strips (or slabs) travel along a free roller conveyor band to the finished slab deposit area where acrylic sheet is applied. From this area the strips (slabs) are fed into the calibrating machine.

GREGORI SYSTEM FIGURE 3



STEP 3

The Polaris 620/30, calibrating machine grinds the strips (slabs) to the desired thickness. It is probable that prior to calibration the jade strips (slabs) would require application of an acrylic backing, (see Step 2) and in fact it may be necessary to apply this backing prior to Step 2. The calibrating machine has three vertical spindle diamond head grinders with a total power of 76.5 h.p. (53 kw). The calibrated strips then travel by a motorized roller conveyor band and/or a motorized tilting device to the polishing machine.

STEP 4

A Vega 620/8+1, polishing machine with 8 planetary polishing heads completes the final polish on the jade strips (slabs). This machine has a total installed 214 h.p. (157 kw). The strips travel along a free roller conveyor band to another motorized roller conveyor and then to a machine for transversal cutting of the strips and along another motorized roller conveyor band, if tiles rather than slabs are to be produced.

STEP 5

A Mini-Super Special, automatic squaring machine complete with hydraulic controls cuts the strips into the desired length (transversal cutting of the strips). This machine carries a 700mm diameter circular blade and has 23.5 installed H.P. (18 kw), as standard. The tiles are then conveyed to the chamfering step.

STEP 6

An Orion, chamfering machine chamfers the edges of the tiles and a Sirio, automatic edge and corner polishing machine finish the edges of the tiles. These two machines in tandem will chamfer tiles of minimum 8mm thick, and have a total installed 27.25 H.P. (20 kw).

STEP 7

The tiles are fed along a motorized roller conveyor band, a motorized curve (to conserve space), to another motorized roller conveyor and into the grooving machine which grooves the bottom of the tiles. The tiles are then moved along another roller conveyor band to the washing and drying sequence.

STEP 8

The final step involves moving the completed tiles along a motorized roller conveyor band to the inspection and packing bench and finished product storage area.

Some Gregori saws are known to be in use in Eastern Canada. Care must be taken that the electrical components and wiring conform to Canadian electrical standards. The circular saws are known to require a lot of water and the losses from the circular sawing and calibrating stages consume a lot of jade in the form of cuttings, (sawdust). Circular saws do not operate very well with segments missing and multi-blade gang saws can ruin slabs if even a single blade failure occurs. In order to cut 3-4mm thick tiles (slabs) the blades will be 3 to 5mm thick. The Gregori plant will produce 1,000 ft^2 per month of 4x4 inch tiles based on a 40 hour work week and seven employees. The addition of two people should allow production of 4x4 inch tiles to increase to 1,500 to 2,000 ft^2 per month.

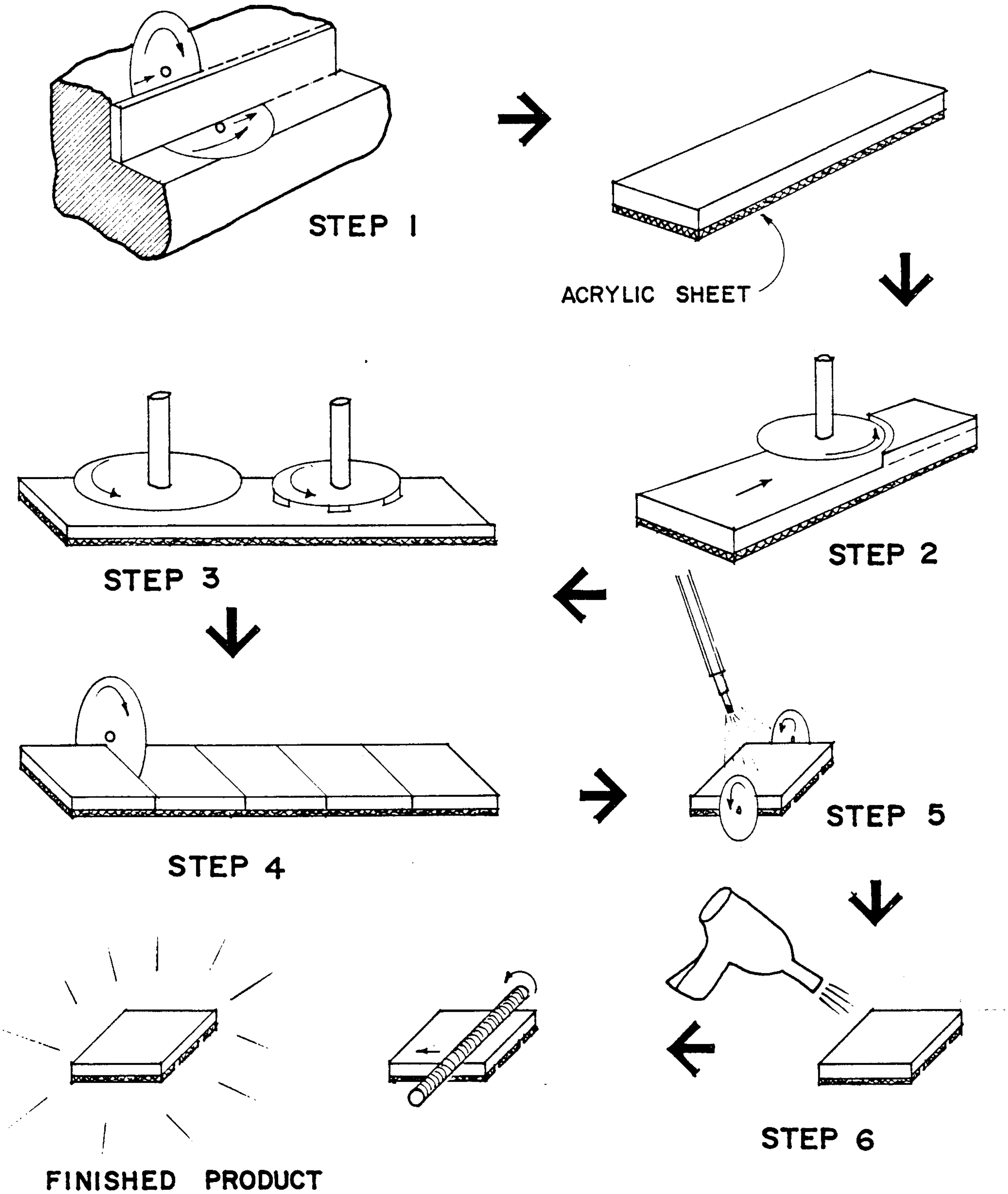
5.3. PEDRINI s.p.a.

Pedrini is an Italian manufacturer of equipment for production of marble and granite slabs and tiles. They employ circular saws for blocking raw boulders and cutting slabs to dimension. Pedrini originally agreed to perform cutting and polishing tests but after studying the jade decided that their cutting technology may require extensive redesign if thin blades and slabs were required. Equipment recommendations for working the jade were made available but overall design of a jade plant was not provided. The equipment listed in each step below and illustrated in **Figure 4**, includes such items as roller conveyors and cranes which would be necessary for a complete plant. The estimated costs of this equipment between the major pieces is $85,000.

STEP 1

This step slices a block into slabs. The block would have to be anchored securely to allow proper operation of the blocking saw. The recommended model is a circular bridge saw with a single vertical and single horizontal blade, Block-cutter Model M535, priced at $202,140. The single vertical diamond disc blade travels along a bridge making progressively deeper cuts until the desired, predetermined depth of cut is reached. Several such cuts are made until enough slices are cut to allow cut-off by the horizonatally mounted diamond disc. The slabs require removal by the operator employing some type of crane. The machine power totals 266 h.p. Maximum cutting depth is approximately 550mm (21 inches), the useful stroke is about 3,850mm and useful cutting width 3,200mm. The slabs would move to a station where acrylic or similar backing is applied to the slabs. Pedrini indicated that the minimum slab thickness would be in excess of 8mm and blade width more than 5mm.

PEDRINI SYSTEM FIGURE 4



STEP 2

After slabbing and acrylic sheet application a Model M541, grinding machine would calibrate the slabs to the desired thickness. This machine is priced at $154,170. This machine comes complete with a roller conveyor at the feed end and three vertical spindle grindling heads, digital electronic thickness control and automatic uniform tool consumption adjustment. The machine has a total installed 122.75 h.p. A motorized roller conveyor band would be required to move the slabs to the polishing machine.

STEP 3

The Model M536, polishing machine with up to 17 vertical spindle polishing heads and plates would polish the slabs. Probably a nine head machine run at slow speed would accomplish the desired polish. The nine head polisher is priced at $294,840. This machine has a total power of 138.5 h.p. A motorized conveyor would be required to move the polished slabs to the next step.

STEP 4

A Model M539 cross cutting machine priced at $24,390 would cut the slabs (strips) to the desired length to produce the final dimensioned product. This single, 350mm diameter diamond disc will cut tile lengths from 125mm to 800mm and to widths of 510mm; total power is 10.5 h.p. A motorized conveyor would feed the tiles to the chamfering machine.

STEP 5

The Model M538/G-3, chamfering machine bevels the tile edges, polishes the edges, grooves the tiles, washes, blow dries and buffs the finished tiles for packaging. This machine is priced at $150,210. All motors for this step total 44.25 h.p. A packaging table is included as part of this equipment.

Pedrini did not quote on a plant for manufacturing jade, thus granite tile and slab manufacturing equipment was considered appropriate. The Pedrini plant would be capable of producing an estimated 5,000 ft^2 per month of granite tiles and slabs and approximately 4,000 ft^2 per month of 4x4 inch granite tiles. It is estimated that this equipment would produce 3,000 to 3,500 ft^2 per month of 4x4 inch jade tiles based upon an 8 hour day, 5 day week. At full production the plant would require approximately nine people, although the addition of extra equipment at an added cost of approximately $98,000 would reduce the number of people. At a production rate of 1,000 ft^2 per month of 4x4 inch jade tiles approximately six people would be required in the plant. The capital cost of equipment including turntables, roller conveyors between machines would be about $910,750.

5.4 CARL MEYER

This West German manufacturer of stone cutting and polishing machines provides the most comprehensive service of any manufacturer approached for test cutting and polishing. They provide complete engineering and plant design support and are considered superior for equipment design, technical support and overall performance. Carl Meyer provided very detailed information on plant specifications, estimated tool costs, water and power consumption. Their recommended system is a five step sequence using five primary machines for blocking, cutting, polishing tiles and slabs and chamfering tiles. Carl Meyer expects to have a complete line set-up by December of 1986 for full scale continuous production testing. Test work to-date was conducted at several locations where their equipment is operating. Details on the Carl Meyer system is described below and illustrate in **Figure 5.**

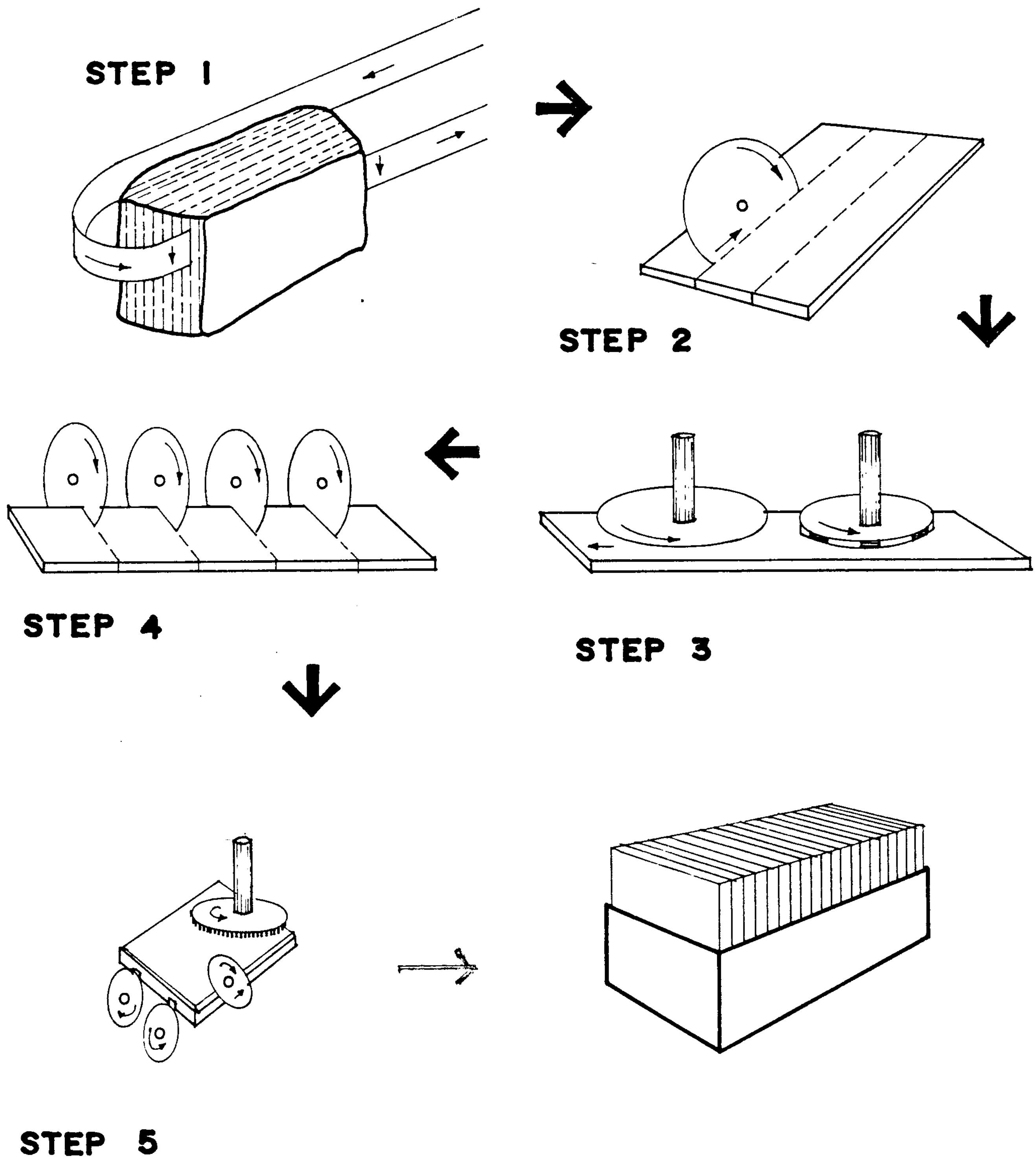
STEP 1

Carl Meyer manufactures and actually tested several saw types including a diamond disc saw before recommending their unique bandsaw, Model 463K. This fully automatic, diamond segment bandsaw, will cut slabs as thin as 4mm and up to any desired thickness making it an ideal slabbing and blocking saw. It uses at least 30 percent less water than any equivalent blocking saw. The saw is quiet, low pressure and can operate with diamond segments missing from the band. This results in low jade losses from cutting and substantially lower tool costs (estimated at 1/2 reciprocating or circular (disc) saws) than other saws designed for blocking or slabbing. The band does not deflect when initiating a cut or during cutting. This allows the first cut to be started close to the boulder edge. The band does not require regular "tensioning" necessary for large diameter diamond disc blades.

The following is a summary of the technical data for this saw:

1. Will cut blocks up to 2200mm long and 1600mm high
2. Sawblade kerf loss is 4mm

CARL MEYER SYSTEM FIGURE 5



3. Will cut 1.2 m^2 per hr. (12 ft^2 per hr.) This translates to approximately 2000 ft^2 per month based on a 5 day, 8 hour per day week.
4 Production on a one shift per day basis (5 day work week can be expanded to 3200 ft^2 per month with the addition of a second turntable (approximate cost $30,000).
5. Tool costs to cut jade (diamond segments and band consumption) is estimated at $26.50 per m^2 ($2.50 per ft^2).
6. Power requirement is 21 h.p. (16 kw).
7. Space required - 7.5m long
5.0m high
4.5m wide
8. Uses 100 litres of water per minute (1½" water line).
9. Foundation requires 1.6 m deep concrete on each side of saw.
10. Price F.O.B. West Germany including pallets, oil system and other extras $415,000.

STEP 2

This step squares up the slabs and produces strips up to 2000x1200mm using a diamond disc Bucking Saw, Model 442. This saw will accept 300, 350 or 400mm blades which will cut to a depth of 70 to 120mm. The strips move along a motorized roller conveyor to Step 3. Technical data for the saw are:

1. Power total is 6 h.p. (4.4 kw)
2. Requires 6 atu of compressed air
3. Cuts 20 linear metres per hour. This is approximately 16 ft^2 per hour of 4"x4" tiles
4. Tool costs are estimated at $10.50 per m^2 ($1.00 per ft^2)
5. Price including conveyor and conveyor drive $17,000.

STEP 3

The slabs (strips) are polished in this step using an eight head, vertical spindle, low pressure polisher, Model 306 G/8, complete with a 6 metre long conveyor. The high speed heads will grind and polish thin (3mm) slabs without any backing on the slabs. Details on this machine include:

1. Total power is 120 h.p. (90 kw).
2. Tool costs estimated at $8.40 per m^2 ($ .80 per ft^2).
3. Machine will lap and polish 5 m^2 per hour (52 ft^2/hr.), but the feed rate can be adjusted according to the whole line production rate which should result in a tool cost reduction.
4. Machine, including conveyor is priced at $133,000.

STEP 4

A motorized conveyor will convey the polished strips to this step if tiles are desired rather than slabs. The machine at this step is a multiblade cross-cutting circular diamond saw, Model 452, used for cutting the polished strips into tiles. This machine will hold four disc blades and comes complete with 2 meters of roller conveyor and an extra transferable blade (disc) shaft. This machine:

1. Will cut 80 running metres per hour which translates to approximately 40 ft^2 per hour of 4"x4" tiles.
2. Has an installed 30 h.p. (22 kw).
3. Will have tool costs estimated at $1.00 per ft^2 ($10.50 per m^2).
4. Cost is $30,000.

STEP 5

After the tiles are dimensioned in Step 4 a finishing machine similar to Carl Meyer's Model 390 grooves and calibrates the tile, bevels and polishes the edges and then washes, dries and buffs the finished tiles. This machine comes complete with a turntable so that all four edges are chamfered and polished.

Details for this machine are as follows:

1. Total installed power is 27 h.p. (20 kw).
2. Tool costs are estimated at $0.21 per running metre of tile edge (0.5¢ per inch). For a 4"x4" tile the cost is $0.08 per tile or $0.78 per ft^2.
3. Ninety linear feet of tile edge per hour can be processed. This is a production rate of 7.5 ft^2 per hr. for 4"x4" tiles or about 1300 ft^2 per month.
4. Equipment cost quoted at $82,000.

Carl Meyer estimated equipment costs between machines such as conveyors, cranes, etc. would be an additional $65,000 bringing the total capital cost comparable to the other manufacturers for a similar plant to $742,000.

Detailed power cost estimates were possible from the information provided by Carl Meyer for a 1000 ft^2 per month plant manufacturing 4x4 inch tiles:

STEP 1:	83	hrs. per month x	16 kw =	1328 kwh
STEP 2:	63	hrs. per month x	4.4 kw =	277 kwh
STEP 3:	20	hrs. per month x	90 kw =	1800 kwh
STEP 4:	25	hrs. per month x	22 kw =	550 kwh
STEP 5:	133	hrs. per month x	20 kw =	2660 kwh
MISC:	133	hrs. per month x	10 kw =	1330 kwh
TOTAL/MO.	**457**	**HRS**	**162.4KW**	**7945 KWH.**

As outlined on **Table I** - Carl Meyer had superior performance in 11 out of a possible 15 categories:

1. Thickness of tile/slabs produced is 3 to 5mm.
2. Yield from the raw boulders estimated at 50 percent.

3. Production costs for labour, tools and jade estimated to be $22.55 per ft^2.
4. Appraisal of factory/parts support considered superior.
5. Plant area requirements - 4,800 ft^2.
6. Water requirements - 1.5 million litres per month.
7. Power requirements total about 200 kw.
8. Number of employees required is at least 4 to 5.
9. Training provided.
10. Test work success.
11. Backing on tiles or slabs not required for production.

In the remaining four categories Carl Meyer's only negative aspect is the higher capital cost of the equipment and this higher capital cost is mainly attributable to the bandsaw which accounts for more than one-half of the $742,000 in capital.

5.5 LOFFLER - Maschinenbau oHG

This West Germany company manufactures a full line of stone cutting and polishing equipment. However, they do not manufacture a tile finishing machine to chamfer, groove and clean the tiles. The engineering and design support is not considered as good as the other two German companies and Breton's engineering support is also considered superior to Loffler, although Loffler's after sales support and parts availability is probably better than Breton. Loffler's primary technology for blocking the jade and cutting tiles and slabs are circular (disc) type diamond saws. An interesting difference from other manufacturers is the blocking saw. The saw blade and power head for the blade is fixed on a bridge and the bed holding the block to be cut moves back and forth.

STEP 1

The recommended blocking saw is a circular bridge saw, Model TS 3000 G. As already mentioned the 3000mm diameter diamond disc blade is fixed on this machine. This saw blade takes a 12mm wide kerf. Loffler recommends cutting slabs the width of the tile to be produced (ie: for 4x4 inch tiles cut slabs slightly more than 4 inches thick). Jade losses at this step are estimated at 1/3 of original weight.

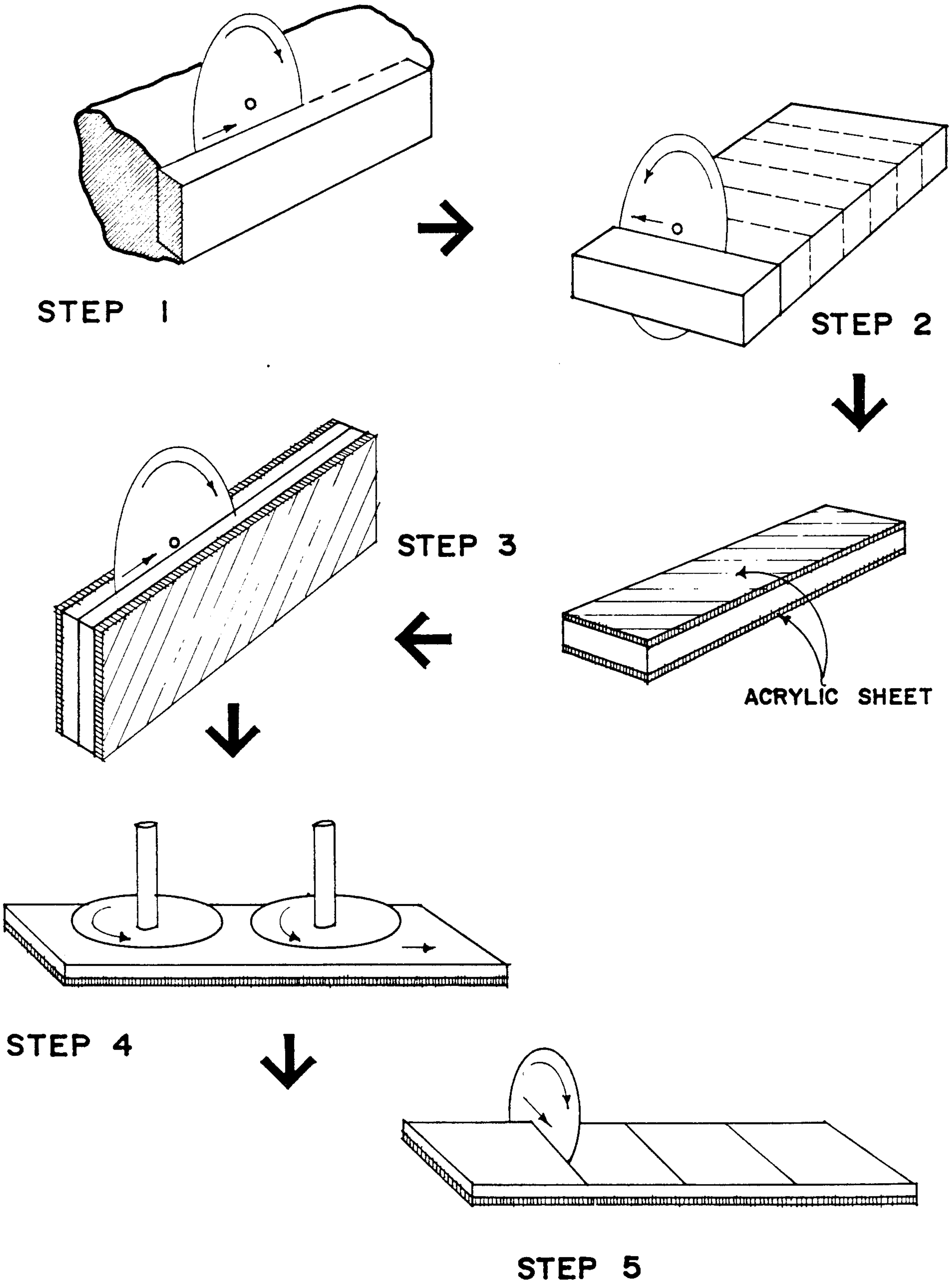
The Model TS 3000G:

1. Has a total installed 78 h.p.
2. Has full electronic control
3. Costs $169,500.

STEP 2

A circular (disc) cutting saw holding a 1000mm diameter by 8mm thick diamond blade cuts the tile width slabs (ie: 4 inch slabs for 4x4 tiles) into blocks twice the final jade thickness (2x3mm) plus the kerf loss

LOFFLER SYSTEM FIGURE 6



in Step 3 (6mm). The resultant 12mm thick slab then has acrylic sheet equal in thickness to the finished tile thickness less the final jade thickness bonded to the two opposing sides which will eventually be on the bottom of the finished tile. An estimated loss of 40 per cent to saw kerf is suffered at this stage. The recommended saw is a Model TB 1000 Bridgesaw which has a fixed carriage for the slab and a moving bridge. An automatic option can be obtained for this saw. Saw details are as follows:

1. 20 h.p. motor
2. Saw holds a 1000 mm diameter blade (disc) approximately 8mm thick.
3. Price $99,300.

STEP 3

A circular (disc) diamond cutting saw, Model TB 800, fully automatic, bridge saw, holding a 800mm saw blade, slices the acrylic backed slabs longitudinally. The resultant two acrylic backed strips the desired tile width are then ready for polishing (Step 4). The TB 800 saw is essentially a smaller version of the saw used in Step 2. Details are as follows:

1. Saw blade 800mm diameter, width approximately 6mm.
2. Motor is 25 h.p., 18.5 kw.
3. Price, including automatic bridge control $80,000.

STEP 4

The acrylic backed strips are polished by an 8 spindle, Model FS 30, polisher. This polisher will polish up to 300mm wide slabs, relying on high pressures which would probably break unbacked, thin jade slabs. The Model FS 30 polisher:

1. Has a total installed 64 h.p. (44 kw).
2. Costs $125,600.

STEP 5

The polished strips are dimensioned to the desired length by a Model KS 30/600, cross-cutting saw equipped with a 600mm diameter diamond disc blade. This saw will cut slabs (strips) up to 60mm thick. The Model KS 30/600:

1. Has an installed 4 h.p. (3 kw)
2. Costs $23,500

Loffler does not manufacture a finishing machine for bevelling, buffing and cleaning the tiles. The cost of this type of machine and additional equipment installed between machines for moving the material is estimated at an additional $165,000. An estimated six people would be required to operate the plant. Total tool costs are estimated at $8.50/ft^2$ for production of 4x4 inch tiles.

5.6 HENSEL

Eisenwerk Hensel Bayreuth, a West German company, manufactures stone cutting and grinding equipment. They employ circular (disc) diamond saws for cutting hard minerals such as granite and jade. Hensel has recommended a tile production system similar to the ourrent Mohawk procedure, but without the "billet" grinding stage or the initial slabbing stage. Hensel's eight step plan, illustrated in **Figure 7**, takes the jade from the raw boulder to the finished, packaged product. Their price quotation did not include necessary intermediate equipment such as roller conveyors or cranes. The plant is not very automatic and would probably require more than the four operators suggested as minimum by the manufacturer.

STEP 1

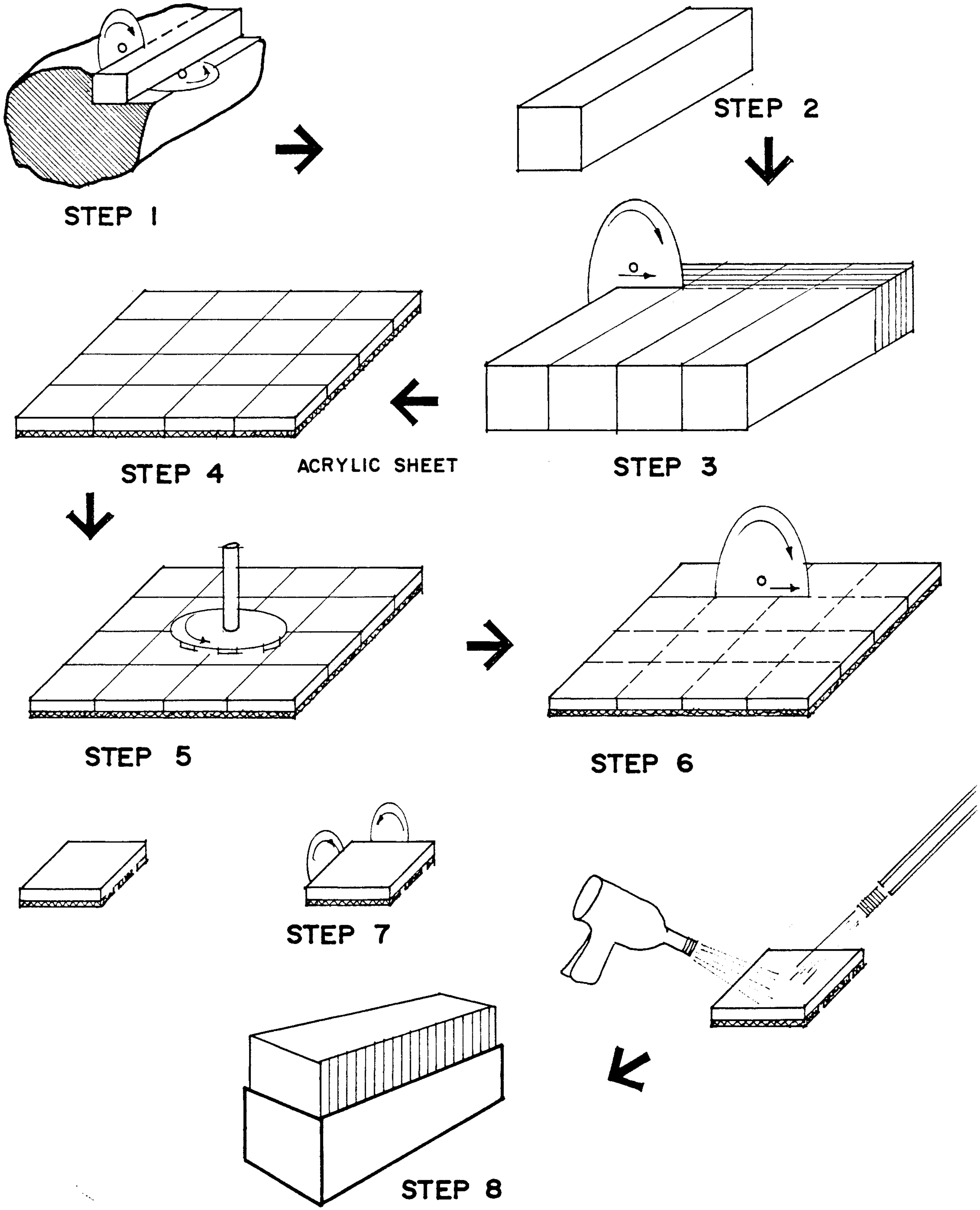
The rough jade boulders are cut into billets of the appropriate dimension, depending upon the size of tile to be produced. This is accomplished with a Model 55W, angular cut saw. This saw has one vertical diamond disc 1000mm in diameter and one horizontal 800mm diameter diamond disc. This saw costs approximately $206,100. Technical data on the Model 550W:

1. Water consumption approximately 30 l. per min.
2. Total installed power approximately 94 kw but variable for horizonal and vertical blade motors.
3. Can be designed for fully automatic operation, but not quoted as such for this study.

STEP 2

An overhead crane, costing an estimated $5,500 or a fork lift would move the billets to an interim storage area where the billets would be fixed in a bed of plaster, several billets beside eaoh other. These billets would be mounted on a concrete table which would go under the circular saw, Model 511/III.

HENSEL SYSTEM FIGURE 7



STEP 3

A diamond disc saw, Model 511/III would cut tiles the desired thickness (3 to 5mm) from the billets cemented together. This gantry type saw is capable of cutting mitre as well as vertical cuts. It would be equipped with automatic controls and would require installation of a concrete table. This saw can be set-up to have the work fed through on rollers. Technical specifications are as follows:

1. Price $76,600
2. Saw blade 400 to 800 mm diameter
3. Maximum output 1.2 m^2 per hour (12.5 ft^2/hr.) or approximately 2000 ft^2 per month.

STEP 4

Individual tiles are removed from the saw at Step 3, (Model 511/III) and cemented to plexiglass or acrylic sheet to reach their final thickness. The tiles would be placed in a template to ensure that the last sawing step, (Step 6) would produce tiles of the exact dimension required. It is recommended that the gap between single tiles should be a little less than the thickness of the sawblade at position 6. The slabs of backed tiles would measure approximately 10 to 40 ft^2.

STEP 5

The sheets of backed tiles would be transported by travelling crane and a vacuum suction device to the grinding and polishing step. A Model 503 e, single head grinding and polishing machine would lap and polish the multi-tile sheets. It is expected that an eight stage lapping and grinding operation would be required. This would mean changing the head 8 times by hand to achieve the desired polish. The tool costs at this stage are estimated at about $8.40 per m^2 ($0.80 per ft^2). The machine cost is $84,000.

STEP 6

The polished tile-slabs would be transported by roller conveyor or overhead crane and vacuum suction device to the final sawing stage where a circular saw Model 541, would perform the last cuts on the tiles. This saw would perform the necessary first cuts automatically and then the turntable would turn exactly 90 degrees and the last cuts performed. This single disc diamond bridge saw costs $70,000.

Hensel did not quote prices or equipment for chamfering, cleaning or grooving the tiles. They estimated 120 kw of total installed prower for their machines plus any additional power required for cranes, conveyors, the final chamfering and tile finishing etc. Their equipment would require 150 l. per min. of water and 50 l. per hr. of compressed air. The chamfering grooving and washing is expected to require 130 l. per min. of water. It is expected that a total of five people would be required to operate the plant including a chamfering, grooving and cleaning stage.

5.7 MOHAWK

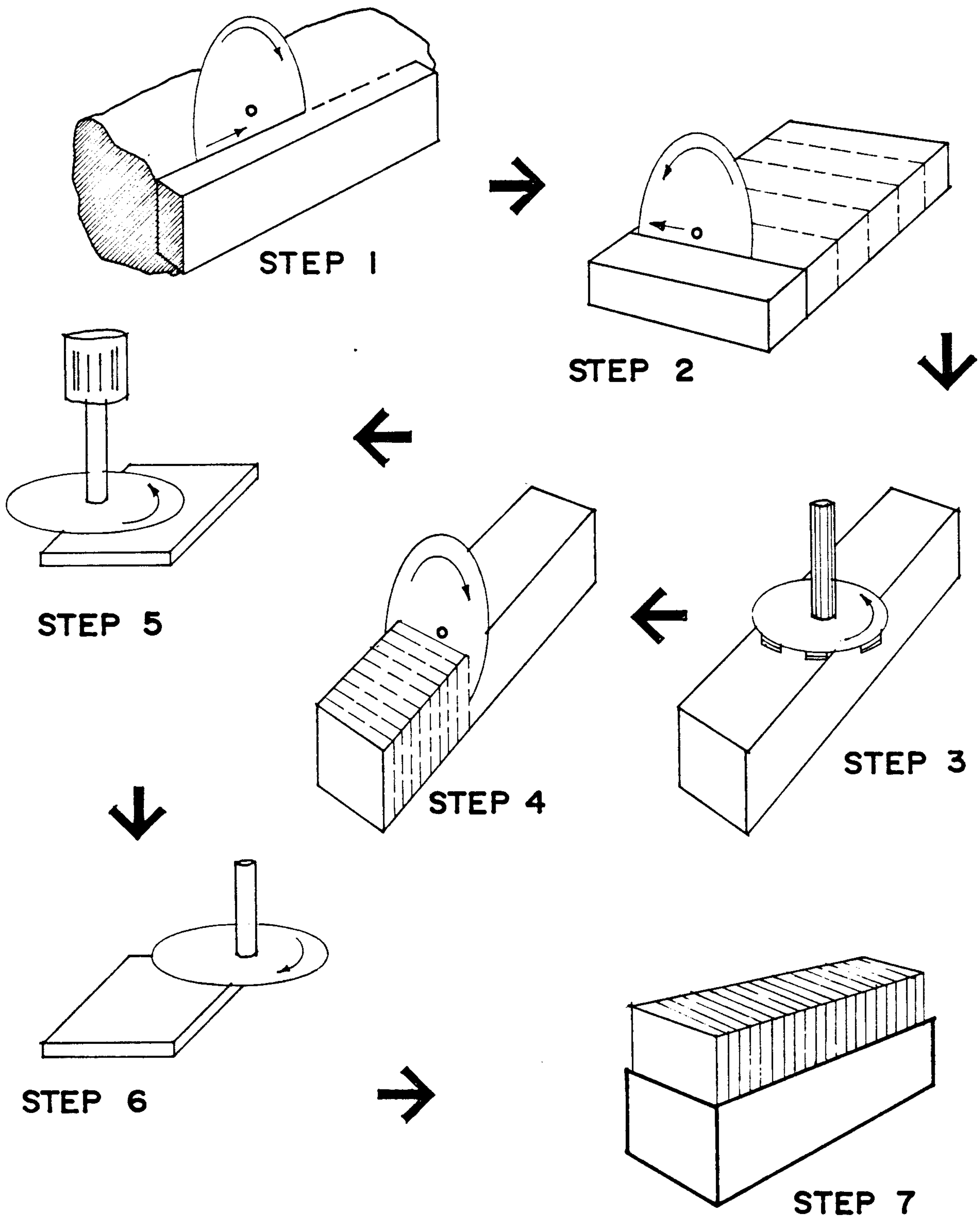
The Mohawk System of tile manufacturing was developed from technology used in the lapidary and silicon chip industries. The plant was constructed as a research and development project for the manufacture of 4x4 inch square jade tiles. The tiles produced were then to be introduced to the market and marketing data collected. An initial designer net sale price of $14.50 (U.S.) and showroom cost (wholesale) of $10.80 were established. These prices in no way reflected the actual production costs for the tiles. These costs were considered to be much higher at a pilot plant scale then they would be once commercial production was established, after collection and analysis of the market research data. The basic tile manufacturing system employs circular (disc) type diamond saws, machine shop type grinders and lapidary type lappers and polishers. There is not provision for grooving, chamfering or buffing the tiles in the process.

5.7.1 CURRENT PLANT CONFIGURATION

Mohawk's tile manufacturing sequence was developed from known jade cutting techniques, the lapidary industry and the silicon chip industry. The steps in the sequence were performed in various geographic locations. The rough jade boulders were cut into billets in Vernon where the main Mining Division office was located. The billets cut in Vernon from rough boulders were precision ground on a custom basis in Vancouver and the tiles cut from these billets in our own plant located in San Jose, California. There were several reasons for having the manufacturing steps in such diverse locations, including duty considerations.

The high production costs associated with this pilot scale plant led to the decision to study the feasibility of manufacturing tiles at a much lower cost. The market information that had been gathered since inception of the tile manufacturing indicated that significant sales increases could be anticipated if the price of the tiles could be reduced. The plant as set-up is capable of producing between 200 and 250 ft^2 of 4x4 inch 1/8 inch thick jade tiles per month. No other tile sizes have been produced by Mohawk, although the equipment is probably capable of also manufacturing 4x8 and 6x6 inch tiles.

MOHAWK SYSTEM FIGURE 8



STEP 1

The rough boulders are cut into slabs slightly more than 4 inches thick using a circular 48 inch diameter diamond segmented hydraulic bridge saw of Mohawk's own design. The blade moves along the bridge using a gear advance mechanism driven hydraulically. The bridge can be advanced manually for each successive slab. However, the jade boulder often must be moved because the saw is limited to a cutting depth of about 21 inches.

STEP 2

The 48 inch diameter saw used in Step 1 is used again in Step 2 to cut the slabs into billets slightly greater than 4 inches square. A total of approximately 70 linear feet of billets are produced monthly. This is sufficient to produce about 225 ft^2 of 4x4 tiles. The cost of tools, labour and consumables for Step 1 and 2 is about $12.70 per ft^2. The billets are than crated and shipped to the custom grinding plant at a total cost of $0.90 per ft^2.

STEP 3

The rough billets are precision ground to exactly 4x4 inches and square. A vertical spindle grinder is used for this process. Mohawk purchased such a machine in 1985 at a cost of $60,000 but it has never been set-up or used to grind billets. This used grinder is a, MAS Model BRV 70. It has an installed 40 h.p. (55 kw), requires 100 litres/min. of coolant and is probably capable of grinding enough billets to supply at least 1000 ft^2 of 4x4 inch tiles per month. The cost of custom grinding the billets is $18.27 per ft^2 of 4x4 inch tiles. Freight and duty on the billets to San Jose totals $7.56 per ft2.

STEP 4

The slicing machine, a DO ALL, Model 70 1/D Micro Slicer, equipped with a diamond disc blade cuts tiles from the billets. This machine will handle 14" to 18" diameter blades and is capable of cutting a maximum of 225 ft^2 per month of 4x4 inch tiles. This machine does not cut as accurately as desired, has high kerf losses (approximately 4mm per cut) will cut a maximum 4 inch billet and requires an operator almost full time. This machine was set-up in the California plant. The billets are glued on plates prior to cutting.

STEP 5

The tiles are placed on the lapping table, a Speedfam Model SNF 48 BTAW, lapper which is capable of lapping 48 - 4x4 inch tiles at one time in about 10 minutes. This is 2,750 ft^2 per month actual production. This machine requires an operator, when operating at 2,000 tiles per month, approximately one half time.

STEP 6

The lapped tiles are carried to the polishing section where 2, Speedfam Model SNG 32 SPAW, polishers polish the tiles to a mirror finish. Each polisher will hold 12 - 4x4 inch tiles and is capable of polishing approximately 1,000 ft^2 per month, a combined 2,000 ft^2 per month of actual production. One person operates two polishers plus inspects tiles at 2,000 tiles (225 ft^2) per month production.

STEP 7

The polished tiles are removed from the polisher, sorted cleaned, inspected and packaged for storage or shipment.

The total cost breakdown is illustrated in **Table II**. The total cost of Steps 4 through 7, is $47.75 for labour, maintenance and tools per ft^2. The labour increment is $33.00 per ft^2. Labour, tools and jade costs total 97.68 per ft^2, which is the comparable figure to the other manufactures described and compared in the report, including the **Table I** comparison. Actual costs of operating, not including overhead and administration total $115.71 per ft^2. The Mohawk plant employs a total of five people.

TABLE II

MOHAWK PLANT COSTS

	ITEM	CURRENT COST PER FT^2 ($)	IMPROVED COST PER FT^2 ($)
1.	Labour for blocking (cutting billets) (Steps 1 to 2)	7.90	7.90
2.	Labour for cutting and polishing (Steps 4 to 7)	33.00	17.50
3.	Tools and consumables (Steps 1 to 2)	4.80	3.85
4.	Tools and consumables (Steps 4 to 7)	14.25	11.40
5.	Grinding billets	18.27	6.05
6.	Freight and duty	8.46	2.75
7.	Cost of Jade @ $1.50/lb. - Vancouver	11.00	8.50
SUB-TOTAL (labour, tools, jade)		**97.68**	**57.95**
8.	Miscellaneous Costs (rent, depreciation, utilities)	18.03	7.85
TOTAL OPERATING COSTS (exclusive of administration & overhead)		**$115.71**	**$65.80**

5.7.2 MOHAWK PLANT IMPROVEMENTS

Mohawk's current pilot plant costs total approximately $98.00 per ft^2 to manufacture 4x4 inch jade tiles exclusive of rent, depreciation, utilities overhead and administrative charges **(Table II)**. Assuming a modest overhead and administrative charge of 20 percent, the actual manufacturing costs are probably about $140.00 per ft^2. Several areas in the manufacturing process can be identified which could be modified to reduce the manufacturing costs:

1. Increase the production rate from the current 225 ft^2 per month while maintaining labour costs or allowing incrementally small labour increases in order to take advantage of economy of scale and maintaining fixed cost levels.

2. Reduce freight and duty charges for transporting billets.

3. Improve recovery (yield) of jade from boulders.

4. Reduce or eliminate grinding costs for billets.

Some of the economies outlined above would involve:

1. Purchase five additional slicing machines at a cost of about $105,000. This would involve hiring an estimated three additional employees, but would increase production at Step 4 of the process to about 1,125 ft^2 per month. Purchasing one, large automated saw would probably be more appropriate. The total cost would be similar but only one additional employee would be required.

2. Increased production would also require purchasing three more blocking saws at a cost of about $100,000 and require three more employees. Improved sawing techniques would reduce billet grinding costs and improve jade yield to an estimated 35%.

3. One additional large polisher capable of polishing 8x8 tiles would allow production at Step 6 to attain about 1,250 ft^2 per month of tiles larger than 4x4 inch. The estimated capital cost is $40,000; two additional employees would be required at Steps 5, 6 and 7.

4. The vertical spindle surface grinder could grind the billets square and to dimension. A required 280 linear feet of billets would have to be ground to produce 1,000 ft^2 of finished tile. Tools, power and consumables would cost an estimated $1.50 per ft^2 of tile ($5.36 per linear foot of billet). One employee would be required to operate this machine.

5. Buying consumables in bulk is expected to result in a 20% reduction in tools and consumables costs.

6. Duty into the United States should be not more than 5% of the declared value (manufacturing costs). This duty reduction may require Federal and Provincial Government assistance.

A detailed cost comparison of the current and improved Mohawk System is illustrated in **Table II.** If all improvements could be implemented there would be a 40 percent reduction in labour, tools and jade production costs and a 43 percent reduction in costs if rent, depreciation and utility costs are included. However, these reduced costs still do not meet the target retail price of less than $100.00 per ft^2. The labour, tools and jade costs for a plant would have to be in the $35.00 to $40.00 per ft^2 range or less to meet the target pricing criteria.

6. PREFERRED MANUFACTURING SYSTEM

In order for a system to qualify as a candidate for consideration, the labour, tool and jade costs of production of 4x4 inch tiles must be $35.00 to $40.00 per ft^2 or less. The current or modified Mohawk Systems do not qualify on this basis, primarily due to the high labour costs associated with this manufacturing process. All other equipment manufacturers meet the cost criteria. Fifteen separate criteria including production costs were identified as being most important in assessing and comparing the various equipment manufacturers. These criteria and the manufacturers' performance are summarized on **Table I.** Carl Meyer performed best in six of the fifteen categories including cost of production and performed very well in another five categories. The other manufacturer that rated well was Hensel. This manufacturer was rated best in the equipment cost category and second best or equal to Carl Meyer in five other categories. However, the capital cost differential between Carl Meyer and Hensel would be equalized in four years or less by the lower operating costs forecast for the Carl Meyer plant. Moreover there are several unique benefits to be derived from the Carl Meyer plant:

1. The bandsaw Model 463K will cut thin slabs (3-5mm thick) and produce large slabs (2200mmx1600mm).

2. Bandsaw kerf loss is approximately 1/2 any comparable system.

3. The bandsaw is quiet, requires approximately 10 percent the power of some comparable systems, uses about 30 percent less water, and has tool costs about one-half any comparable system.

4. The bandsaw is also ideal for blocking jade for sale as bulk since it can cut slabs of any thickness down to about 4mm.

5. The bandsaw blade does not deflect when starting a cut, can operate with diamond segments missing and does not require continual tensioning.

6. Acrylic or similar type of backing is not required for production of tiles or slabs, although for some applications it would probably be appropriate.

7. The total power requirement for the plant is low (an estimated 200 kw). This will reflect directly on the cost of energy and the demand charge, which is a fixed charge dependent upon installed, operating horsepower.

8. Total water requirements are about one-half the closest competitor (Hensel). This will be reflected in lower water charges and the most inexpensive water reclamation and filtration system.

9. Carl Meyer's engineering design and factory support is considered superior and after sales support is also expected to be excellent.

6.1 DETAILED COST ANALYSIS - CARL MEYER

As outlined in **Table I** the basic plant equipment cost is estimated at $742,000. However, there are other costs which would be incurred irrespective of the equipment manufacturer chosen. Therefore, these cost were not considered in the cost comparison but will be real costs incurred never-the-less.

1. CAPITAL COSTS

Equipment for tile manufacture	$ 742,000
Installation, airfare, training - Carl Meyer	21,000
Freight, taxes etc.	88,000
Miscellaneous other equipment	100,000
Building renovation	50,000
Contingencies	150,000
TOTAL	**$ 1,151,000**

2. OPERATING COSTS (4x4 inch tile production @ 1000 ft^2 per mo.)

Tools	6.08
Jade (@ $1.50 /lb.)	5.95
Labour	10.52
Electric power	1.70
Water reclamation & consumption	.50
Rent ($5/$ft^2$/yr)	2.00
Miscellaneous	2.50
Amortization and depreciation @ 10%/yr.	9.59
TOTAL	**$ 38.84**

The economics of the project are enhanced when one considers that:

1. 4x4 inch tiles have the lowest production rates and the highest associated tool costs. Other size tiles should be less expensive to produce.

2. The plant is capable of producing 1,720 ft^2 of 4x4 inch tiles monthly. This production rate will result in lower unit costs.

3. Revenues will be realized from bulk jade liberated as part of the tile manufacturing process.

4. Other jade products are likely to be manufactured using the same equipment required for tile manufacture.

7. PLANT SITE SELECTION

Selection of a site for the proposed tile manufacturing plant is to be made on the basis of several operating and economic factors including:

1. Marketing considerations for tiles, slabs and bulk jade including access to domestic and international markets. Convenience of the plant and products to customers are considered important.

2. Transportation costs of raw materials from the minesite and finished products to the customers.

3. Suitable land and building costs and availabilities.

4. Utility availabilities and costs including power, water, sewer, garbage disposal, effluent disposal, etc.

5. Government assistance programs available in alternative locations.

6. Taxation rates in alternative locations.

7. Operating considerations including weather conditions in alternative locations.

8. Availability of skilled or technical labour force.

Based upon the above criteria two areas of the Province were considered for the plant location; a northern location on the transportation route from the minesite having a relatively moderate climate and a Lower Mainland location. Terrace stood out as the best candidate for the north and the municipality of Surrey, Langley or Delta are probable southern B.C. locations. Central interior cities such as Prince George were eliminated due to severe winter weather conditions.

7.1 TERRACE

Communities in North Central British columbia have organized the Northern Development Council operated by Pacific Congress Projects Corp. located at:

638-999 Canada Place
VANCOUVER, B.C. V6C 3E1

<u>ATTENTION:</u> Jim Davidson
PHONE: (604) 683-0401
TELEX: 04-54244

Information was received from the Northern Development Council, the City of Terrace and Kitimat. For information on Kitimat the contact is:

Brian Mayhew
Director of Planning, District of Kitimat
270 City Centre
KITIMAT, B.C. V8C 2H7

PHONE: (604) 632-2161
TELEX: 047-84515

Terrace contact is:

Robert Greno, City Director
The City of Terrace
3215 Eby Street,
TERRACE, B.C. V8G 2X8

PHONE: (605) 635-6311
1-800-772-9886

Information on Terrace, Kitimat and vicinity was gathered from all the above sources. Information on Federal, Provincial and Municipal grants were acquired from these same sources plus the Department of Regional Industrial Expansion and the Ministry of Industry and Small Business. No up-to-date information was available regarding Provincial employment and training incentive programs as this area is currently under review by the Provincial Government. Federal employment grants are available for areas of high unemployment. Assistance programs also are available at the Municipal level. Terrace will provide Civil Engineering estimates and some capital works for the plant if it is located in Terrace.

Pertinent details regarding Terrace are listed below. **Figure 1** shows the location of Terrace and information on climatic conditions.

1. Warehouse - commercial type property is in surplus and leases at absolute net for $3.00 to $6.00 per ft^2 per year.

2. Industrial taxes are about $46 per $1,000 of net taxable value. The Partnership in Enterprise Program will privde a 52 percent property tax reduction.

3. Industrial/Commercial property sells for $15,000 to $30,000 per acre.

4. Water rates are $.171 per cubic metre per month.

5. Sewer rates are $.142 per cubic metre per month.

6. Garbage rates are $28.60 per 3 yard container per month.

7. Transportation links include; C.N.R. Terrace Kitimat branchline and Edmonton to Prince Rupert mainline; Highway 16 connecting Prince Rupert and Prince George and Highway 37 to Kitimat, a distance of

57 kilometers; airport with two C.P. flights daily and one P.W. flight daily connecting to Vancouver; access to the Ports of Kitimat and Prince Rupert.

8. Electricity rates are the same in the north and south of the Province and are detailed in **Appendix IV.**

7.2 SURREY

Surrey and other municipalities in the vicinity such as Langley and Delta offer similar business opportunities. Like Terrace, Surrey is also a participant in Partnership in Enterprise and offers similar tax incentives to those offered by Terrace. Details on Surrey are as follows:

1. Commercial/industrial property leases for \$4.00 to \$6.00 per ft^2 per year. Surrey also has more industrial land than any other B.C. municipality including 8 industrial parks of various sizes.

2. Industrial taxes average about \$31 per \$1,000 of net taxable value.

3. Land prices for industrial/commercial property ranges between \$60,000 and \$160,000 per acre.

4. Water rates are graduated, depending upon quantity used, with the rate decreasing as consumption increases. The basic rate is \$20.83 per 100 ft^2 per quarter.

5. Sewer rates are essentially the same as Terrace.

6. Commercial garbage rates vary to some extent but are generally in the \$25 to \$30 per month range for a 3 yard container.

7. Transportation links include:

   (a) Within 29 kilometers of Vancouver International Airport.

   (b) Served by Highways - 1, 1A, 10, 15, 99, 99A, 91.

   (c) Railway lines of B.C. Hydro, B.N.R., C.N.R. and C.P.R.

   (d) Port on the Fraser River serving deep water shipping, and adjacent to the Port of Vancouver and New Westminster.

8. Electricity rates are the same in the north and south of the Province and are detailed in **Appendix IV.**

7.3 CONCLUSIONS AND RECOMMENDATIONS

Until such time as an actual plant site is selected, and the decision to purchase and build or lease and renovate is made, the actual costs related to land and buildings can not be finalized. Estimated building construction costs are illustrated in **Table IV.** Construction costs may be marginally lower in Surrey.

Land costs are substantially lower in Terrace than on the Lower Mainland, with lease costs marginally lower in Terrace. Taxes are 25% lower in Surrey based on value, but land values are higher, resulting in an overall higher tax cost in Surrey.

Marketing jade tiles, bulk jade and jade products will require a showroom, sales, administrative office in the Lower Mainland. Therefore, although a Terrace location for a plant site will be less expensive than a Surrey location, the economy of a northern plant location will be reduced by the need for two business places. Plant, marketing and administrative facilities would be combined for a Lower Mainland location.

Other costs for consideration include:

- 38 percent lower water rates in Surrey.
- Lower marketing costs related to showing clients bulk jade at a Lower Mainland location.
- Increased costs related to separating the manufacturing and marketing such as administration.
- Proximity to the U.S.A. market. A Surrey location actually borders on the U.S.A.
- The cost of transportation of raw jade is approximately $.15 per pound cheaper to Terrace than to Surrey and the savings on transporting finished products is only marginally cheaper from Surrey than from Terrace.

TABLE IV

BUILDING CONSTRUCTION COST ESTIMATE

PROPOSED JADE TILE PLANT/WAREHOUSE/OFFICE

Vancouver, B.C. (Area)

	($)
Warehouse structure (metal superstructure, tin roof) Approx. 40 x 120 with 16-0 ceiling, slab floor, & industrial overhead doors	86,400.00
Service to structure (allowance)	15,000.00
Mechanical (plumbing, heating, water, sewer, gas, etc.)	30,000.00
Electrical (service entrance, power, lighting, etc.)	25,000.00
Earthworks, Site preparation, & Paving/Gravelling	40,000.00
Office Structure & partitioning including washrooms and lunchroom. Approx. 40 x 60 frame prefabricated with 8-0 ceiling and required doors & windows	86,400.00
Mechanical	20,000.00
Electrical	15,000.00
Loading Dock and Ramp for Vehicles	15,000.00
Chain Link Fencing (approx. 800 lin. ft.)	8,500.00
Access/Egress driveways and curb cuts	5,000.00
Development Charges (Municipal)	5,000.00
Consultants, plans, specifications, etc.	8,000.00
Contract Management, supervision, etc.	12,000.00
TOTAL	**$ 371,300.00**

In conclusion:

Capital costs including land	TERRACE
Operating costs including water and weather considerations	LOWER MAINLAND
Marketing considerations including convenience for viewing the process and products and providing customer services.	LOWER MAINLAND

IT IS RECOMMENDED THAT A LOWER MAINLAND PLANT LOCATION, SUCH AS SURREY, WOULD BE MOST ADVANTAGEOUS FOR THE ONGOING SUCCESS OF THE BUSINESS VENTURE.

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APPENDIX I

EQUIPMENT MANUFACTURERS - CUTTING & GRINDING TECHNOLOGY

PEDRINI s.p.a.
Via Fusine, 1 - 24060 Carobbio degli Angeli (Bergamo)
ITALY

PHONE: 035/951043
TELEX: 302182 PEDRIN 1

Sales Manager: Sergio Berti

* * *

GREGORI s.p.a.
6015 Schio (VI) - Italia
P.O. Box N. 129

PHONE: (0445) 23231
TELEX: 480473 GREG-1

Sales Manager: Nico Cazzola

* * *

ADMAC
21246 - 68th Avenue South
KENT, Washington 98032, USA.

PHONE: (206) 872-7153

Rod Draughton
Jim White

* * *

CUT-A-DIE CANADA LTD.
7447 Victoria Park Avenue
MARKHAM, Ontario
L3R 2Y7 CANADA

PHONE: (416) 475-0324
(416) 499-7333

Manager: Jim McMicking

BRETON s.p.a.
31030 Castello Di Godego (TV)
ITALY

PHONE: (0423) 468141
TELEX: 410539 - 431445 BRETON 1

BRETON OF THE AMERICAS, INC.
3221 N.W. 10th Terrace
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FT. LAUDERDALE, Florida
33309 USA

PHONE: (305) 564-2708
TELEX: 821915

Secretary: Joseph Wetzel
President: Roger N. Baker

* * *

LOFFLER Maschinenbau oHG
8831 Langenaltheim 1 Bay
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PHONE: (09145) 461
TELEX: 624606

Owner: Mr. Loffler

GRANQUARTZ TRADING INC. - U.S.A. Representative for Loffler
788 Scottdale Road
P.O. Box 33569
DECATUR, Georgia
30033-0569

PHONE: (404) 292-0135

Peter Edwards

* * *

EISENWERK HENSEL BAYREUTH/Dipl-Ing. Burkhardt GmbH
Postfach 5020
D-8580, Bayreuth 13,
WEST GERMANY

PHONE: (0921) 508-0
TELEX: 642823 ebubt

Marketing Director: Wolfgang Behr/Franz Kostner - Dipl-ING
Sales Manager: Norbert Sieder

* * *

CARL MEYER
Postfach 380
D-8590 Marktredwitz
WEST GERMANY

PHONE: (09231) 4133
TELEX: 641274

G. Keichel
A.K. Backmund

* * *

ARVAN
1995 Boundary Road
VANCOUVER, B.C.

PHONE: (604) 299-6100

Plant Manager: Bob Armstrong

APPENDIX II

JADE TILE FEASIBILITY STUDY PLAN

JADE TILE

FEASIBILITY STUDY

PLAN

MARCH 1986

PREPARED BY:

M. WALDNER

J. SMITH

TABLE OF CONTENTS

APPENDIXES

1. INTRODUCTION

1.1 HISTORY

- Cry Lake Jade Mines Ltd., a wholly owned subsidiary of Mohawk Oil Co. Ltd., first began the in-situ mining of Nephrite (B.C.) Jade as a primary product in 1976 near Dease Lake in Northern British Columbia.

- During the 10 year period approximately 830 tons of jade has been shipped from the minesite via "cat-train" and by air to Dease Lake and thence by truck to Southern B.C.

- In 1982 Mohawk began investigating jade tile manufacturing as a method of using the lower quality jade which accounted for about 60% of production or 75% to 95% of reserves. This would also assist in liberating and recovering the higher quality jade.

- Beginning in 1983 jade tiles were manufactured. The process involved transporting jade from the mine site to Vernon where rough billets were cut. These billets were then precision ground by a contractor in Vancouver. These precision billets were then cut, lapped and polished in Mohawk's plant in California.

- A marketing campaign was organized at about the same time that tile manufacturing was initiated.

- Expenditures related to tile manufacturing and marketing has totaled approximately $1,449,700 since 1983. This includes:

(i)	Manufacturing Equipment in the U.S.	$ 74,500.00
(ii)	Manufacturing Equipment in Canada	$ 93,500.00
(iii)	Marketing expenses (Advertising primarily)	$531,700.00
(iv)	Manufacturing expenses in the U.S.	$379,100.00
(v)	Manufacturing expenses and related Administration in Canada	$370,900.00

- Revenues since 1983 from jade tile sales and other jade products such as table legs and book ends which are made from lower quality jade total approximately $170,000 (Canadian Funds).

- Manufacturing costs for 1/8" thick 4"x4" square tiles have been approximately $10.00 per tile or $90.00 per square foot. These tiles retail for about $17.50, or about $150.00 per square foot, although normal mark-ups should have these tiles retailing at more than $175.00 per square foot.

1.2 PHILOSOPHY AND PURPOSE OF STUDY

- The general focus is on marketing lower quality jade. In fact the viability of the entire jade mining operation may be contingent upon developing a market for this lower grade material which constitutes a major portion of the mining production and reserves.

- Tile manufacturing has been identifed as the focus of the study. Marketing and business arrangements will certainly come as "fall-out" from the study, but will not be considered as part of the study.

- Progression to Facility Design, preparation of a Business Plan, and Marketing Studies will all be contingent upon the outcome of the manufacturing study.

2. FEASIBILITY STUDY - INVESTIGATION OF TILE MANUFACTURING

- As a result of our past marketing efforts it has been determined that jade tiles must retail for $70.00 to $90.00 per square foot or less to be competitive with comparable products and for sales to reach reasonable volumes. This equates to a manufacturing cost of about $45.00 per square foot (approximately $5.00 for a 4"x4" tile).

- Based on the premise that the tile manufacturing must be accomplished for approximately $45.00 per square foot the following issues must be addressed.

  (i) Can low quality jade be cut and polished economically?

  (ii) What is the yield from the boulders mined?

  (iii) What are the optimum tile dimensions?

  (iv) Where might the plant be located?

  (v) What alternative manufacturing processes are there?

- The study will focus on our current plant configuration, possible current plant modification and alternate processes.

2.1 CURRENT PLANT CONFIGURATION

- Conduct an engineering study analyzing equipment, operating techniques, production levels of individual segments of the entire existing operation, including individual pieces of equipment in each segment of the tile manufacturing process identifying "bottle-necks", inappropriate equipment, inefficient and/or ineffective plant design.

- Identify total manufacturing cost including cost of raw material and costs of each segment of the manufacturing process.

- Investigate alternative locations for plant.

2.2 CURRENT PLANT MODIFICATION

- Identify alternate production equipment that can be added to the existing equipment or replace existing equipment.

- Investigate modifications to existing tile manufacturing equipment to improve production and recovery of raw material. (Decision point #1, see Appendices I and II).

- Investigate alternative locations for a modified plant.

2.3 ALTERNATE PROCESSES

- Identify companies which manufacture tiles, slabs or comparable products to jade tiles.

- Identify equipment that may be suitable for cutting, grinding, lapping and polishing jade. This equipment may be in use in the stone working business or technology from unrelated industries which may be adapted to jade.

- Identify appropriate government agencies which may:
  (i) assist in establishing the business
  (ii) regulate sectors of the business
  (iii) assist in identifying appropriate companies to contact to complete equipment, manufacturing and marketing research for the study.

- Correspondence with identified organizations and individuals who may be able to supply input into the study will be done initially. The correspondence would be followed by shipment of jade for pilot testing where appropriate. (Decision point #1, see Appendices I and II).

- Feedback from pilot tests will be discussed and analyzed and further meetings scheduled to discuss topics relevant to the organizational or individual expertise, if warranted. These tests should provide necessary information on equipment, manufacturing processes, materials flow and eventually plant design. (Decision points #2 and #3, see Appendices I and II).

2.4 REPORT PREPARATION

- The report preparation would include compilation and analyses of all data collected in Sections 2.1 to 2.4.

- Included will be detailed economics of possible facility configuration including:
  (i) Capital cost estimates
  (ii) Operating cost estimates
  (iii) Profit margin estimates
  (iv) Return on investment estimates
  (v) Estimates of related mining, exploration and transportation costs.

- The risks associated with exploration and mining and/or jade supply, transportation, manufacturing and marketing would be identified and risk analyses completed. These risks would include, but not be limited to:
  (i) Jade reserves/inventory/supply
  (ii) Mining costs
  (iii) Transportation costs and losses of raw and finished products
  (iv) Operating costs and overhead
  (v) Capital costs
  (vi) Domestic and foreign politics (if applicable)
  (vii) Marketing risks such as cost of sales, advertising, distribution
  (viii) Business arrangements (e.g. partnership) (if applicable)

3. FEASIBILITY STUDY SCHEDULE AND PERSONNEL

- The study has been divided into four segments:

  2.1 Current Plant Configuration

  2.2 Current Plant Modification

  2.3 Alternate Processes

  2.4 Report Preparation

- The study is expected to extend from mid-March until mid-July, 1986. The primary functions include:

  (i) Identification of equipment and tile manufacturers who may provide input into manufacturing processes.

  (ii) Test work, including cutting, grinding, lapping and polishing leading to production of a finished product.

  (iii) Data reduction and appraisal of known technology leading to conclusions and recommendations.

  A schedule of planned activities and involved personnel are detailed in Appendices I and II.

- Personnel involved in the study include:

  (i) Beverly Bland - Jade Intarsia - Mohawk Oil Co. Ltd.

  (ii) Joseph Smith - Manager, Jade Division - Mohawk Oil Co. Ltd.

  (iii) Matt Waldner - Manager, Minerals Division - Mohawk Oil Co. Ltd.

  (iv) Eugene Plank - Consultant - Canbis - Toronto, Ontario

  Additionally there may be specialty consultants required for segments of the study. Details on personnel and their activities are listed by week in Appendix II.

- Three go/no-go decision points occur in the plan. These "hurdles" must be overcome before proceeding to the subsequent segment in the plan. Costs of each segment are outlined in the following budget section.

4. BUDGET

- Clear go/no-go decision points have been defined in the planned Feasibility Study. There are four planned segments and three decision points:

  #1 about the third week of April after a budgeted $6,050 has been spent.

  #2 about the end of May after a budgeted additional amount of $33,650 has been spent.

  #3 about mid-June after a budgeted additional amount of $36,200 has been spent. A third decision to proceed essentially approves a further $17,900 expenditure. Travel-meeting costs in Asia and the U.S. may be justifiable resulting in an additional $30,000 expenditure.

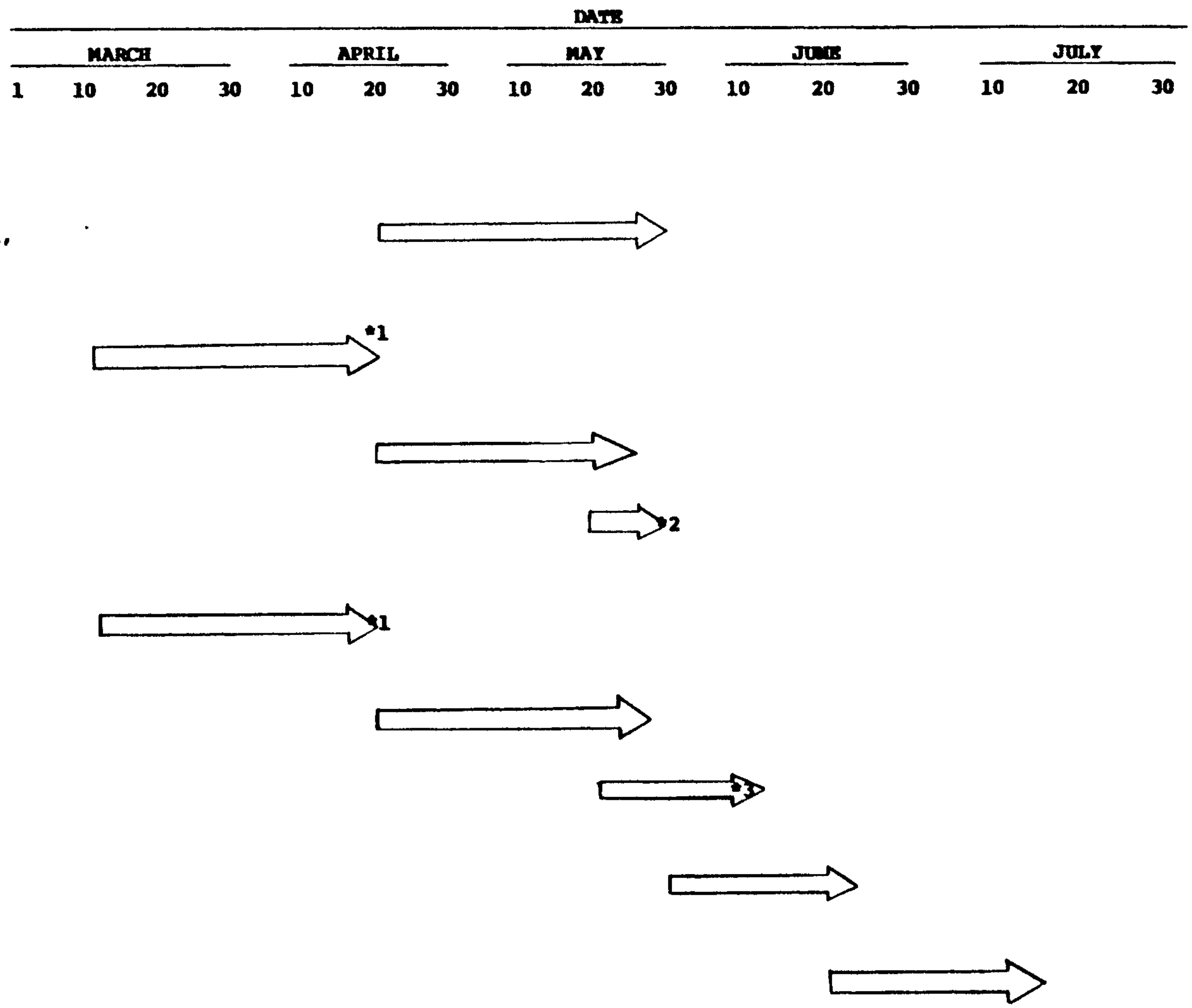
- If research into European Technology identifies a feasible tile manufacturing process then this would preclude Asian and U.S. meetings estimated to cost $30,000 even given positive Asian and American test results. American meetings alone would cost approximately $10,500 and would also require justification.

- The budgeted cost of the Feasibility Study is estimated at $103,800. If Asian and American meetings are necessary the budget rises to $133,800. If American meetings are justifiable then the total study cost is estimated at $114,300.

- The cost details of each segment in the plan are illustrated in Appendix II.

APPENDIX I

FEASIBILITY STUDY SCHEDULE



2. **PROPOSED FEASIBILITY STUDY**

2.1 CURRENT PLANT CONFIGURATION
Appraisal of technology, plant design, costs

2.2 CURRENT PLANT MODIFICATION
Identify modifications &/or equipment changes to current plant to achieve targets costs & production

Ship jade to positive respondents for tests

Pilot tests (Europe)

2.3 ALTERNATE PROCESSES
Identify alternate processes/plants/equipment to achieve target costs & production

Ship jade to positive respondents for tests

Pilot tests (Europe & Asia)

2.4 REPORT PREPARATION
Data reduction & analyses, options generation, U.S. & Asian meetings if warranted

Preparation of written report with conclusions & recommendations.

* Decision points to proceed with study or suspend if responses negative.

1. Decision to ship jade for tests only if appropriate positive responses received.
2. Decision to proceed with study if any positive tests results obtained from European tests.
3. Decision to meet with U.S. & Asian manufacturers if warranted from U.S. & Asian test results & European test results.

APPENDIX II

SCHEDULED PERSONNEL AND ACTIVITIES

TIME INTERVAL	ACTIVITIES	PERSONNEL & COSTS
March 10 to April 20	Prepare list of contacts for tile manufacturing. Initiate inquiries & await responses regarding manufacturing tests with equipment manufacturers & tile producers. (Research ends if no positive responses.) *1	- Salaries for Smith, Waldner, Consultant - Expenses
April 21 to May 30	Ship jade to positive respondents for test cutting, lapping, polishing. Await results of test manufacturing. (Research ends if no positive respondents.) *2	- Freight & test costs
	Research and organize information on Mohawk's tile manufacturing process, processing equipment, costs and plant design.	- Salaries for Smith, Waldner, Bland
June 1 to June 30	Meet with European manufacturers who have demonstrated that they are able to produce tiles/slabs of acceptable quality.	- Salaries for Smith, Waldner, Consultant - Travel & Expenses
	Reduction and appraisal of test data. (Research and appraisals end if negative.) *3 Additional meetings (Asia and/or U.S.A.) if warranted.	- Salaries for Smith, Waldner, Consultant - Expenses - (Travel & Expenses)
July 1 to July 15	Prepare report including all data related to tile manufacturing and information unearthed during the study pertinent to tile manufacturing, marketing, distribution and volume jade sales and/or consumption. Conclusions and recommendations will be significant, mandatory sections of the report.	- Salaries for Smith, Waldner, Bland, Consultant - Expenses

* Decision Points to continue or discontinue study. Require positive feedback for continuity.

Note: (1) Consultants's expenses include 2 to 3 trips from Toronto to Vancouver return.
(2) Salaries reduced to per diem rates and applied only when working on study.

APPENDIX III

MINERALS DIVISION

BUDGET DETAILS

Costs From Study Start-up to Decision Point #1			
Personnel:	Consultant 10 days @ 190/day =	1,900	
	M. Waldner 5 days @ 250/day =	1,250	
	J. Smith 10 days @ 190/day =	1,900	
Expenses:	(Consultant & misc.)	1,000	$ 6,050
Costs From Decision Point #1 to #2			
Personnel:	Consultant 15 days @ 190/day =	2,850	
	M. Waldner 15 days @ 250/day =	3,750	
	J. Smith 20 days @ 190/day =	3,800	
	B. Bland 10 days @ 100/day =	1,000	
Test Work:		15,000	
Freight:		5,000	
Expenses:		2,250	33,650
Costs From Decision Point #2 to #3			
Personnel:	Consultant 20 days @ 190/day =	3,800	
	M. Waldner 20 days @ 250/day =	5,000	
	J. Smith 20 days @ 190/day =	3,800	
	B. Bland 10 days @ 100/day =	1,000	
Travel:	(Europe)	18,800	
Expenses:		5,800	36,200
Costs From Decision Point #3 to Study Conclusion			
Personnel:	Consultant 20 days @ 190/day =	3,800	
	M. Waldner 20 days @ 250/day =	5,000	
	J. Smith 20 days @ 190/day =	3,800	
	B. Bland 10 days @ 100/day =	1,000	
Expenses:		4,300	17,900
Contingencies			10,000
Travel:	(U.S.)	(10,500)	
	(Asia)	(19,500)	
TOTAL		**$ (133,800)**	**$103,800**

APPENDIX III

B.C. HYDRO - POWER COST ESTIMATES

British Columbia Hydro and Power Authority provided estimates for electrical energy costs and peak demand charges. These estimates were used to determine plant electrical costs.

1. **ENERGY COST**

KWH	COST PER KWH
0 to 275	7.47¢
276 to 6725	5.51¢
6725 to 29725	4.08¢
+29728	2.64¢

2. **DEMAND CHARGE**

KW	COST PER KW
1st to 35	NO CHARGE
36 to 115	$3.13
+115	$6.01

- Power factor penalties may apply if plant design inefficient.
- Minimum monthly charge of $11.09 and a basic charge of $3.91 per month.
- Minimum charge equal to 50 percent of maximum demand charge measured between November 1st and March 31st.

APPENDIX IV

MOHAWK JADE TILE PLANT EQUIPMENT

1.	Do All Model 70 l/D - Micro Slicer	
2.	Speedfam Model SNG 32 SPAW - Polishers (2)	
3.	Speedfam Model SNF 48 BTAW - Lapper	
4.	Dayton Speedair 5 h.p. Air Compressor	
5.	Do All Surface Grinder	
6.	Bench Grinder	
7.	Lapper Solution Conditioner Tank	
8.	Lapper Reclaim Tank	
9.	Small Tools, Pumps & Motors, Scale, Washer	
	San Jose Plant items 1 - 9	$103,490.00
10.	Vertical Spindle Grinder-MAS Model BRV70	52,700.00
11.	Platform Scale	3,140.00
12.	Hydraulic 48 Inch Diameter Blocking Saw Complete With One Blade	33,500.00
13.	Overhead Crane Included Trollies	15,640.00
14.	Radial Arm Saw (B&D 16")	6,080.00
15.	Gasoline Motor Powered Forklift (F.M.V.)	2,000.00
	TOTAL	**$216,550.00**

APPENDIX V

STONE-WORKING INDUSTRY COMPANIES

W e s t g e r m a n y

Firma
Krupp-Polysius AG
Baustofftechnik
D- 472o Beckum/W.Germ.

Telefax: (o2525) 71-21
Telex: 8 9 481-o

Planning,consultancy and erection of complete plants for the manufacture of building stone and similar products.

Firma
Porsfeld GmbH & Co Betriebs KG
Hauptstrasse 3o

D-8399 Ruhstorf(Rott) W.Germ.
Telex: 5 7 283

Hydraulic rock drilling equipment, cleaving units and machines; planning of complete quarries.

Firma
Fickert KG
Maschinenfabrik
Lohbachstrasse 3
D- 8676 Schwarzenbach/W.Germ.

Telex: 6 43 818

Stoneworking machines such as sawing,milling and grinding machines,special machines, complete production lines, grinding,polishing and cutting discs for stoneworking.

Firma
Arbes KG
Maschinenfabrik
Bruchgarten 1-5
D-591o Kreuztal-Krombach/W.Germ.
Tel.: (o2732)8712
no telex #

Stone-cutting, multiple-blade saws, frames, stone gang saws, circular stone-saws and stone-milling machines.

Firma
Carl Meyer KG
Steinbearbeitungs-Maschinenfabrik
Kraussoldstrasse 19
D-859o Marktredwitz/ W.Germ.

Telex: 6 41 274 meyer d

basic same fabrication rpoducts like Fickert KG

Firma
A. Volkenborn Maschinenfabrik
Hauptstrasse 13
D- 562o Velbert 11(Langenberg) W.Germ.

Telex: 8 516 717

Building site circular saws and masonry saws

A u s t r i a

Manufacturers of machinery for stoneindustry.
Unfortunately the austrian literature and library infos are not specific to find out, which particular machine they produce. Basic any type of specialmade equipment for stoneindustry.

Firma
Johann Leinweber
Industriegelaende Nord
A-27oo Wiener Neustadt/Austria

Telex: o16-657

Firma
Austroplan
Oesterr.Planungsges.m,b,H.
Linke Wienzeile 234
A-115o Wien/ Austria

Telex: 1 32997

Firma
Anderle Karl
Werkzeugmaschinenbau
Gleinker Hauptstr.3
A-44o7 Steyr/ Austria

Telex: no
Telefon: o7252/ 632 68

Firma
Mannsberger Eduard Ing.Ges.m.b.H.
Hauptstr. 44
A-2544 Leobersdorf/Austria

Telex: o14-446

W e s t g e r m a n y

Firma
Otto Suhner GmbH
Bauvereinstr.18
D-788o Bad Saeckingen 1/West Germ.

Telex: 7 92 32o

Flexible shaft-machine tools for stone-dressing tools and attachments for the former,drill feed units, special-purpose machines.

Firma
KHD Humboldt Wedag AG
Wiersbergstrasse
D-5ooo Koeln 91/W.Germ.

Telefax: (o221) 8 23-72 4o Group 3
Telef: (o221) 8 23-o
Telex: 8 812-o

This company is specialised in:
Machines and plants for processing raw materials and minerals, plants for the production of quarry products.

Most of the companies on page -1- are also involved in setting up of complete plants and production streets for the stone industry.

If you need more informations in the miningindustry, concerning the Jade-quarry by itself, pls. let me know.
These would be complete different types of manufacturers.

W e s t g e r m a n y

Firma
Martin Kolb
Maschinenbau
Zeughausweg 26
D-79o5 Dietenheim 1/W.Germ.

Stonecutting machinery

Telex: 7 12 295 kolb d

Firma
Eisenwerk Hensel Bayreuth
Dipl.Ing.Burkhardt GmbH
Rathenaustrasse 47
D-858o Bayreuth/ W.Germ.

complete line of stone-working machinery and tooles.

Telex: 6 42 823

Firma
Robert Schlatter GmbH & Co
Maschinenfabrik
Dettinger Str.82
D-7312 Kirchheim(Teck)

Machinery for working natural and antificial stone.

Tel.: (o7o21) 5 47 3o

Firma
Petzing & Hartmann
Maschinenfabrik GesnbH & Co KG
Leipziger Str. 158-168
D-35oo Kassel-Bettenhausen

Pehaka-bandsaws for all sawing problems, and sawing installation

Telex: 9 9 668

Firma
Schindler
Steinbearbeitungsmaschinen
Anlagentechnik GmbH
Donaustauferstr.15o
D-84oo Regensburg/W.Germ.

Machinery and plant for slabs and steps.

Telex: 6 5 639

Firma
Helmut Darda
Maschinenbau
D-7712 Blumberg(Baden) 1/W.Germ.
Telex: 921 219

Building f.above-ground buildg. and civil underground working; rock-splitters