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INDUSTRIAL
PROJECTS
SERVICE

PROJECT PROFILES FOR HASIDA PROJECT

UNDER UNIDO CONTRACT 86/113/MK

FINAL REPORT

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Your ref 10520.01/CDH/RTS

Our ref

Date 22nd June 1987

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Vienna International Centre
PO Box 300
A-1400 Vienna
Austria
Attention: Mr D Gardellin

Industrial Projects Service
PO Box 2569
Addis Ababa
Ethiopia
Attention: Mr Bruck Kebede

Dear Sir

Hasida Project Profiles

We have pleasure in submitting our final report on the ten project profiles required for your Hasida project.

Following our draft report you were kind enough to write to Hasida (copied to Atkins) to say that the draft was acceptable both in terms of coverage and extent of details. The comments you added at that time have been taken into account in preparing this final report.

You may like to know that in seven of the ten projects we took the opportunity to make visits to selected manufacturers to refresh our understanding and data. In the other three we have been in close touch with manufacturers by phone, telex and post to review our basic information about these operations.

Yours faithfully
For and on behalf of
WS ATKINS INTERNATIONAL

D B Butcher
Director

C D Humphrey
Study Manager

INDUSTRIAL PROJECTS SERVICE
Addis Ababa, Ethiopia

16

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Woodcote Grove
Ashley Road
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JUNE 1987

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CONTENTS

INTRODUCTION

In November 1986 Atkins was requested by UNIDO to prepare ten project profiles for Industrial Projects Service (IPS) in Ethiopia. IPS is an autonomous consulting house under the Ministry of Industry, and has a contract with Hasida (Handicraft and Small Scale Industries Development Agency) to prepare a large portfolio of project opportunities. The Atkins portfolio forms a small part of this.

The Atkins brief covers the provision of basic technology and cost information for projects to meet previously specified demand figures. IPS have undertaken the overall demand estimates and will undertake the economic evaluation.

Accordingly Atkins were asked to supply the following:

* product description and cif prices
* manufacturing process, machinery and space requirements
* capital costs
* materials requirements and costs and other operating requirements and costs
* employment and training needs.

A Draft Report was submitted in February. This was approved by IPS, who also asked that some further detail be given in the Final Report. These requests have been incorporated in the present version as described in Appendix 1.

SUMMARY AND GENERAL COMMENTS

1. General Conclusions

Some general conclusions about each of the profiles are drawn below. The profiles do not contain economic evaluations but the cost structures, capacity utilisations and general opinions within the industry make it possible to offer guidance about competitive advantage compared to imports (all costs and prices exclude duties). References to total capital costs include rough building cost estimates based on specified areas.

A-Welding electrodes (1990 demand - 831 tonnes)

A 400 tpy plant is fully utilised on one-shift operation manufacturing electrodes from preblended fluxes and predrawn wires. It should be strongly competitive.

B-Mortice locks (1990 total demand - 154,000 sets)

A 100,000 sets plant is heavily underutilised. A quarter million sets are needed for economic production; similarly with handles.

C-Padlocks (demand about 500,000/year)

A 450,000 plant with simple machinery appropriate to simple lever locks should be competitive, but local manufacture can only satisfy part of the range and smaller volumes are not competitive.

D-Razor blades (1990 demand - 167 million)

A minimum scale plant can produce 100 million blades per year (two shift working). This should be competitive. Capital cost is around $7½ million. Second hand plants are available with outputs from 50 million blades per year but although plant cost is less, other fixed costs change little and so there is no commercial advantage. Some advantage can be gained by uprating a second hand plant.

E-Abrasive wheels (1990 demand - 649 tonnes)

A plant making 180 tpy can be fully utilised for 2-shift working and has a capital cost of around $1.1 million. This should be competitive.

F-Water meters (1995 demand - 49,000)

Manufacture is not competitive below about ¼ million (counter mechanisms at ½ million). Supply of different components from other higher output, factories might be possible at under 100,000. Assembly of kits has very low value added and is still not competitive.

G-Adhesive tape (1995 demand - 1.2 million rolls)

Opportunity is mainly packaging. PVC tape for insulation and packaging is now nearly universal. Modern lines are up to sixty times the Ethiopian volume, and with high investment. The only possibility is to import small rolls and chop them. Low value added and not competitive.

H-Needles and pins (1990 demand 32 tonnes hand needles· 53 tonnes machine needles; 48 tonnes safety pins)

Volumes specified are surprisingly high. All three products are made on different plants, usually in different businesses. We strongly advise only considering plants around 2½ tpy. But even when fully utilised on two shifts these are highly uncompetitive. Even at much higher volumes Ethiopia is most unlikely to be competitive.

I-Abrasive sheets (1994 demand - 101 tonnes)

A small 100 tpy plant can be fully utilised on one-shift working and should be competitive. Total capital cost is over $1½ million.

J-Saws (1990 demand - 84 tonnes)

A hacksaw-only process line is fully utilised on one shift at about 44 tpy but is not competitive. At 2-shift working its costs should be only a little above imports. Circular saws and bandsaws in small volumes are not competitive and have not been included.

2. Comments on Costing

In most profiles the volume of production has been selected after taking a commercial view of the market opportunity or technical problems, within the overall demand specified.

These profiles are based on the assumption that each business is stand-alone with its own administrative and technical support staff and site workers together with drivers, trainees etc. Employment numbers reflect the lack of industrial heritage. Where employment costs are given these are based on:

	Annual weighed mean total wage cost to the business
Professional/technical	$8,500
Skilled	$4,500
Semi skilled	$3,500
Unskilled	$1,000

Sometimes it may be possible to reduce employee numbers overall by merging duties but at early stages of industrial development employees usually have much difficulty in covering a range of tasks.

Building layouts are also generously sized to reflect the relatively high manning and non-continuous processing of some projects.

The procedure adopted in estimating capital costs has been to establish the plant supply costs first, then to add cif costs plus a small element for port costs in order to arrive at a port gate cost. To this has been added the cost of erection and of mechanical and electrical services plus an allocation for design and engineering. Vehicles form an important part of the cost of small business and these have been added. No duties are included in any of the estimates.

Building areas have been specified and in order to develop a 'feel' for total capital cost. These have been converted to cost at $460 (except in one or two cases where special building facilities justify higher cost).

In most cases the estimates of technical assistance contract costs are those of the consultant. In some cases manufacturers have given an indication. Initial TA/know-how cost depend on whether there are other sources of know how sale such as plant sale price or material supply. Annual TA costs are based largely on time and subsistence charge for visits.

Cif prices of imported finished products are generally based on the cheapest source, usually South East Asia.

In general the capital and operating costs have been estimated taking into account the problems which Ethiopia will have in introducing new manufacturing ventures.

WELDING ELECTRODES

This profile deals with coated manual metal arc electrodes made from drawn wire and pre-mixed powders at 400 tpy on one shift working.

1. Product Type, Volume and Price

Electrode type

This profile deals with manual metal arc electrodes for general fabrication work. The steel wire is coated with a fluxing material except at one end where the wire is bared for insertion into the welders clamp.

Manual metal arc electrodes, known as 'stick' electrodes, vary in diameter from about $1\frac{1}{2}$mm to over 6mm. The smallest diameter electrodes are usually about 250mm long, the largest about 450mm.

Commonly about 70 percent of the consumption is of 3.25 and 4mm diameter mild steel grades. The Ethiopian demand is probably around the following.

	Percent
Mild Steel:	
Under 3.25mm	5
3.25 and 4mm	75
4-5mm	10
Over 5mm	5
	95
Other qualities	5
	100

It will be assumed here that a plant in Ethiopia will meet 90 percent of the mild steel product range, ie. 85 percent of total requirement.

Demand

Ethiopian demand has been specified by IPS as follows:

	tpy
1986	718
1990	831
1995	971
2000	1113

The market opportunity open to local manufacture (85 percent) will thus be:

	tpy
1995	825
2000	946

A plant which began construction at end 1987 would be in operation by end 1989 and might satisfy say 50 percent of the market after 2 years. Thus by 1991, output could be, say 408 tonnes (859 x 0.95 x 0.5 = 408), growing strongly after that.

Price

Stick electrodes can be purchased from very many sources. From reliable suppliers in the industrialised countries typical prices are as shown in Table 1.

Qualities other than ordinary mild steel electrodes will be of very different prices. It is also likely that selective purchases of electrodes from developing country producers or from East bloc suppliers will be at discounts to the above quoted price which may range up to 20 percent (but quality and supply reliability must be taken into account).

This profile takes no account of automatic and semi-automatic welding electrodes including flux cored wires, submerged arc wires and wires for TIG and MIG welding. Such demands in Ethiopia will be very small.

2. Process and Technology

The stages of development of stick welding electrode manufacture are as follows:

A Import coiled wire or cut wires and pre-blended coatings, mix the pre-blended coatings into a paste and coat the wires.

B Import wire rod and draw it to electrode wires. The wire drawing would not normally be done at the minimum scale of electrode manufacture.

C Import the coating materials from various sources and make the blends.

A single electrode coating extrusion line can be designed with an economical throughput of about 400 tonnes per year on single shift working.

If a greater output is required then this extrusion line would be duplicated or the single line would switch to 2-shift operation.

Wire drawing could be contemplated at 500 tpy but the economic output of a 4 die machine working one shift would be over 1000 tpy. The extra plant required increases the investment requirement (pointer, decoiler, acid descale, wash, dry, draw, recoil, degrease). Wire drawing plant exists in Ethiopia and it would be logical to purchase drawn wire from there.

Blending of the flux coatings is a complex and costly operation. Electrode quality is critically affected by the quality of the coating. Considerable testing is required. The operation must be automated. Blending would not normally be carried out until electrode production reaches at least 5000 tpy and not normally until about 10,000 tpy.

The main electrode coating plant is a high speed operation and is automated. The electrodes are automatically loaded onto trays and these pass to a drying oven. Thereafter at the packing stage, there is more opportunity for manual labour instead of machinery.

Some additional plant can be considered. For example a high temperature baking oven can be installed. This can bake special coatings at up to 500°C. It is thought that demand for such coatings in Ethiopia will be too small to justify the investment in the early years of the project.

A typical coating extrusion plant will produce around 120 sticks per minute. Standard 350mm electrodes with steel cores of 3.25 and 4mm diameter, and with coating being 30 percent of total weight, weigh 32 and 48 grms respectively. Maximum output is then 230 and 346 kgs/hour respectively. The average is 288 kgs/hour.

Using 65 percent operating hours on an 8 hour day the plant produces 1.5 tpd. Using 48 weeks of 5½ days per week the annual capacity is 396 tpy - say 400 tpy on one shift.

An appropriate plant would be built around a single extrusion line. When demand exceeds 400 tpy the plant could switch to 2-shift operation.

Technology

Leading welding electrode manufacturers supply technology and sometimes machinery. A good source would be:

Murex Welding Products Ltd
Hertford Road
Waltham Cross
Hertfordshire EN8 7RP,
UK
Telex 21498

Murex is a large company and is a part of Esab, the very large Swedish electrode company. Murex have supplied full electrode plants overseas.

Another company with experience of setting up overseas plants is Oerlikon Welding.

3. Machinery and Cost

The process flow is shown in Figure 1. Wire coils from the wire store is unpacked and passes to the cutting line where it is decoiled, straightened on a spinner and cropped into 350mm lengths with the pieces dropping into a holding frame (stillage). The stillage is then carried by hand truck to the extruder where it is mounted on the feed end of the machine.

Electrode coating powder bags (50 kg) are removed from store and tipped into the wet mixer ('Z' type mixer) through a hopper with dust extracter. A measured amount of rutile powder may be added to most mixes. A small quantity of sodium silicate liquid is tipped into the measuring tube and discharged into the mixer. The whole is then mixed to a paste. Heat is generated. Sometimes liquid nitrogen is used to cool the resulting paste. When cold it has a shelf life of 4 hours; otherwise it is shorter. If partly solidified bits form in the paste at any stage, it will block the extrusion port and stop the extrusion process. Measuring of pre-mixed powders to the mixer together with silicate and rutile is simple and does not require special equipment.

The paste is then compressed into 'pugs', or cylinders, about 150mm diameter and 200mm long. In the extrusion plant the cut wires roll out from the stillage and end-to-end they pass continuously through the extrusion tube into which a 500 tonne ram forces the pug of coating paste. The wires are forced through by rollers at the feed end and they emerge coated to strike a plate (target) before dropping to a conveyor passing at right angles to the emerging rod. They are gently rolled about 1½ turns to ensure concentricity of coating (this is periodically checked by the operator, using a microscope device).

Next, still on the same line, the rods are wire brush scoured at one end to produce the exposed end for the welders clamp. The ground-off paste falls to a small bin and is carried back to the mixer.

At the end of the extrusion plant line, the rods are automatically loaded onto a multilayer frame and they pass round on a chain-drawn conveyor to wait for 1-2 days air drying. In some small plants the unloading can be done manually.

Finally the rods, in open layers on a frame pass into the tunnel drying oven which is zoned and raises the rods to about 150°C for about 1½ hours. They emerge from the oven to a machine which withdraws the rods from the drying frames and tips them in bulk into a second frame called a cot. This can also be done manually.

From the cot, the rods are usually automatically printed, bundled and boxed. In Ethiopia it would be appropriate to hand box them into 5 kg printed cartons. Printing is advisable prior to boxing but costs about $5000. The cartons are automatically wrapped in polythene film which is then heat shrunk onto the carton. These cartons are then packed into larger boxes and pass to store.

Inspection is simple, consisting of a moisture tester and equipment for practical weld-testing of the electrodes.

The reject rate should be 1-2 percent. Perhaps half the rejects can be reclaimed in the undried condition by knocking off the coating. A permanent loss of about 1½ percent is assumed in this profile.

The capital costs of the plant and equipment amount to $666,000 as shown in Table 2.

4. Layout

The layout is shown in Figure 2. It shows a total covered area of 525 square metres, including offices and locker rooms.

The building is about 4½ metres to the eaves. No EOT cranes are needed so bay arrangement is not critical. Some single rail mounted hoists can be erected above the plant to simplify handling.

5. Materials and Costs

The raw materials purchases are described in Table 3:

a) Coils of drawn wire 2-6 mm diameter supplied in sealed bags, and already degreased by the wire drawer. The coiled 5.5mm rods would be imported by the electrode manufacturer and supplied 'free-issue' to a local wire drawer in Addis Ababa for drawing.

400 tonnes of electrodes, 70 percent of which is wire. Allow 1½ percent non-recoverable scrap hence annual requirement 284 tonnes of drawn wire.

b) Pre-mixed electrode coatings containing fluxes and ferro-alloys. About 5 or 6 different mixes would be sufficient to make up the product range for the Ethiopian plant. These are normally supplied in 50 kg bags.

400 tonnes of electrodes with 30 kgs/tonne of coating supplied as pre-mixed powder. Assume 1½ percent permanent loss. Hence 120 tonnes of pre-mix.

c) Rutile (titanium oxide) is used as a flux and is often added to the pre-mix at the electrode plant. It is assumed in this profile to be included in the mix.

d) Silicate for turning the powders into paste. Total nearly 18,000 litres.

e) Printed cartons to take 5 kgs of electrodes, and 30 kg cardboard boxes. At 400 tpy the requirement is for about 80,000 5 kg boxes and about 13,300 larger boxes.

f) Other consumable items include a small amount of polythene for shrink wrapping the smaller boxes and small quantities of printing ink and technical leaflets.

The costs of the above materials are also presented in Table 3.

Sourcing

All the above items with the exception of the cartons and assorted supplies can be provided by suppliers in the industrialised countries. Murex, the company mentioned previously would supply all these materials if required. Sometimes a decision is taken to buy the two main items (wires and pre-mixes) from different countries.

It is usual to purchase the wires from industrialised countries eg. Eastern bloc, Japan, Germany, UK. The pre-mixes may also, however, be supplied from countries like India (eg. Advani Oerlikon).

Provision should be made for stocking about 6 weeks supply of foreign goods and 2 weeks supply of local goods.

6. Other Operating Requirements

Other operating supplies are shown in Table 4.

There is no special treatment of wastes.

7. Manpower and training

Employment

The plant can be operated on a single shift basis with 32 employees as shown in Table 5. This is more than would normally be required in an industrially skilled environment but is appropriate to Ethiopia.

A second shift could be operated by adding a further 19 employees.

Training

The plant could be started by a single expatriate technologist who should be at the works for about three months with provision for a visit of about 2 weeks per quarter year thereafter for about 1 year.

Prior to start-up there will be a training programme of about 1 month when the expatriate technologist and the expatriate installations engineer would supervise the training of:

General Manager
Foreman
Wire Cutter
Wet mix operator
Extruder
Maintenance (2)
Quality technician

Subsequent training would be during - production instruction.

The technical assistance programme for start up would cost about $70,000.

8. Concluding Remarks

Although this profile is not required to complete the financial analysis it seems from a preliminary review of the capital and operating costs that the project will show a very good return compared to the border price of the imports at 400 tpy. Even if imports from developing countries cost only 80 percent of the developed country prices quoted here, the project is viable at 400 tpy. Moving to a second shift of operation would make the project still more attractive.

TABLE 1 - WELDING ELECTRODE PRICES

		Price ex works Europe $/tonne
General purpose (1)	3.2mm	2760*
	4.0mm	2560*
Hardfacing (2)	3.2mm	3700*
Weighted	47.5% General 3.2mm	
	47.5% General 4.0mm	
	5% Hardfacing	2710
Freight to Assab	$230/t	
	hence total	2940
Cost with port costs 2½ %		3014
		$ thousand
Border cost of:	400 tpy	1206
	800 tpy	2411

* Substantial discounts may be available from some developing country producers.

(1) Mild steel work in all positions (low carbon electrode)

(2) Chrome manganese for surfacing and repair.

TABLE 2 - CAPITAL COST WELDING ELECTRODES

	Thousand Pounds
Wire cutting	18
Mixing	31
Extrusion	109
Drying oven	77
Packing	9
Laboratory/quality control	21
Printing and other equipment	15
	280
Spares	32
Maintenance shop	20
	332
Freight and insurance	23
Mechanical and electrical services	35
Erection	21
Design and project management	20
Vehicles (2)	13
	444

	$ Thousand
Expressed in $US	666
Building could be costed at $US 460/m^2 for 525 m^2 including fittings	242

Excluding duties on plant
Excluding site costs, fencing, roads and landscaping

TABLE 3 - WELDING ELECTRODE MATERIALS

At 400 tpy electrodes:

Fluxes - general	30kg/tonne	114 tonnes
Fluxes - special	30kg/tonne	6 tonnes
Silicate	44 litres/tonne	17640 litres
Plain wires	70kg/tonne	266 tonnes
Special wires	70kg/tonne	14 tonnes

	Price $/unit	Total cost $ thousand
General fluxes	1020	116
Special fluxes	2295	14
Silicate	0.77/litre	14
Wires plain	700	186
Wires special	800	11
		341
Freight for 400 tonnes		92
		433
Take permanent loss 1½ percent	hence	440
Packing materials and literature		10

TABLE 4 - OTHER WELDING ELECTRODE COSTS

	$ Thousand
Investment costs	
Technical assistance	70
Start up costs for recruitment training and commissioning	29

	$ Thousand per year
Labour 32 x say 3600	115
Electricity 190,000 kWh	13
Water 500 gallons/day	3
Maintenance materials and spares	
Plant	17
Buildings	8
Administration expenses	63
Vehicle maintenance	10
Technical assistance (3 weeks/year)	16
Advertising	5

Working capital

Average 4 months raw materials
4 weeks in process and finished product
6 weeks debtors

TABLE 5 - EMPLOYMENT WELDING ELECTRODES

	Number per shift
Direct workers:	
Foremen	1
Wire cutting	1
Mixer	1
Extrusion	3
Oven	2
Packing	3
Stores	1
Inspection	1
Carriers, cleaners	3
Site	2
	18
Dayworkers:	
Supervisor	1
Manager	1
Drivers	2
Maintenance	2
Administration	7
Site	1
	32

	Number	%
Skill distribution:		
Management/professional	6	19
Skilled	7	22
Semi-skilled	15	46
Unskilled	4	13
	32	100

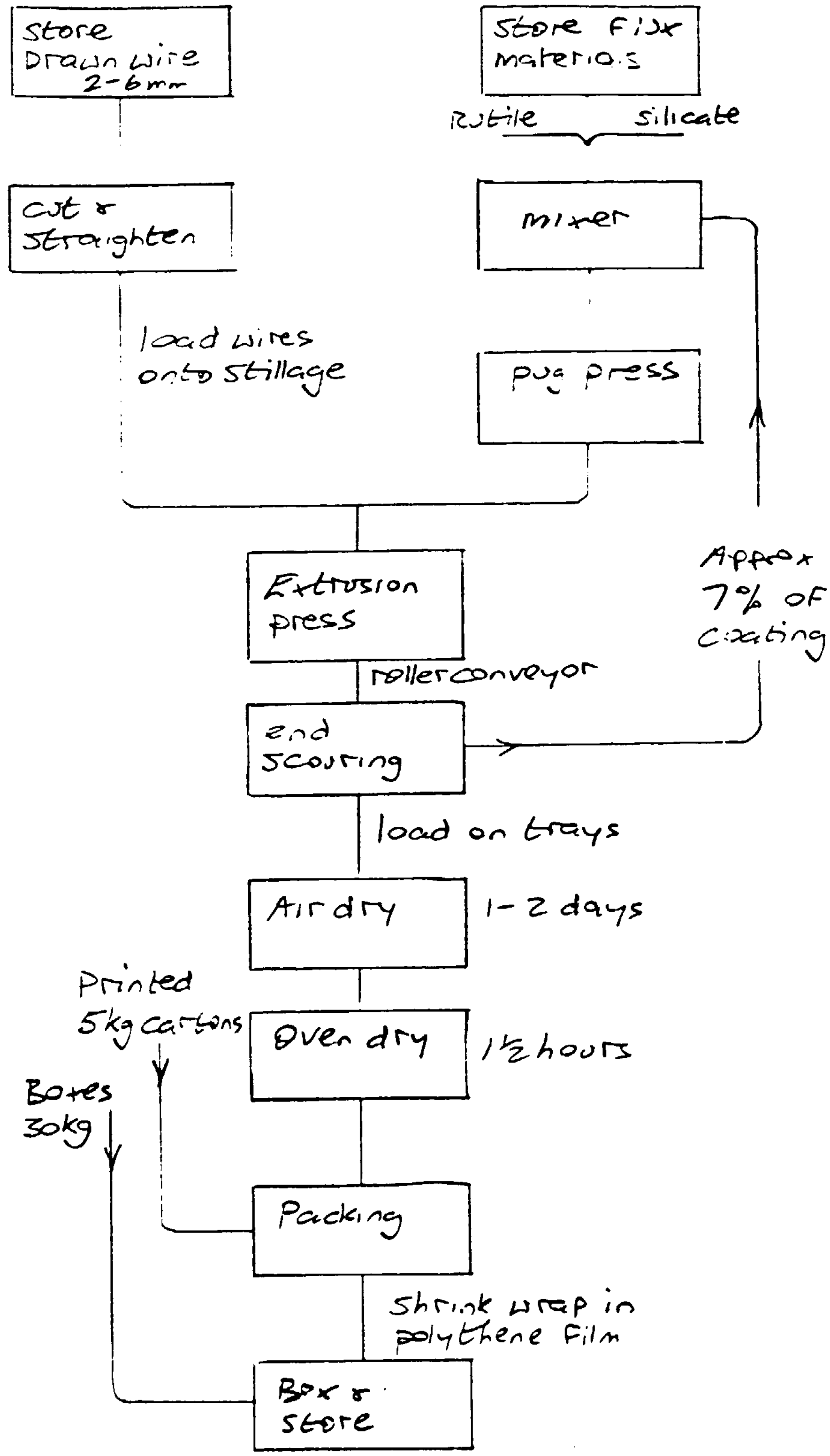

FIGURE 1 - WELDING ELECTRODE PROCESS WS/Atkins

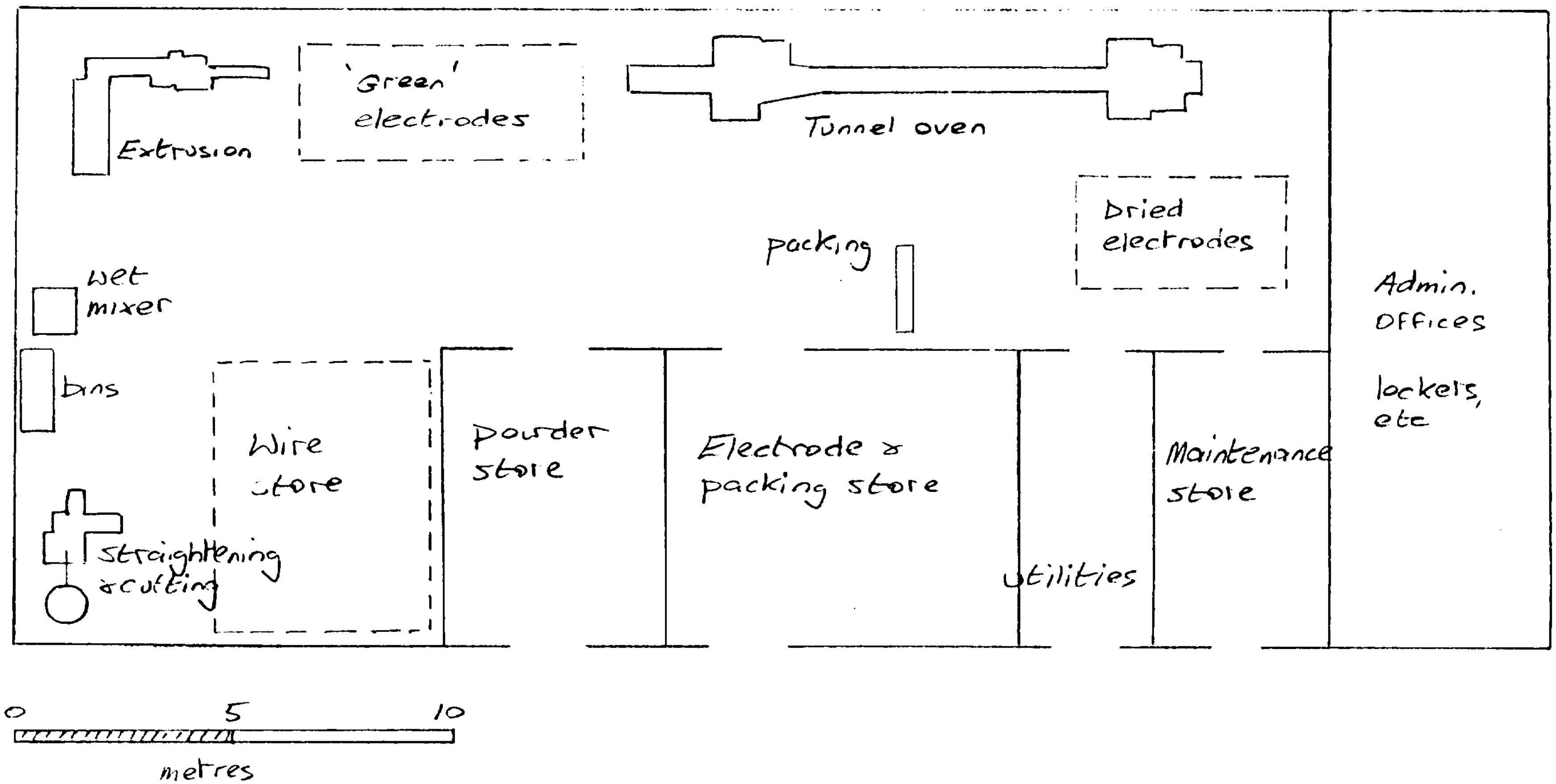

FIGURE 2 - ELECTRODE PLANT LAYOUT

MORTICE LOCKS

This profile describes a project for manufacture of mortice locks at about 100,000/year in Ethiopia

1. Product Type, Volume and Price

Mortice lock type

This profile deals with mortice locks of about 2½ inches, with two or three levers. The most common mortice lock is that fitted to internal doors in domestic properties. This normally has two levers. The lever is the mechanism which is released by the key, allowing the bolt to be shot. The more levers the more secure the lock. Security locks have 5 or more levers.

Most mortice lock producers make a range of products starting with a simple sheet metal tubular lock containing only the bolt operated by the door handle and without a key bolt. The range extends to expensive 5 lever locks. This plant deals only with 2½ inch, 2 and 3 lever locks and does not include the much cheaper mortice fitments without locks.

Demand

IPS has specified the demand as:

	thousand sets
1988	111
1990	154
1992	182
1994	219
1996	280

A plant with a limited range, coming into operation around 1990 might achieve a market penetration of 100,000/year by 1992/3.

The division of lock type is taken as about two thirds 2-lever locks and one third of the 3-lever type. The 2-lever lock weights about 250 grms and the 3-lever lock weighs about 300 grms. The mechanism is illustrated in Figure 1. There are many designs but most work on exactly the same principle.

Price

The prices vary widely with quality and source. Many customers still choose a quality lock and are prepared to pay a much higher price for it. In Europe there are cheap locally made locks available at well under $3 and there are better locks with the same number of levers at over $5 ex-works. In South East Asia and India it is possible to buy a 2½ inch 2 lever lock at under $2 but these are very low quality.

Table 1 shows the prices appropriate to the quality of lock costed in this profile. The weighted average border price is $3.67. These are a medium quality locks.

2. Process and Technology

The component list of the 2 lever lock is shown in Table 2. The 3 lever lock contains the same number of components, or only very slightly more but is normally made to a slightly heavier design and better quality and tolerances, sometimes containing more brass instead of steel.

The machine tools used to stamp, form and perforate the cases can produce, from a single specialist machine, 5 million finished pieces per year (single shift).

Full manufacture of mortice locks is unlikely to be economic below about 300,000/year and even at this level some machines would be used for several operations with dies between changed between runs.

The simplest possible line, having about two presses and with much manual machining and handling, could not be economic below about 200,000/year.

Some specialist machines like coil spring making cannot really be justified at below 1 million pieces per year. Electroplating is also a high volume process and at ¼ million/year cannot be jusified. It should be possible to purchase such services from other plants in Ethiopia.

Much of the necessary equipment would exist at a padlock maker and the two projects could probably be combined with considerable economic benefits. This is however unusual today; mortice lock manufacture is usually separated from lever padlock manufacture.

Technology

Mortice lock making appears simple but the designs have been developed over many years. A skilled engineering company can copy a design (although this may be illegal) but such skill probably does not exist in Ethiopia at present. The largest mortice lock maker in the UK and possibly the largest in Europe, is:

Josiah Parkes (Union Lock) Company
Union Works
Gower Street
Willenhall
West Midlands WV13 1JX

Parkes is now owned by Chubb a well know lock maker, which in turn is owned by Racal, the electronics firm. Parkes does have overseas ventures, including a plant in Kenya but is unlikely to be interested at only around 200,000/year.

3. Machinery and Cost

Table 3 gives the manufacturing sequence and Table 4 gives a capital investment. The equipment list has been cut to that appropriate to about 100,000/year. At 200,000 some additions would be needed. This would include an extra press and some small machines. The cost in that case would increase by about 10-15 percent. The single largest cost is for tooling.

4. Layout

The area requirements are:

	m^2
Machine shops	270
Assembly, test, pack	60
Stores and maintenance	170
Administration ...	60
	560

The building is of light construction, 4½ metres to eaves and without cranes. The layout is shown in Figure 2.

5. Materials

Table 5 shows the materials requirements and the border prices. Cold rolled sheets are widely available and standard mild steel qualities will suffice.

Wires could be drawn in Ethiopia by a company with a demand for several thousand tonnes per year.

Aluminium is used for lock mechanisms and the followers in cheaper locks.

It is assumed that springs will be purchased within Ethiopia. The forend and keys will be electroplated and probably the striker plate.

6. Employment and Training

Table 6 shows the employment number and skill distributions. A problem with small ventures of this kind is that the plant operators must cover a wider range of duties thus needing more skill.

Provision is made for trainees and for development staff since considerable trouble shooting and product/process modification and improvement will be needed, especially with services being purchased outside the factory.

Skilled workers will need previous engineering industry training. It would be advisable to provide overseas plant visit and process familiarisation for:

Manager
Maintenance Engineer
Development Engineer
Press Operator
1 Foreman

One to two months overseas will be sufficient. These staff will also need 2-3 months preparation (mostly in the factory during commissioning). Other skilled workers will need 2-4 weeks training.

The 39 employees listed in Table 5 could produce 100,000 locks/year. With an increase to about 60 employees (and with the previously mentioned small increase in plant costs) the works could produce about 300,000/year.

7. Other Costs

Table 7 presents the other costs to be taken into account in preparing the costing of the project profile.

8. Concluding Comment

Although this project profile is not required to complete the financial analysis, it seems from a preliminary review of the capital and operating costs that the total costs will far exceed the expected revenues at 100,000 units/year.

The minimum economic scale of output for this type of operation is probably around 250,000/year.

TABLE 1 - MORTICE LOCK PRICES

	Price ex works United Kingdom* $US each
65mm 2-lever	3.05
65mm 3-lever	4.93
Weighted ⅔ 2-lever, ⅓ 3-lever	3.67
Revenue from 100,000	$0.367 million

* Including 5% agency and cif cost plus 2½ percent port cost.

TABLE 2 - MORTICE LOCK COMPONENTS

Forend front plate (plated)
Case back
Case front
Runner plate
Bolt lath
2 levers
Followers (Zn-Mg diecast)
Striker plate for door frame
Bolt
Dead bolt
Rivets
2 coil springs
5 screws
2 keys and rings
Display card.

TABLE 3 - MANUFACTURING SEQUENCE MORTICE LOCKS

Stamp case front and back
Press case shape
Perforate holes
Rivet spring foot, stump, etc onto case
Paint cases
Drill and tap the case screw thread
Stamp and punch forend and striker plate
Electroplate forend and striker plate
Rivet forend to case
Machine bolt and dead bolt
Fold runner plate
Rivet bolts to plates
Rivet levels to bolt lath
Make coil springs
Assemble lock

Stamp key ends and cut shank
Weld key
Electroplate key

Pack

TABLE 4 - CAPITAL COST MORTICE LOCKS

	Thousand Pounds
Plant costs (cif):	
Press (multipurpose)	41
Smaller press perforating	20
5 machines for bolts	28
Key blanking and welding	17
5 machines for rivetting	22
Painting, packing, racking	29
Maintenance shop	15
Tools and tooling	70
	242
Spares	9
Erection of plant	23
Mechanical and electrical services	14
Design and project management	19
	307
Vehicles (2)	13
	320

	$ Thousand
Expressed in $US at 1.5$/	480
Building could be costed at $US 460/m^2 for 560m^2 including fittings	258

Excluding duties on plant

Excluding site costs, fencing, road, landscaping

TABLE 5 - MORTICE LOCK MATERIALS

	Tonnes
Cold rolled steel sheets	39½
Wires (steel)	2
Aluminium bars	14¾

	Percent
Average yields:	
Cold rolled sheets	55
Steel wires	85
Aluminium	25

	$/tonne
Cold rolled sheets	700
Wires	1600
Aluminium	2800

Scrap recovery:

Sheets	42% at $100
Wires	zero
Aluminium	70% at $520

5 plated screws/springs per set	$10,000
Printed cards 0.1 million	$8,000
Cartons	$2,000
Other consumables	$1,000
Electroplating services	$10,000

TABLE 6 - EMPLOYMENT (MORTICE LOCKS)

	Number
Machine tools and process	12
Assembly, testing, packing, stores	4
Maintenance	2
Labouring, carrying, cleaning	5
Drivers	2
Trainees	2
Development	2
Foremen	2
Manager	1
Administration and sales	4
Site	3
	39

	Number	%
Skill levels:		
Professional and engineers	5	13
Skilled	11	28
Semi-skilled	15	39
Unskilled	8	20
	39	100

TABLE 7 - OTHER MORTICE LOCK COSTS

	Thousand $
Investment costs:	
Technical assistance contract	75
Start up Labour (take approx. ¼ of full annual wage cost for recruitment, training, operations, start up	

	Thousand $ per year
Operating costs:	
Labour	-
Electricity 48,000 kWh	4
Water 800 gallons/day	4
Maintenance materials and spares:	
Plant	12
Buildings	7
Administration Expenses	81
Vehicle maintenance	10
Technical assistance (3 weeks visit/year) plus some development support	16
Advertising	10

Working Capital:

- Average 5 months raw materials
- 6 weeks in-process and finished product
- 4 weeks debtors

APPENDIX TO MORTICE
LOCK PROJECT PROFILE

Many lockmakers also manufacture handle sets. The handle sets consists of

* 2 cast handles (zinc or aluminium)
* 2 door plates (either cast mazac or pressed aluminium
* 2 retaining washers
* 2 circlips.

The manufacturing procedure involves melting aluminium or zinc-aluminium tipping into a crucible and transporting the molten metal by monorail to the tundish of a diecasting machine.

A single melter and diecasting machine could make 200,000 handle sets/year. If the door plate is cast then a second diecasting machine would be needed.

If the cheapest handle set is used then the door plate can be pressed from aluminium sheet. A press suitable for this will exist in the mortice lock plant. The sheet must first be stamped to size.

The handles are broken from the casting by hand. Sprues and runners are remelted. The handle is then fettled by hand on a grindstone. Then the handles are hand polished.

Better quality handles in Zn/Mg are chromium plated. Good quality handles in aluminium would be anodised.

The addition of door handles could justify electroplating which would then be available for the mortice lock forends and striking plates.

As very general guides the investment in plant and equipment, excluding electroplating is about $250,000 and the buildings would cost about $300,000. The plant would need about 35 employees if it were added to the mortice lock plant.

Such a plant should be economic at around 200,000 handle sets per year.

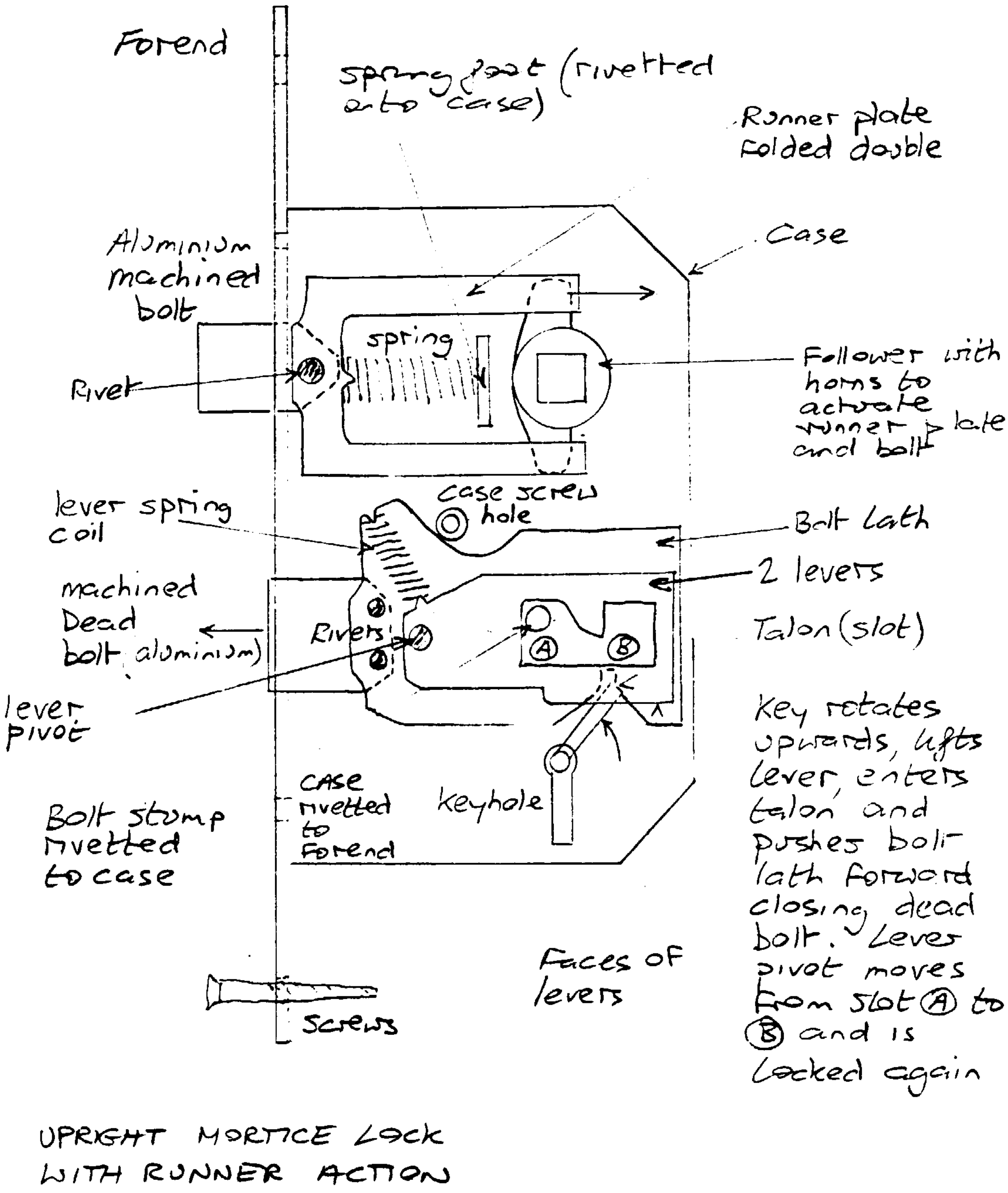

FIGURE 1 - MORTICE LOCK

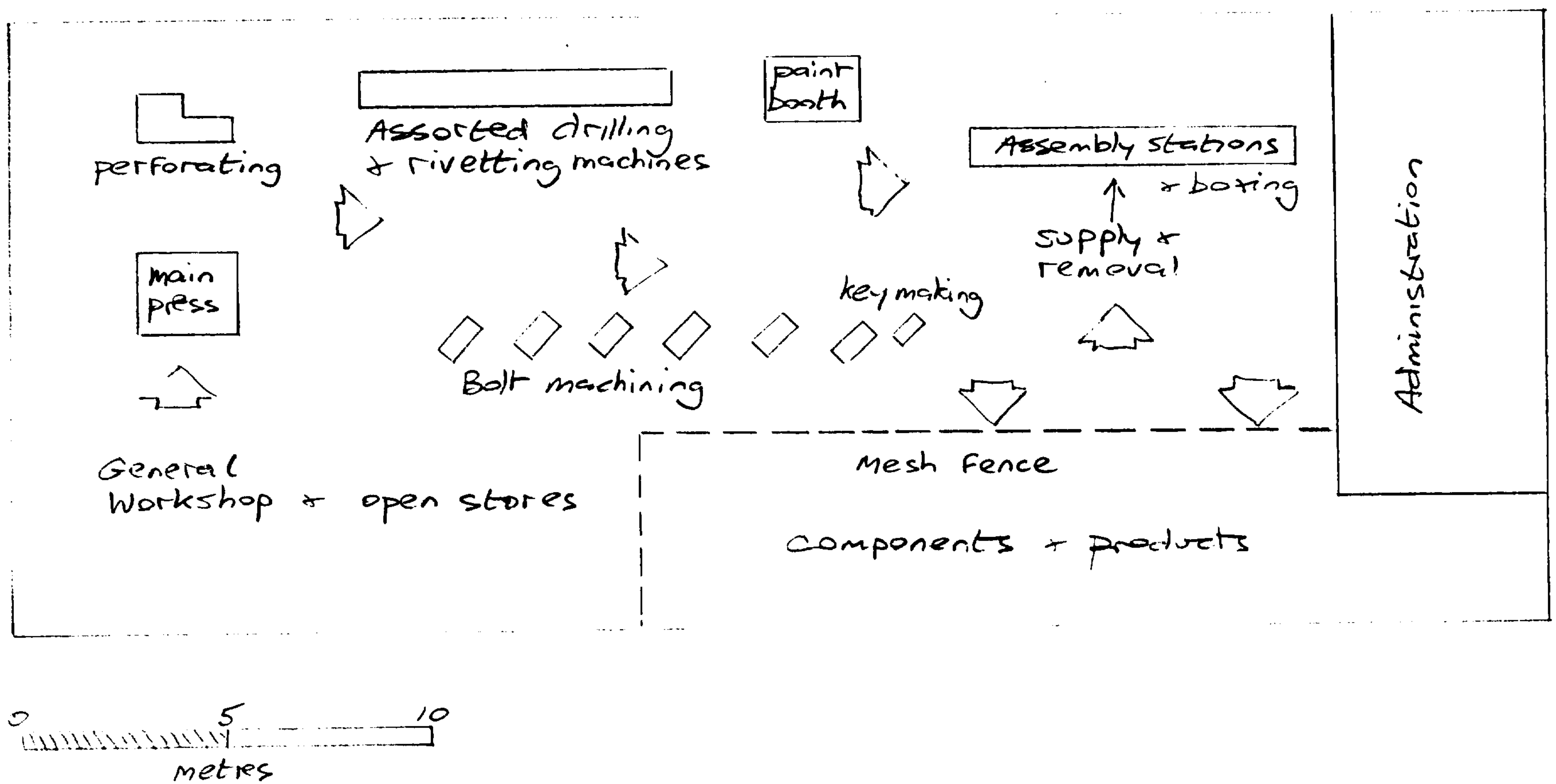

FIGURE 2 - MORTICE LOCK LAYOUT (INDICATIVE)

PADLOCKS

This profile describes a project for making relatively low quality padlocks at about 0.45 million/year in Ethiopia

1. Product Type, Volume and Price

Padlock type

This profile deals with padlocks from 25 to 45mm dimension. Many padlocks are larger than 45mm but sizes around 40mm are common in domestic use on personal boxes, bicycles, gates etc.

Common padlocks fall into two broad categories: lever locks and pin tumbler locks. Pin tumblers, sometimes called cylinder locks contain a precision mechanism of several spring loaded pins set in a machined cylinder.

It is not considered appropriate to make pin tumblers in Ethiopia. The mechanisms require more precision in the manufacture than most lever types and the machinery itself is complex. Pin tumbler mechanisms are made on machining centres, ie. a rotary table on which the part passes from one machining operation to another in sequence. Such centres produce well over 1 million pieces per year and might cost $½ million for the machine alone.

The padlocks described in this profile are not security type. They can be broken open and will not deter a determined thief. They might be described as 'padlocks for keeping honest people out'. It is likely that owners of godowns etc would require a heavier duty lock. Such locks cannot be made economically at the scale of opportunity in Ethiopia. Their manufacturing cost and price is much higher than the locks described here.

This profile describes two types of padlock. The first weighs about 70grms (at 40mm), has 2 levers and no brass parts other than a key guide. The second type has brass levers and locking mechanism and is rather sturdier, weighing 100 grms (at 40mm). The padlock types are shown in Figure 1.

Even lighter padlocks are available in the market with bodies pressed together from thinner gauge material. They are unsuitable for outside use.

Demand

IPS has specified the demand as about 450,000 units per year between 25 and 45mm. 25mm is a less common size than 40mm so it will be assumed that one-third of the demand is 25mm and two-thirds is 45mm.

The division of quality is taken as half of the cheapest type and half of the better quality.

It should be noted that this factory can only satisfy part of the Ethiopian product range.

Price

The prices ex-works from South East Asian manufacturers are given in Table 1. Together with transport costs, but without duties the weighted border price of the mix of products described is $US/1.026 million.

2. Process and Technology

The component list of the two locks is shown in Table 2. The second lock contains more brass parts and has a brass cover over the keyhole - purely a decorative feature.

A reasonable quality cheap lock cannot be made on simple machinery. The quality of finish and the dimesional tolerance will not permit this. Nor is it possible to convert the operation to largely hand manufacture. The stamping machines making the main parts can produce at least one million per year in a single 8 hour shift. The operation to stamp, perforate and shape the case is often done on a single purpose built machine producing several million parts per year (single shift).

An appropriate procedure in Ethiopia would be to split the operation into its component parts, each on a separate machine, i.e. stamp the blanks, perforate the holes, and shape the edges. The manufacturing sequences are given in Tables 3 and 4.

Technology

The large lock making companies are interested in participating in overseas ventures but would be difficult to attract at 0.45 million units per year. The venture cannot be undertaken without foreign assistance. The largest company in the UK making padlocks of the type described here is:

Henry Squire and Sons
New Invention
Willenhall
West Midlands
UK.

The supply of materials is not a problem. These can be sourced anywhere. But the equipment design does require know-how from experienced lockmakers.

Most leading lock designs are patented but these designs can be made available, though not necessarily with the name.

3. **Machinery and Cost**

Table 5 describes the main items of equipment and the costs. Two stamping presses are installed together with two perforating presses and two forming presses. One line makes cases and the other the small parts like levers and keys. The presses would operate on sheets rather than coils. The plant costs reflect the need to incorporate specialist design features. Tooling is a costly item.

4. **Layout**

The plant does not need to be laid out as a flow line. Volumes are small and parts can be made or stored in bins. The area requirements are as follows:

	m^2
Machine shops	550
Assembly, test, pack	270
Stores and maintenance	100
Administration	160
	1080

The building is about 4½ metres to the eaves. No craneage is needed. The building layout is shown in Figure 2.

5. **Materials and Costs**

Table 6 presents the materials requirements and the border prices. Total metallic materials amount to only just over 1 tonne per week.

The cold rolled sheets must be imported in packs. The wires can be drawn locally from imported steel and brass rod.

Materials can be separately and widely sourced.

6. Other First Costs and Operating Requirements

Annual maintenance materials and spares for plant should be costed at 5 percent of the plant items. An allowance must be made for building maintenance (3 percent per year would be satisfactory).

Project technical assistance and know-how should be allowed for at around $100,000 in the capital cost, or perhaps accounted as an annual charge.

Annual technical assistance should be allowed for at one month of visiting per year plus some small development charges, say $20,000/year.

Start up labour cost and recruitment allow 3 months of full annual charge.

Vehicle maintenance for 4 vehicles say $20,000 without duties on any items.

Expenses insurances, rates, phones, office items etc at say $145,000/year.

Advertising will be needed at say $16,000/year.

Electricity connected lead at 120 kVA with consumption at 80,000 kWh/year.

Water at 2000 gallons/day potable and industrial use.

Working capital should be allowed for at say:

Average 5 months materials
Average 6 weeks in process and finished
4 weeks debtors.

There is no special treatment of wastes. Metal scrap is sold. Acids are neutralised and discharged. Quantities are small.

7. **Manpower and Training**

Employment is given in Table 7.

The plant could be started by a single expatriate who would remain for about 6 months. Visits to a manufacturing plant overseas would be needed for the following:

General manager	1
Supervisor	1
Foremen	2
Maintenance engineer	1
Development engineer	1
	6

Approximately half the 30 or so technical operatives/foremen/ maintenance technicians would need to have received a preliminary engineering machinery training of about 6-12 months.

TABLE 1 - PADLOCK PRICES

	Price ex-works South East Asia $US each
Cheapest locks:	
25mm	1.35) Average
45mm	2.29) 1.82
Better quality:	
25mm	1.69) Average
45mm	2.86) 2.28

Weighted price ⅓ @ 25mm, ⅔ @ 45mm
½ cheap, ½ better quality
= $2.12

Add 5% agency and cif and 2½% port costs
= $2.28

Hence border price of 0.45 million = $1.026 million

Note: Padlocks from Europe/USA/Japan are substantially more costly.
Also quality padlocks are much more costly.

TABLE 2 - PADLOCK COMPONENTS

Component List - Cheap padlock:

- 2 pressed case sides
- 3 rivets and 1 flat post
- 3 small tubes to cover rivets inside
- Wrought steel shackle with collar
- Coiled spring (compression)
- 2 levers and 4 spacers
- 2 thin spring strips
- Brass key guide
- 2 keys (one piece stamped) with ring
- Display card (shrink wrapped).

Component List - Better padlock:

- 2 stamped faces
- Rolled strip forming body between faces
- 4 rivets and 3 location pins
- 4 small tubes to cover rivets inside
- Wrought steel shackle
- Brass actuator plate
- 4 brass levers
- 4 strip springs
- Brass keyhole surround
- Brass slider covering keyhole
- 2 welded keys
- Display card (shrink wrapped).

TABLE 3 - MANUFACTURING CHEAP LOCK

Stamp case front and back
Press shape case sides
Perforate rivet and key holes
Stamp levers and keys
Cut shackle bar
Roll form shackle
Grind shackle ends
Fit shackle collar
Form coil spring
Cut strip springs
Turn brass key guide as rod
Slot key guide as rod
Cut key guide to length
Cut rivet lengths and tubing
Electroplate steel parts
Rivet locating pins onto back
Assemble and press rivets
Inspect
Pack

TABLE 4 - MANUFACTURE BETTER LOCK

Stamp case front and back
Perforate rivet holes

Forge shackle shape
Roll form shackle
Grind shackle end

Roll form the outer strip forming the edge of case between front and back

Stamp actuator and levers and key cover
Press actuator lips and key cover
Crimp springs to lever

Stamp key parts and cut shaft
Weld key together
Grind key
Cut rivet lengths and tubes
Electroplate zinc on steel parts
Nickel plate keys

Assemble
Press rivets
Inspect
Pack

TABLE 5 - CAPITAL COSTS PADLOCKS

	Thousand Pounds
Plant (cif):	
Case stamping presses)	
Small parts stamping)	94
Shaping presses)	
Tooling	80
Shackle heating)	
Shackle bending)	
Shackle grinding)	
Body roll shaping)	52
Wire straightening)	
Rivet cutting)	
Spring coiling machine)	
Brass turning, slotting, cutting)	63
Key making	37
Electroplating line, tanks, pumps, etc	75
Assembly, packaging etc	45
Mobile equipment, maintenance, testing, racking, etc	90
	536
Spares	24
Plant erection	36
Mechanical and electrical services	36
Design and project management	29
	661
Vehicles cars and vans (4)	37
	698

	Thousand $US
Expressed in $US @ 1.5$/£	1047
Buildings could be costed as $US 460/m^2 for 1080m^2 including fittings	497

Excluding duties on plant, and site costs such as land, fencing, road landscaping

TABLE 6 - PADLOCK MATERIALS

	Tonnes
Cold rolled sheet 1mm for cases	22
Cold rolled sheet for levers	5
Cold rolled sheet for keys	6
Brass for levers	3
Bar for shackles	15
Brass rod for guides	2½
Steel wire for rivets and springs	¾

	$US
Port costs excluding duties:	
Cold rolled sheets	700/tonne
Wires	1600/tonne
Rod for shackles	900/tonne
Brass sheet and rods	2000/tonne

Scrap recovery at: 40% of brass @ $500
30% of steel @ $100

Printed cards 0.45 million	$23,000
Cartons	$ 2,000
Other consumables	$ 2,000
Electroplating chemicals	$11,500

TABLE 7 - EMPLOYMENT

	Number
Machine tools	19
Assembly, testing, packing, stores	13
Maintenance	5
Labouring, carrying, cleaning	14
Drivers	4
Trainees	5
Development	2
Foreman	4
Managers/supervisors	2
Administration and sales	11
Site	6
	85

Skill levels:	Number	%
Managers/supervisors/engineers/professional	8	9
Skilled	22	26
Semi-skilled	35	41
Unskilled	21	24
	85	100

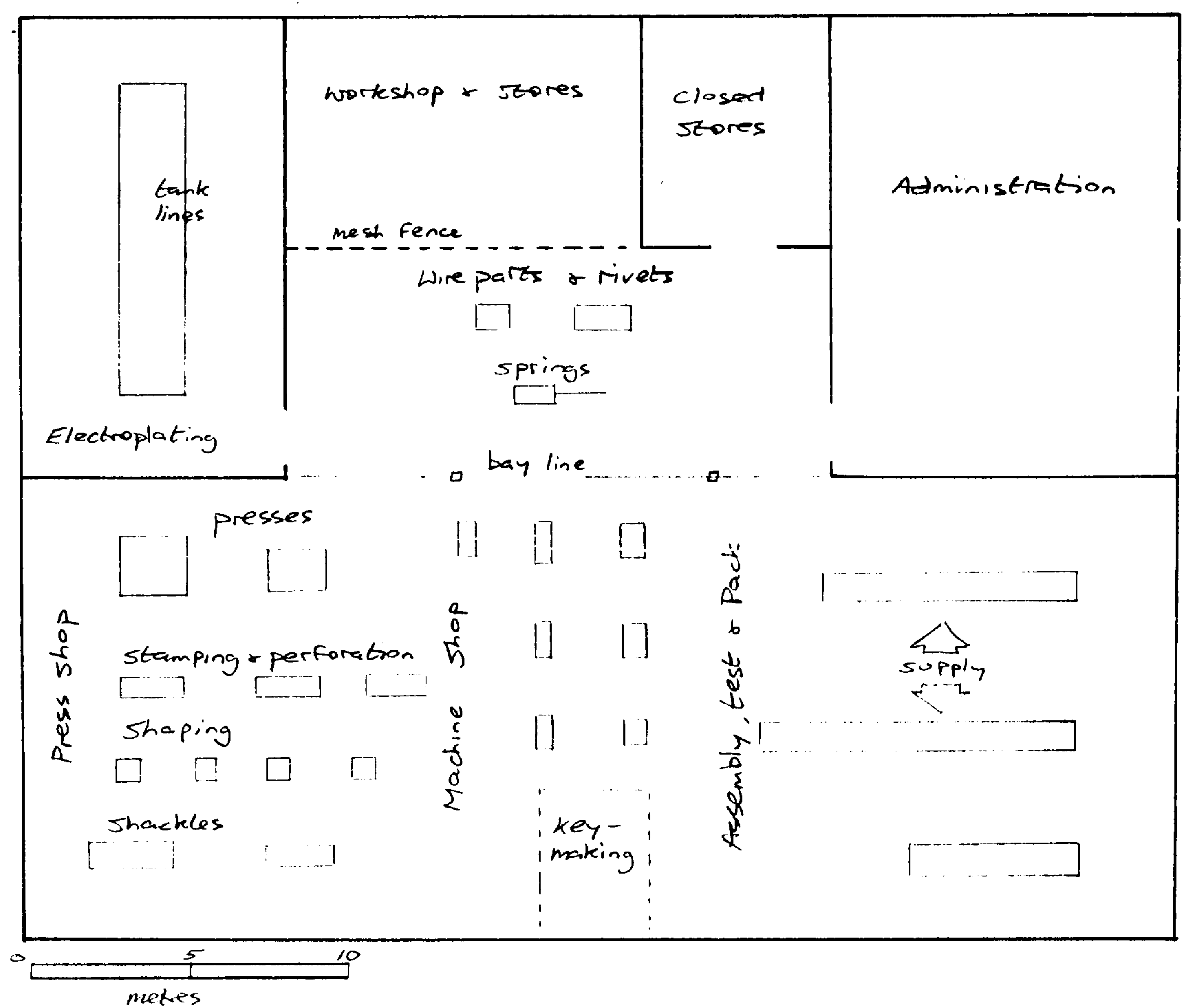

FIGURE 2 - PADLOCK LAYOUT

RAZOR BLADES

This project looks at the production of standard double edged razor blades on sophisticated equipment which can produce up to 100m blades per year. Reference is also made to second hand lines working at around 50 million/year

1. Product, Type, Volume and Price

The Product

Razor blades are small strips of thin Teflon coated stainless steel ground to a very sharp edge on two sides. The equipment discussed in this project enables production of marked double wrapped high quality blades. This is the basic equipment which can be easily modified or added to allow subsequent production of Premium (ie. chromium and Teflon coated blades) or Systems (ie. single edged and disposable products).

Volume

The Ethiopian market for razor blades has been identified as 160 tpy in 1986 rising to 183 tonnes by the year 2000. This represents a range from 160 million blades to 183 million. The plant described can make up to 100 million blades a year using two shifts and is the minimum that would be required to produce razor blades from steel strip to the finished product.

Price

Quality brand name razor blades in Europe cost around $6 per 100 and lesser known products around $4. This profile is based on 100 million blades, with a total ex-works price of $4 million. Transport and port costs add about $24,000 making a border price of $4.02 million

2. Process and Technology

Razor blade production is a continuous high speed and highly accurate process. Steel strip is perforated at up to 800 blades a minute, heat treated and then joined into longer strips before being printed, having its edges sharpened and being coated with an anti-friction polymer. The process involves electrostatic spraying, the use of cracked ammonia and the production of a product with a tolerance in places of less than three-tenths of a micron.

Technology

Wilkinson Sword, one of the world's largest producers of razor blades is able to offer a range of services from simple plant supply through to complete factory installations, training and technical back up. They are at:

Wilkinson Sword Ltd
Sword House
Totteridge Road
High Wycombe HP13 6EJ

3. Machinery and Cost

Machinery

The process flow is shown in Figure .. Coiled razor blade strip is pierced and notched in a high speed press at a speed which is infinitely variable between 200 and 800 blades per minute. A press feed unit is connected electrically to the press and the size of the unwind and wind up loops are controlled electronically by sensors thus ensuring an even flow of material through the press. A 99% accuracy to within +/- .002 inch for pitch and centrality is essential to allow further processing.

The strips then pass through a furnace assembly which cleans and hardens the blades at a speed of 28000 per hour. The furnace has seven independantly controlled heating zones. Strip passes through stainless steel muffle tubes which have a continuous flow of cracked ammonia flowing through them to prevent oxidation. The strip is then quenched to less than -60 degrees centigrade in the ice box and passed over a heated inspection plate which dries it and allows inspection for visible defects.

The strip must then be tempered to allow further processing without fracture. End tempering involves passing the strip between pairs of free running, water cooled phosphor bronze rollers which pass a 30 amp current to locally temper the blades. Cracked ammonia is again used to prevent oxidation. The strip is finally quenched using a chill block and rewound onto loops for transportation to the next stage.

Coil joining and strip inspection is done on one machine at up to 15000 blades an hour. The machine is used to examine strip visually for defects such as corrosion, scratching, indents etc., and to automatically check it for deformations such as dishing, bent corners and bad joints. Small coils are spot welded together to fill larger transportation drums of 100,000 blade capacity and are ground to make sure the strip fits all relevant dimensional parameters. If the dimensions are not right, the machine will break the strip and stop.

Printing is not an essential part of the process but allows the blades to be ink printed with name and trade marks simultaneously on both sides at up to 70,000 per hour. After printing the ink is cured by passing the strip between a pair of gas burner tubes, cooled by passing through water cooled chilling rollers, inspected by means of a permanently sited stroboscope, demagnetised and wound onto the take-off drum.

The next stage is grinding where the strip is ground, rough and fine honed and reduce to individual blades in one operation at 16,000 blades an hour. After this the ground honed blank is turned into a finished stropped blade with an extremely fine edge, free from major irregularities and a blade tip cross-section controlled to within three tenths of a micron. Stringent inspection tests are imposed on the finished stropped blades where the tip section is measured on a special microscope and the cutting force required is recorded. This is the balance between ease of cutting and premature edge break down.

The blades are then coated with anti-friction polymer (PTFE) in order to improve shaving comfort and increase shaving life. Around 34,000 blades an hour can be processed through one complete line. In the PTFE coating process the blades are stacked 30,000 to a carrier and six carriers in a cannister and thoroughly cleaned in an atmosphere of cracked ammonia. These are then placed in a cooled, controlled 20% relative humidity cabinet. The blades are preheated and electrostatically sprayed with a water based polymer dispersion which is sintered onto the blade edge in order to obtain an adherent, durable film.

The blades are then inspected, wrapped and packed. The costs for the various pieces of equipment are given below in Table 1.

The capital investment is very high but there is second hand equipment available at half the price. Also packing does not need to be so sophisticated.

4. Layout

The building must have a minimum ceiling height of 4 metres.

The factory requires 1800m^2 of space, split approximately as follows:

	m^2
Factory line	1025
Test and packing	150
Storage	300
Engineering	150
Administration	175
	1800

5. Materials and Costs

The likely imports or raw materials required will be as follows:

- Stainless steel strip
- Grinding wheels
- Stropping leathers
- Refrigerant R13 and R502
- Polishing compound
- Tygertape
- Controlled atmosphere gases
- Printing ink
- Stropping compound
- Vydax and Freon
- Wax paper

The costs of these products are shown in Table 2.

6. Other Operating Requirements

Other operating requirements include a stable and constant electricity supply with a total KVA of 250 and a standby generator and voltage stabilizing equipment would be advisable. These costs are shown in Table 3.

7. Manpower and Training

Manpower

The manpower requirements per shift are listed in Table 4. The factory will run with about fifty per shift.

Training

Six people will need to visit a manufacturer for up to 3 months and there will be a further 2 months preparatory work in Ethiopia during commissioning. All skilled workers will need about 2 months training during start-up. Two weeks should be allowed for semi-skilled workers.

8. Concluding Remarks

At the stated volume the capital costs far exceed the guideline maximum of $1 million but the plant would be highly utilised on two-shift working. Such a plant has a relatively high fixed cost element and relatively low materials cost. In these circumstances the plant should be competitive, even with the lower priced imports.

Second hand plants with lower outputs and hence lower revenues (50 million blades per year) can be purchased with substantial capital cost savings (Wilkinson is currently offering such a plant). These plants do however require supervision of dismantling and considerable refurbishment. They can be uprated and in this case may show some commercial advantage over a new plant.

TABLE 1 - CAPITAL COSTS

Item	$ Thousand
Plant costs (cif):	
Perforation	275
Heat treatment	589
Coil joining/strip inspection	156
Passivation	176
Printing	217
Strip Grinding	1285
Stropping	949
Teflon Coating	214
Ammonia Cracking	38
Inspection laboratory	101
Wrapping/packing	982
Installation equipment	101
Production ancillaries	37
Spares	293
Subtotal	5413*
Freight and insurance	370
Erection	426
Mechanical and electrical services	203
Vehicles	60
Design and engineering	320
	6792
The building can be costed at $460m^2$ for $1800m^2$ =	828

Excluding import duties and all site costs (land, roads, fencing, landscaping etc)

* A second hand plant would cost around $2½ million. After supervision of dismantling plus refurbishment this might amount to about $3¼ million. The cif plant cost would be about $3.5 million. Other costs will be the same. The total plant cost would probably reduce from $6.8 million to under $5.0 million.

TABLE 2 - MATERIALS COSTS

Item	Price	$ Thousand per year
Stainless steel strip	120 tonnes at 3700$/t	444
Grinding wheels	)	
Stropping leathers	)	40
Polishing compound	)	
Stropping compound	)	
Other materials including gases, refrigerants, lubricants, coatings, wax paper and printed packs plus commercial packs and displays		210
		694

TABLE 3 - OTHER OPERATING COSTS (RAZORS)

	$ Thousand
Other Investment costs:	
Technical agreement	300
Start-up labour and admin cost	105

	$ Thousand per year
Labour (weighted cost) $4015 x 117	470
Electricity (50kVA connected) 700,000 kWh	49
Water 1500 gallons/day	2
Maintenance materials and spares:	
Plant	246
Buildings	25
Administration	260
Vehicle maintenance	15
Technical assistance and development	35
Advertising	15

Working capital:
- 4 months materials
- 2 weeks stock
- 6 week debtors

TABLE 4 - EMPLOYMENT (RAZOR BLADES)

Shift manager & supervisors	5
Operators	20
Trainees	4
Quality control	4
Stores	2
Shift maintenance	3
Carriers and cleaners	8
Site	3
Second shift	49
Administration (GM, finance (2), sales(3) admin (1), secretaries (3), drivers (5) shift admin (4)	19
	117

Skill levels:	Number	%
Professional/technical	16	14
Skilled	34	29
Semi skilled	44	38
Unskilled	23	19
	117	100

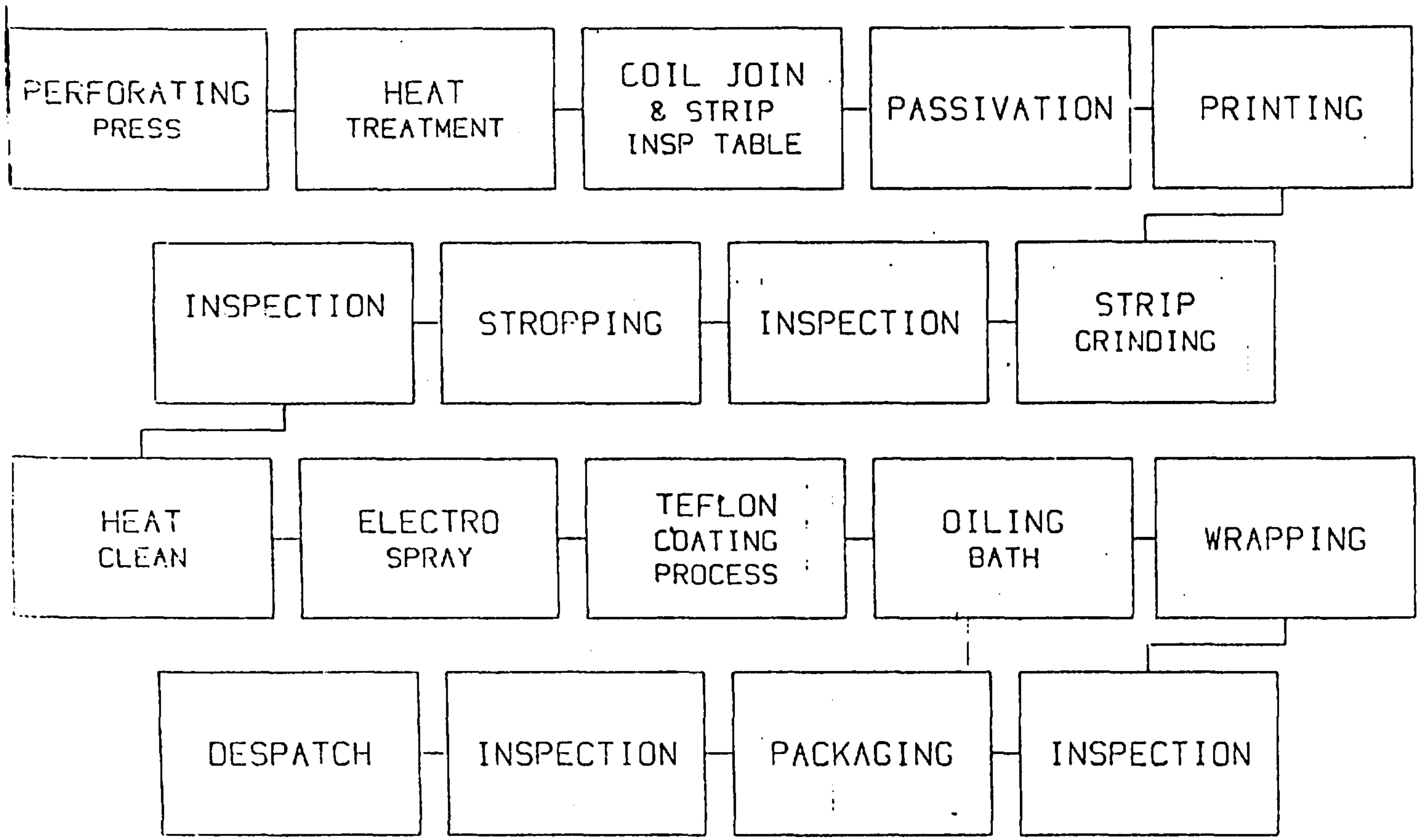

FIGURE 1 - RAZOR BLADE PROCESS

GRINDING WHEELS

A factory designed to manufacture grinding wheels made from powdered abrasives mixed with liquid and dry binders is discussed. A throughput of 160,000 wheels (180 tpy) of standard design on two shifts

1. Product, Type, Volume and Price

Product type

There are two types of grinding wheel - resinoid wheels are used mainly in high speed, dry applications such as fettling and snagging in casting shops and cutting off, because they can break down under wet conditions. Vitreous wheels are used for more general purpose grinding, finishing and sharpening and have the advantage of being unaffected by water. The manufacturing process is very similar for the two types and they are normally combined. Vitreous grinding wheels are used more than resinoid wheels.

The abrasive quality of the wheel is dependent upon a combination of factors - the composition of the abrasive powder, its size and the density with which it fits into the matrix.

An aluminium oxide will be used for tough, high tensile surfaces such as high carbon steel, high alloy steels, high speed steels, annealed maleable iron and tough bronzes. Silicon carbide is used for softer surfaces and hard brittle materials such as grey iron, chilled iron, brass, soft bronze, copper, aluminium, stone and rubber. Generally a fine grain size is best for a hard brittle material and a coarse grain size for a softer one.

The equipment discussed in this project profile is capable of making all qualitities of both vitreous and resinoid grinding wheels in a large number of standard sizes.

Volume of Production

The current market demand has been identified as around 550 tonnes of grinding wheels. This represents 400,000 six inch wheels a year - six inch wheels have been chosen, for calculation purposes, to represent a range from three inch to twelve inch of various thicknesses, qualities and shapes. The demand increases to 649 tonnes in 1990 and 738 tonnes in 1994.

Output in the factory is determined by kiln throughput and as kilns are the most expensive capital item, this profile considers production using one oven for resinoid wheels and one kiln for vitreous wheels. The volume of wheels produced will therefore be up to 100,000 per year for single shift work and 200,000 for two shifts. A figure of 160,000 will be assumed in Ethiopia. This is equivalent to about 130 tonnes of wheels (2 shifts). If the market share of the manufacturing plant exceeds this volume then further capital investment will be required.

Product Price

Grinding wheels have a 70 percent labour factor in their price, so it is generally cheaper to make them at locations where labour costs are relatively low. Also the fragile nature of the finished product means that transport should be minimised. The European ex-works price of the product is size dependant, with three inch wheels costing just over $1½ and twelve inch wheels up to around $60. Resinoid wheels are cheaper than vitrified ones, pure aluminium oxide ones are more expensive than those made of regular aluminium oxide, while silicon carbide wheels are the most expensive of all.

A weighted ex-works price of grinding wheels can be developed as shown in Table 1.

2. Process and Technology

Process

Manufacture of grinding wheels is not a high technology business. It is labour intensive and requires attention to detail to achieve a quality product. Each wheel is made individually and to specification before being loaded in a batch to enter the oven or kiln. The heated wheels are then finished, tested and inspected individually before leaving the factory. The nature of the process means the products are made to order, so one production line with two presses and mixers will be adequate to supply anything up to 50% of the stated demand for grinding wheels. If demand exceeds the production capabilities of one line it is simple to expand a well designed factory to accommodate further production.

Technology

Although manufacture of grinding wheels is not a highly skilled operation it does require a great deal of know-how. One company which could provide all required equipment, raw materials and transfer of technology is Abrafract of Sheffield, which has been in the business sixty years and can offer full training facilities.

Abrafract Ltd
Beulah Road
Sheffield S6 ZAR

Tel: 0742-318971
Tx: Abrafract Sheffield 547202

The process itself is straight forward with no toxic waste products but dust extraction, some air conditioning and also refrigeration for the liquid phenol formaldehyde resin will be required.

3. Machinery and Cost

Machinery

A flow chart of the process is shown in Figure 1. The first step in the process is to weigh out the aluminium oxide, silicon carbide and relevant binders, the amount of which will be dependant upon the specification for the finished product. These powders are then put on a plate to be carried to a sieve to remove lumps, before being placed in a mixer. Mixing takes place until the operator is satisfied with the consistency.

This mixture is taken to the press where an exact amount is weighed cut and placed in the mould. This is compressed until solid and then put on an oven plate to await firing. Alternatively a vibrator can be used to shake the powder down into its mould. The number of mould shapes that fit on the press is only limited by their size. Three basic shapes for each of a range of sizes have been selected for this project. Up to this point the process for resinoid and vitreous wheels is similar, except the vitreous products may require the introduction of a temporary binder at the mixing stage.

Once the firing buggies are full, the resinoid wheels will go into the ovens and the vitrified wheels into the kilns. The process time in the oven is around two days and this requires a careful build up of temperature profile to 200 degrees centigrade followed by controlled cooling. The kiln firing cycle is up to a week and the heating to 1250 degrees centigrade and subsequent cooling is equally controlled.

After firing, the wheels have to be adjusted to their final size. This involves grinding the surfaces parallel both between top and bottom and from middle to edge. Special shapes or indentations will be ground in at this stage. The most critical property of a grinding wheel is that its centre bore is true. A standard size of 31.75mm can be reduced using a leading machine (to form a metallic lead bush) which fills the hole to the prescribed diameter. The result is tested with a 'go, no go' tool which is double ended with one end designed to fit through the whole and the other not to fit.

The wheel is then speed tested at a speed 50 percent greater than its specified operating speed, which must be indicated on the label. There should be a very low failure rate. After speed testing the wheels are visually inspected and then labelled. The label, which doubles as a buffer between the wheel and the grinding machine plate, must indicate the abrasive type, grain size, grade, structure and bond type as well as the maximum operating speed and the source.

Capital Cost

The capital costs of the project are outlined in Table 2.

4. Layout

The area requirements are split as follows:

	m^2
factory	450
stores	500
engineering	50
administration	150
	1150

Adopting a long thin design to the building, which has an overall area of 1150 square metres, makes it simple to expand production when necessary. No overhead cranes are required but if fork lift trucks are available the storage space can be reduced. The layout is shown in Figure 2.

5. Materials and Costs

Materials

The raw materials required are as follows:

a) Around 200 tonnes comprising 80% aluminium oxide and 20% silicon carbide will be required for the first years production.

b) 16 tonnes of dry and powdered phenol formaldehyde resin

c) Labels, printing ink and glue to mark up to 200,000 wheels, lead for bushing

d) Boxes (marked fragile), packing material and binding tape for packaging.

The costs of the above materials are given in Table 3

Sourcing

All the above materials could be supplied by a foreign technical partner if required.

6. Other Operating Requirements

Conversion costs are also included in Table 3. An electricity supply to drive the presses, oven, kiln, compressor and other equipment will be required at 50 kVA.

A special refrigerator will be needed to store the liquid phenol resin at -1 degrees centigrade to prevent it from going off. This will need to be walk-through to ensure the chronological use of supplies.

Dust extractors are required to keep the site free of abrasive and air conditioning in the mixing area to prevent the mixture absorbing moisture from the air.

No toxic wastes are produced by the plant but the extractors will produce a lot of dust.

7. Manpower and Training

Manpower

The plant can be operated with 24 direct employees per shift as shown in Table 4.

Training

The plant would be best started by a single expatriate technologist with experience in grinding wheel manufacture who would remain on site for at least a year, (training of the General Manager for an unlimited length of time is offered free by Abrafract if he is based in the UK works). Other operatives would be trained in-situ during start up.

8. Concluding Remarks

This profile is not intended to provide a commercial evaluation but the following remarks may be helpful.

The plant can operate at full output on a two-shift basis. Materials form one-third of total costs but are widely and competitively available. The capital cost exceeds the $1 million guideline but is probably effectively utilised. There are competitive plants in operation at the above throughput and this plant is probably also competitive.

TABLE 1 - PRICES OF GRINDING WHEELS

		ex-works price per unit in $
Vitreous Wheels:	Aluminium oxide	4.68
	Silicon carbide	6.70
Resinoid:	Aluminium oxide	4.63
	Silicon carbide	6.53

Product distribution:

70% Aluminium oxide
30% Silicon carbide
60% Vitreous
40% Resinoid

Weighted price of 6 inch wheels $5.23

Transport to Assab for this product (727 wheels/tonne) will cost about $0.3. Therefore total $5.53

Hence border price of 200,000 wheels is $1.106 million

TABLE 2 - CAPITAL COST

Item	$ Thousand
Scales - 1 large, 1 medium, 2 small 2 sieves Barrel mixer Dough mixer	39
2 Presses - single acting downstroke with turn table @ 50,000/year Moulds - 3 size of plate for 3", 4", 5", 6", 8", 9", 10" and 12" Segment moulds - 6" lumsden, churchill 8" lumsden, snow & churchill Vibration table	180
1 oven - four feet cubed, 36kW 1 kiln with bogie 12' x 3'6' x 3'	56
Side facing machine 1 lathe 1 cup lathe Topping machine Speed tester Balancer Tooling for tester and balancer	152
Leading bench centering and bushing machine Go, no go gauges and other measuring	53
Tiko press and stencils Handling/plates/miscellaneous Five dust extractor units Compressor Refrigeration unit - 8' x 6' x 4'	108
Spares	29
	617
Packing freight and insurance plus port cost	31
Vehicles	40
Erection	49
Mechanical and electrical services	55
Project design and engineering	38
	830
Buildings 1150m^2 at \$460/m^2	529

Excluding duties and all site costs such as land, fencing, roads, landscaping etc.

TABLE 3 - MATERIALS AND OTHER COSTS

	$ Thousand
Annual materials cost:	
Aluminium oxide 160t @ $950	150
Silicon carbide 40t @ $1400	56
Powdered phenol formaldehyde resin 16t @ $1700	27
Other items, binders, lead bushes, printing, packing and literature	70
	303
Other investment costs:	
Technical assistance contract	350
Start-up costs	20
	370
Conversion Costs:	
Labour 67 x $3425	229
Electricity 996,000 kwh	70
Water 2000 gallons/day	4
Maintenance materials and spares	
Plant	29
Buildings	16
Administration expenses	125
Vehicle maintenance	15
Technical assistance	12
Working capital:	
3 months materials	
6 weeks stock	
4 weeks debtors	

TABLE 4 - EMPLOYMENT - GRINDING WHEELS

	Number
Shift employment:	
Foreman	1
Weighman	1
Mixers	2
Pressing	2
Firing	2
Finishing	4
Leading	1
Testing	2
Inspection	1
Labelling and packing	1
Carriers and cleaners	5
Site workers	2
	24
Second shift	24
maintenance	3
trainees	3
stores	2
Administration (GM, sales (2), finance, clerks, secretaries, drawers	12
	68

Skill distribution:	Number	%
Professional/technical	4	6
Skilled	11	16
Semi Skilled	39	58
Unskilled	14	21
	68	100

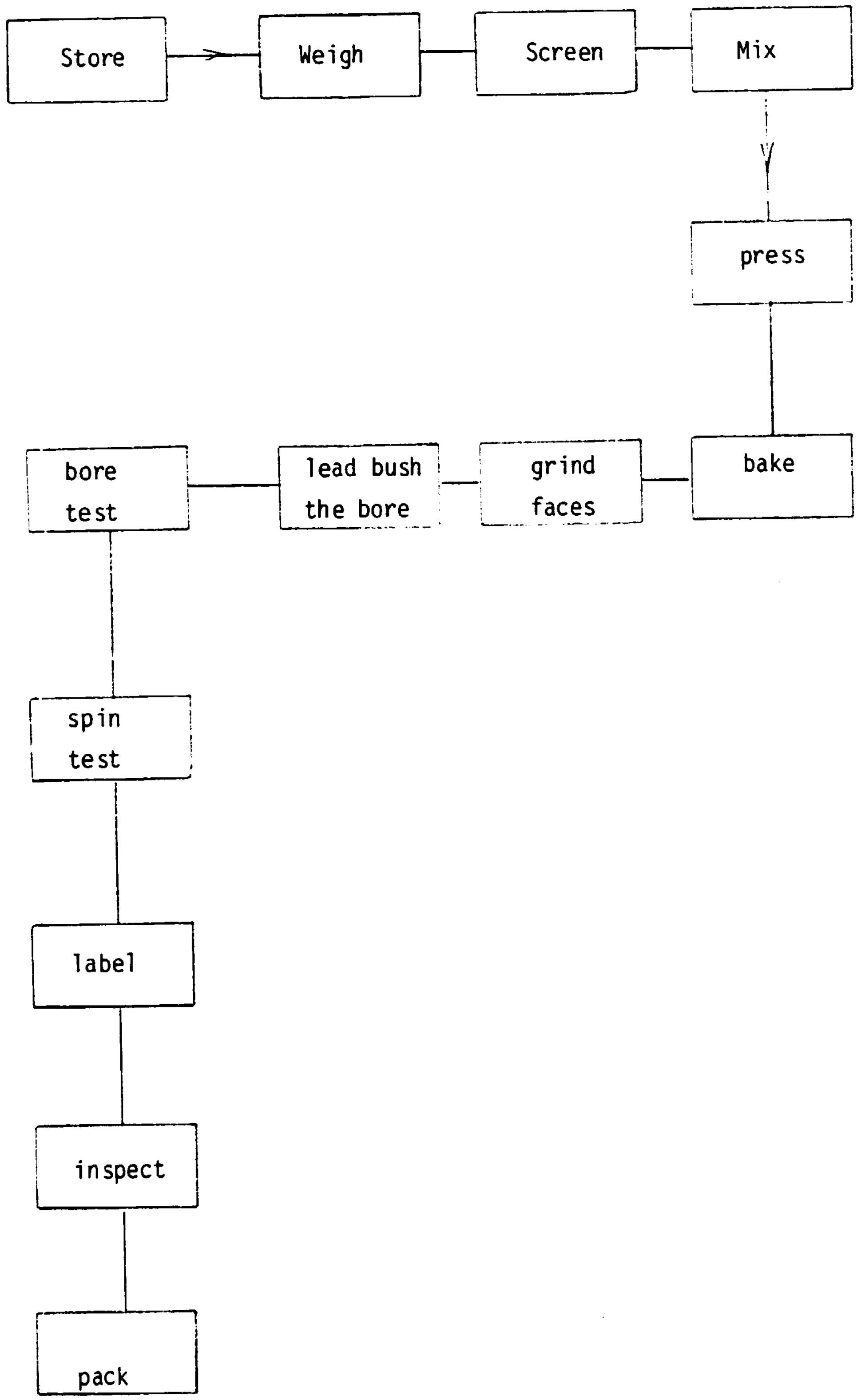

FIGURE 1 - GRINDING WHEELS PROCESS

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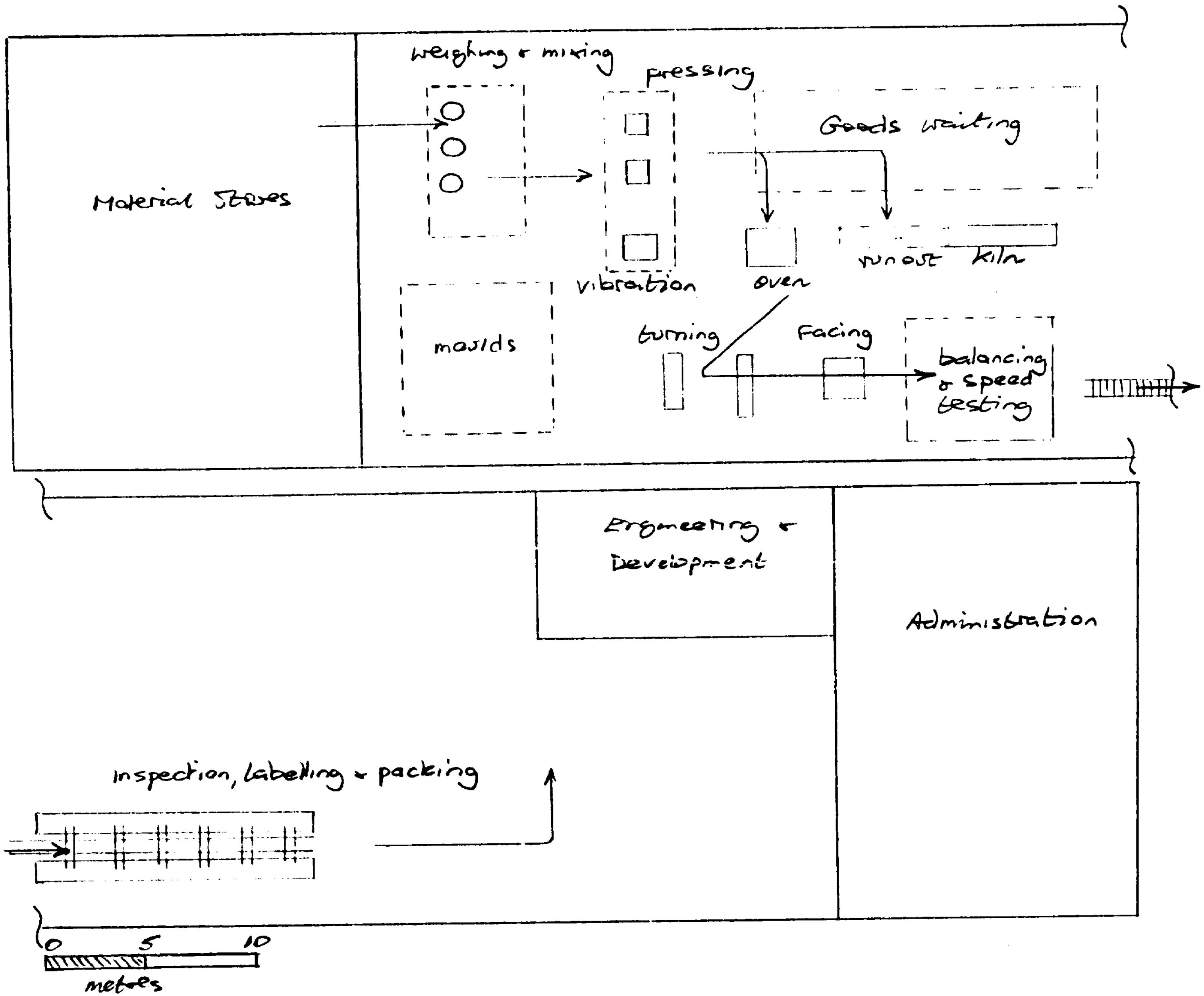

FIGURE 2 - GRINDING WHEEL LAYOUT

WATER METERS

This profile deals with the assembly and part manufacture of 15 and 20mm water meters at up to 50,000/year

1. Product Type, Volume and Price

Product type

Water meters, fall into four main categories (EEC Classification) depending on type and accuracy. In descending order of quality these are.

A Single jet meters actuated by a plastic fan wheel rotor blade; accuracy $\pm$ 2 percent at 130 litres/hour minimum flow.

B Multijet meters with a rotor blade which is driven by several water jets emitting from an annular ring around the rotor blade; accuracy $\pm$ 2 percent at minimum 120 litres/hour and $\pm$ 5 percent at 30 litres/hour. (It is understood that the Koreans and perhaps the Japanese manufacture a single jet meter classed as 'B').

C Piston meter with an eccentric rotation of a light plastic piston around the inside diameter of a plastic cylinder; accuracy $\pm$ 2 percent at 22.5 litres/hour.

D Piston meter of smaller size with greater accuracy $\pm$ 2 percent at 15 litres/hour.

It is important to establish the quality of the water in the area in which the meter is to be used. Where the water supply contains sediment or entrained air, the meter becomes abraded or pitted and damaged. In this case, quality meters of types B, C and D are of no use since their accuracy quickly decreases. Where a water supply is intermittent then sediment nearly always appears.

Sometimes water supply is highly corrosive to materials used in a meter. The general observations made in this profile must be viewed in the light of specific experience by Addis Ababa water and sewage Authority and other water authorities in Ethiopia.

A further fact to be taken into account in selecting a meter type is the purpose of the metering exercise. The lowest quality meters (A type) and jetmeters in general tend to over record water usage and so have the effect of overcharging the consumer based on meter readings. This can lead to disputes. The meters also 'drift' with age.

The meters produced in industrialised countries tend to be of types B, C and D. Fewer A type meters are produced and often these are imported cheaply produced components. Italy produces a popular A type meter.

The type of meter examined in this profile is type A, a single jet rotor meter, designed for 15 and 20mm domestic water connections. These make up a small percentage of the water meter market in developed countries, but around 80 percent in many developing countries. It is understood that this type of meter is popular in Ethiopia.

Demand

Ethiopian demand has been specified by IPS as follows:

	Number per year
1986	15,500
1990	30,200
1995	48,900
2000	92,500

Meters of the dimensions described (½ and ¾ inch normally make up about 80 percent of the market).

A plant which began construction at end 1987 would be in operation by end 1989 and might aim to satisfy over half the market by 1991, say 13,000 units per year increasing to nearly 40,000 by the mid 1990's.

Price

Type A meters would be available from Italy and Korea for about $8 - $8.5 respectively. Allowing 2 percent agency and cif costs plus ½ percent port costs at Assab, the border price of A type meters (average of 15 and 20mm) is $8-50. A plant is operating in Kenya, mainly assembling meters. Attempts to make the bronze body have not been successful. Costs are very high. A plant in Riyadh, Saudi Arabia is diecasting the meter body but importing nearly all the internal ports from France. Costs are said to be three times that of the same meter made at high volume in Europe (even though the internals are not exhorbitantly priced).

A venture making meters could endeavour to cut its costs by procuring the simpler plastic parts from a specialist plastic diecaster (one exists in Addis), the bronze from a bronze/brass factory making taps etc, and met[illegible] parts from a sheet metal works. The meter plant would only assem[illegible] and test.

The three largest water meter manufacturers in the world are:

Kent meters (UK)
Pont a Mousson (France)
Schlumberger (USA)

The main sources of cheap imports are Poland, Korea and Italy. Some cheap developing country producers are actually making pirated meter designs and are not therefore in a position to pass on their technology.

The ex-works price of a quality type B meter would be approx $16 at 15mm and $17-50 at 20mm. Similar dimension but lower quality meters could probably be purchased from countries like Korea and Poland for about $12 and $13 respectively.

2. Process and Technology

The stages of development of water meter assembly and manufacture are as follows:

a) import kits, assemble, test and box. At around 10,000/year assembly is possible. the only parts which might be made are some external plastic parts such as internal packing, thread protective caps and a lid. The boxes could also be provided locally.

b) At about 100,000/year it is possible to consider the manufacture of most parts although there are still serious diseconomies of scale. At this level of output it would not be possible to compete with developed country prices. Consideration could, however, be given to machining the body and to making some plastic parts at over 50,000 per year.

c) Some of the more intricate parts can be made economically at 200,000/year but not the counter mechanism (which accounts for over one-third of total cost).

d) Counter sub-assemblies are made of apparently simple small plastic caps and tumblers but in reality these are made to extremely high tolerances and assembly is intricate. They cannot be made competitively as less than around ½ million /year. Kent meters do establish foreign ventures and would sell kits of parts but they, like the other leading producers, do not produce a very cheap meter suitable for the Ethiopian market. Their own cheap meter uses imported Italian parts and is assembled in the UK on an irregular basis.

A European class B meter kit can be exported fob p: ,13-15. Assembly and testing of these meters would add some $4 to the cost making them $17-19 total (excluding all duties). This compares with the imported A class meter price by about $8.5.

Kent meters could be approached (and have dealt with Ethiopian water authorities in the past). They are at

Kent Meters Ltd
Pondwicks Road
Luten
Bedfordshire LU1 3LJ
England

3. Machinery

The machinery requirements and cost are given in Table 3. The total cost of the machinery fob Europe excluding vehicles and spares is $1.9 million. On one shift, this plant can make 100,000 units per year. On two shifts output could approach 200.000/year. A relatively small increase in investment would be needed to increase output further. An example of the design of a class A meter is shown in Figure 1 and the components are listed in Table 1. The manufacturing sequence is given in Table 2 would achieve substantial further increases in output. Such a plant would have exceedingly high unit costs when producing only 40,000/year.

4. Layout

The layout of the above plant can be arranged in any convenient manner while allowing for a raised ceiling height to accommodate monorails and fume extraction units in the foundry. There are separate manufacturing shops and materials and components are carried around in bins. The area requirements are:

	m^2
foundry	650
machine shop	420
die casting	180
assembly testing, inspection and packing	400
stores	160
maintenance and development	120
administration	170
	2,100

5. Materials

Table 4 gives the materials requirements. Table 5 shows the other operating costs. At this stage the technical agreement and support costs are only indicative.

It should be noted that the counter mechanism forming the top part of the meter is imported complete. Sheet metal parts are also imported or made locally

6. Employment and Training

Table 6 presents the total employment at 106 persons of whom 41 are professional, technical or skilled.

It would be advisable to provide overseas plant visits and process familiarisation to six persons as follows.

General manager
Foundry superintendent
Machine shop superintendent
Diecaster operator
Development engineer
Maintenance engineer

All the professional and technical staff should be employed some three months before start up. About one third of the skilled workers (with at least one year of responsible engineering industry and practical experience) should be recruited about 6 weeks before start up so that they can receive instruction from management and the technical partner.

The remaining skilled workers could be trained in-house after a basic technical education but in this case it will take 3-4 years to reach the output of 40,000 units/year.

7. Concluding Remarks

Manufacture is not competitive below ¼ million (counter mechanisms at ½ million). Supply of different components from other, higher output factories might be possible at under 100,000.

Of the capital costs given in Table 3 only about 10 percent is attributable to the assembly and testing, as shown below:

	percent of total cost
Foundry and machining of bodies	40
Diecasting (and tools) for plastics	50
Assembly and testing	10
	100

The bronze bodies could be cast at another foundry in Ethiopia and machined there or at the meter plant. It is now common practice for meter makers to subcontract the casting of parts. The plastics could perhaps be cast at Ethioplastics where there are sophisticated and underutilised diecasting machines (the tooling for the diecastings would still need to be purchased).

The effect of this subcontracting of components would be to reduce the actual water meter assembly to a very small project. It would however still not compete with imports. We do not know of precedents for establishing manufacturing in this fragmented way. It might prove difficult to secure a satisfactory technical assistance contract with appropriate guarantees.

It would certainly be possible to establish a simple assembly - only venture with components supplied by a leading western manufacturer.

TABLE 1 - WATER METER COMPONENTS

Bronze body
Connections (2) with seals
Brass nuts (2) for connection
Plastic end caps (2) for body threads
Plastic seal for glass top
Plastic turbine
Plastic deflector plate
Sealing ring for pressure plate
Pressure plate with turbine locating pin and magnet
Boiler plate spring
'O' ring

Plastic counter housing
Spacer plate
Magnet follower with pointer
Plastic plate locating counter
Non-return valve
Counter assembly (complete)
Filter
Optional plastic top body
Top body lid

Single jet type

TABLE 2 - MANUFACTURING SEQUENCE: WATER METERS

Induction melting of bronze
Sand cast brass body and pipe fittings
Fettling of body
Machining of body turning, slotting, threading
Machining of nuts and pipe fitting

Die casting of simpler plastic parts:
counter housing, geat plate, cover and lid
pipe thread caps. seals, non-return valve

Die casting of more intricate parts:
turbine, upper gear plate, magnet follower, pointer

Stamping of metal parts: pressure plate, springs

Assembly (with counter*)

Flow testing

Dry, reset

Packing

Counter assembly with glass cover supplied complete

TABLE 3 - CAPITAL COSTS WATER METERS

	$ thousand
Bronze foundry: LF furnace, sand Store and treatment, mixing, moulding machine, core sand plant, mixers, coremakers, core treatment, patterns, casting roller bed, shake-out, conveyors, hoists, fettling and dust control, sand testing, moulding bores etc	435
Body and connector machining, capstan lathes, other lathes, milling, slotting, drilling, threading, tooling	220
Diecasting machines plus ancillaries	680
Tooling for diecasters	195
Assembly, inspection, testing, painting, and miner jobs (serial number rooling, counter testing, drying and resetting etc)	165
Auxiliary plants including maintenance and services, store, mobile plant	170
Vehicles	55
Spares	85
	2005
Cif and port costs	150
Erection and commissioning	270
Mech & Elec services	180
Fittings	100
Project design and engineering	205
	2910
Building could be costed at $US 520/m^2 for 2100m^2	1092

Excluding duties on plant and all site costs such as land fencing roads, landscaping

TABLE 4 - WATER METER MATERIALS

	$ 000
At 40,000 units/year:	40
New ferrous metals (25 tonnes)	
Imported foundry and core sands (60 tonnes)	14
Foundry supplies: binders, abrasives etc	12
Plastics - various (5 tonnes)	13
Machine shop supplies (excl. maint.)	9
Assembled counter mechanisms	95
Sheet metal parts	7
Seals, rubber components, varnishes etc	4
Packing and literature	8

TABLE 5 - OTHER WATER METER COSTS

	$ Thousand
Investment costs:	
Technical agreement	300
Start-up costs for recruitment training and commissioning	133

	$ Thousand Per year
Labour 106 x $3755	398
Electricity (installed 180 kva) 235,000 kwh	16
Water 2400 gallons/day	3
Maintenance materials & spares:	
Plant	93
Buildings	33
Administration	219
Vehicle running costs	19
Technical assistance and development	50

Provision for replacement of plastic moulds every 3-6 years

Working capital
- 4 months materials
- 8 weeks process and stock
- 4 weeks debtors

TABLE 6 - EMPLOYMENT: WATER METERS

		Number	
Foundry:	Operators	9	
	Labourers and cleaners	6	
	Trainees	2	
	Supervision/technicians	2	
			19
Machining:	Operators	15	
	Labourers and cleaners	5	
	Trainees	3	
	Supervision	1	
			24
Diecasting:	Operators	4	
	Helpers	3	
	Labourers	3	
	Supervision/technicians	3	
			13
Assembly, testing & inspection, packing			20
Stores			3
Maintenance			4
Development			2
Administration			21
			106
Skill distribution:			
	Profession/technical	11	10
	Skilled	30	28
	Semi-skilled	45	43
	Unskilled	20	19
		106	100

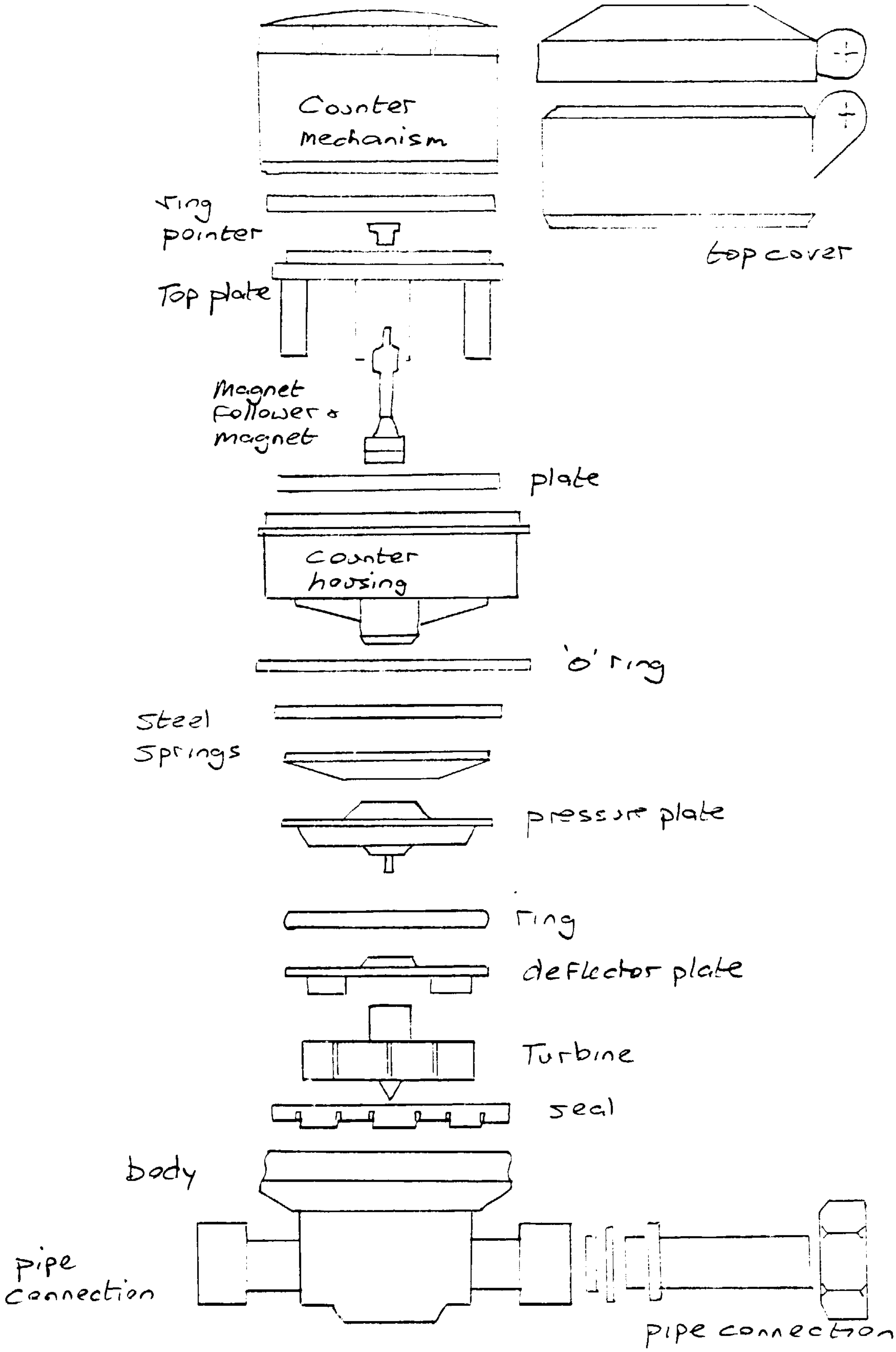

FIGURE 1 - WATER METER (A TYPE)

WS/Atkins

SELF-ADHESIVE TAPE

This profile discusses the process economics of self-adhesive tape and considers the economics of small scale manufacturing of insulating and packing tapes

1. Product Type, Volume and Price

Product type

Opaque self adhesive tapes are used mainly for electrical insulation and for packaging. Cotton-based and paper based tapes were widely used until 10 years ago but have been displaced by plastic based tapes. Previously insulating tape and packaging tape were very different processes. Now a single PVC coating process combines both. Tape making is dominated by the cost of the substrate (over three quarters of total cost) and so the cheaper PVC base materials now offer a big cost advantage. They are also processable at higher speeds and can achieve high adhesion with less adhesive, both characteristics which contribute to cost reduction.

Insulating tape is normally packaged as small rolls typically 5-10 metres length. Packaging tape is larger, 20-45 metres, and wider but thinner. A typical insulating tape contains 0.2 m^2 of tape and a packaging tape about 2.0m^2.

The same plant is also able to make transparent adhesive tape of the 'sellotape' type.

Volume

IPS have specified the demand for tapes as follows:

	Insulating rolls	Packaging rolls
1986	290,000	290,000
1994	575,000	575,000

taking the 1994 output as a basis for long-term demand calculations the area of tape to be processed can be roughly estimated as:

	m^2
Insulating 575,000 x 0.2 =	115,000
Packaging 575,000 x 1.8 =	1,035,000
	1,150,000

The insulating tapes average 133 grms/m^2 and the packaging tapes about 104 gms/m^2. On this basis the weights of products are:

	tonnes
insulating tapes	15
packaging tapes	108
	123

Cardboard cores add about 5 percent to the total weight.

Price

Tape rolls of the kind described above are available ex-works at around

$ 0.14/roll insulating tape

$ 0.95/roll packaging tape

The ex-works price of the above volume at the above price is about $627,000 and with a gross weight of about 129 tonnes. Hence the cif cost will be about $220/tonne ie $28,000. Adding about 5,000 for port costs the border price becomes $o60,000.

2. Process and Technology

Process

The basic process involves:

a) Receipt of 1.5 metre wide 'jumbo' rolls of plastic about 10,000 metres long

b) Dispensing and mixing adhesive, at up to 35 grams/m^2 of plastic

c) Running the plastic through a three-roll coater. The bottom roll packs up adhesive from the tank and transfers it to the roll above. The plastic sheet runs between the top two rolls and is coated by the lower of these two.

d) Passage over a steam heated drying drum with ducted extraction of the vapour from the drying solvent.

e) Re-rolling into logs of finished roll diameter, with paper tube core

f) Chopping into thin rolls.

g) Labelling and wrapping in cellophane for sale.

The process is described more fully in Appendix 1.

The line runs at speeds up to 600 metres minute. At this speed and with a 70 percent machine utilisation, the plant can produce over 70 million square metres of tape per year. This is sixty times the volume under consideration for Ethiopia and is equivalent to over 20,000 small rolls per week.

It is generally considered that output must be at least half a million rolls per week in order to achieve a competitively priced output.

Such a line making the volume specified for Ethiopian could operate at around 4-5 metres/minute. Lines are designed to be variable speed and those with a slower speed range are cheaper, but still uneconomic. Modern thin adhesive tapes cannot be uniformly produced at slow speeds.

The plant and equipment to mix adhesives, coat, reroll and cut, together with the building and all the services would cost over $4 million and require a building of some $1900m^2$. The employment on single shift operation would be 50-60 depending on the line speed. The cost structure at full one - shift output in an industrialised country would be

	%
Materials	76
Capital charges	7
Labour	7
Conversion costs	4
Expenses/administration	4
Working capital	2
	100

Taking account of the fixed and variable cost elements, and the potential for adjustment of partly fixed cost, the costs would fall to 96 percent with 2 shift operation. But if the output on 1 shift is halved, costs increase to 120 percent, and at quarter output they increase to nearly 140 percent.

In Ethiopia the output would be a tiny fraction of one shift potential and the fixed cost element would make the unit cost many times the imports.

The only course of action which might be practicable is to import 'logs' (long thin rolls) of adhesive coated PVC and to slit them into the finished short rolls for sale.

Technology

The processing lines are made as standard machinery, predominantly by Italian companies.

The major producers are prepared to consider selling logs to foreign slitters although this is unusual. One of the largest European producers is:

3M Europe sa
106 Boulevard de la Woluwe
B-1200 Brussels
Telex 24 775 mmmco B

3. The Plant (1.15 millions plus/year)

The plant consists only of a slitting machine. The machine is a slotted bed for the 1.5 metre long roll of tape and a block of cutting knives which slits the tube into 30-80 separate rolls. It is also possible to arrange slitting on a lathe for small volumes.

The plant will store about 2 months (average) of long rolls of 3-7 kgs each. Monthly consumption will be about 1500, weighing 10 tonnes. These will be in a variety of thicknesses, qualities and colours.

Average hourly throughput is 10 long rolls. After chopping they are cellophane wrapped together with a printed label. Finally they are packed in larger boxes and stored.

Details of the plant are shown in Table 1.

It is not possible at this stage to say what the cost of the logs would be but it is unlikely that they will be much less than the cost of the finished chopped rolls. In order to transport logs they must be very carefully packed. A preliminary costing should assume 95 percent of the cif cost of the chopped and wrapped rolls.

A visit by the (technical) manager of the plant to a foreign supplier for 2-3 months is all the preparation that is needed.

The PVC costs over $4000 per tonne when supplied separately and the adhesives over $6000 per tonne.

Supplied as a long roll of prepared adhesive tape the cost is likely to be over $5000 per tonne. $4500-5000/roll (average packaging and insulating).

4. Concluding Remarks

Prices are now determined by production on high speed lines able to make sixty times the Ethiopian requirement. Slower lines, producing 4-5 metres/minute (see Section 2) can produce about 300,000 rolls/year (single shift, 60 percent capacity utilisation). Total investment, including all services and ancillary plant, building and craneage etc is likely to be around $¾ million. The capital charge alone for such a plant (excluding all materials and operating costs will be more than $0.3. This is about three times the ex-works price of packaging rolls from economic suppliers. Moreover, the quality of product from the slow speed lines is not up to the quality of imported product.

TABLE 1 - ADHESIVE TAPE PLANT (SLITTING)

	$ Thousand
Slitting machine and tools	35
Cif and spares	4
Packing in stores	10
General factory furniture	8
Offices	10
Vehicles (2)	17
Services	12
Installation and project management	6
	102

Building:

	m^2	
Stores	90	
Cutting room	40	
Administration	70	
	200	at $460/$m^2$

Employment:
- Storeman (2), cutters (2) packers
- cleaners/general (2), admin (3)
- Total employees 11
- Very little skill or training

Materials:
- 18000 long thin rolls
- Packing materials

Conversion costs:

Electricity	12,000 kWh/year
Water	140 gallons/day
Vehicles	$4,000
Administration	$18,000
Miscellaneous plant costs	$3,000
Advertising materials also required	

APPENDIX 1 - HIGH OUTPUT TAPE MAKING

Self adhesive tape is made by mixing up the adhesive, laying it upon the substrate, drying and then cutting it up into rolls which are wrapped and marked according to product.

Because each pass through the continuous process is a roll or substrate, which is around 10,000 metres long, the minimum number of average sized final product rolls of one type that will result is about 250. This five tonne roll of substrate will pass through the machine in twenty minutes if run at full speed.

The machinery for self adhesive tape manufacture is proprietory, with the expertise of each producer determining the specifications for the required equipment. The mixing and matching of adhesive to substrate is also a critical technology because if wrong the adhesive can react with the tape and spoil the process.

The first stage in the process involves special dispensing equipment which is used to proportion, mix and degas multi-component adhesives. These adhesives tend to be self cleaning in that they leave the feeders free of debris, but they have a limited shelf life.

This vertical or in-line reverse roll coater has a gravure roll at the bottom with a mechanically or chemically etched face whose cell size determines the amount of coating which will be applied to the substrate. It is equipped with a coating supply, doctor blade and a variable speed reversible drive which allows the flow of the web to be reversed if a thicker coater is required. The middle applicator roll is covered in an elastomer which drives against the direction of the web, lightly nipping the gravure roll where it takes on the coating. This coating is applied to the web which is held against the central roll by a metal back up roll. The coating weight is controlled by adjusting the speed of the gravure roll and its pattern is adjusted with the aplicator roll speed. The web travels at up to 900 square metres a minute and up to 35 grams per square metre squared of coating can be applied.

The web is then dried by steam heated rotating cast iron drums that lead the substrate through the drying or curing process in a serpentine fashion.

After drying the tape is rolled into a log like product which is the length of the finished tape but needs cutting to the required width. This is done in cutting machhine which holds the log firmly while blades cut through it at right angles. These finished tapes are then wrapped in cellophane by hand and labelled accordingly.

NEEDLES AND PINS

This profile provides basic information about the manufacture and costs of sewing needles, machine sewing needles and safety pins

1. Product Type, Volume and Price

Product type

Needle and pin manufacture is a very complex operation on highly specialised machinery.

The manufacture of hand sewing needles, machine sewing needles and safety pins are three different operations and are nearly always undertaken by different factories, usually with no commercial connection.

Hand sewing needles are made in a wide variety of types. This profile considers sharps (general purpose sewing, with short round eyes for strength, 30-50 cms), darners (mending needles, 40-70mm, with long eyes) and betweens (short needles, 20-40mms, for quick, even stitching, normally professional).

Machine sewing needles are heavier and of higher quality.

Safety pins are of lower quality than needles and in this profile are made in sizes from 25mm to 45mm.

Volume

Needles and pins last many years, often a lifetime. Often the users of domestic sewing machines continue to use the original needle set all their life. Even in rich countries family women may go for years without buying hand sewing needles.

IPS have specified volume approximately as follows:

	Hand sewing needles	Machine sewing needles	Safety pins
		tonnes	
1986	29	48	29
1990	32	53	32
1994	35	58	35

Plants for making needles and safety pins can be designed to suit much smaller volumes than those shown above. Indeed, surprise was expressed by manufacturers at these volumes, and an investment of many millions of $US would be needed to establish such ventures.

A hand sewing needle volume of 30 tonnes corresponds to some 130 million needles. Bearing in mind the likely Ethiopian demand and the fact that a plant can be designed for 15 million needles (single shift) this level of output has been selected for hand sewing needles and separately also for machine needles and safety pins.

Prices

Prices of all three products are given in Table 1. Needles vary widely in price according to type and quality. Project profiles of this type are only indicative and prices should really only be used in connection with a specification of products and range. Some very cheap products are available from China and Korea.

The hand sewing needles are sold in envelopes of 3-20. Machine needles in Ethiopia would be in packs of 1-3. Safety pins are sold in clear plastic bubbles on a card, in mixed packs of 5-50.

2. Process and Technology

The procedure for needle manufacture is given below:

a) Buy drawn wire coils
b) Straighten and cut to length of two needles
c) Point both ends
d) Stamp on flat needle centre
e) Punch two eye holes
f) Break into two needles
g) Grind the edge of the eyes
h) Induction harden the needles
i) Temper to correct hardness
j) Scour the needle clean (after the heat treatment)
k) Re-point
l) Electroplate a nickel coating
m) Wash and dry
n) Inspect every needle
o) Place in paper holder
p) Pack and store

The above process for hand sewing needles involves 12-15 machines (depending on needle type) and some 15-20 work stations.

In the case of machine sewing needles these are heavier (typically 3 times as heavy) and made to a higher quality to withstand the harder operating conditions and long life requirements. There will be about 40 percent more machine steps and work stations. The needle is ground from heavier gauge wire, so that there is a heavy shank to fit into the machine. The eye is punched near the point and the section around the eye is also ground into a recess.

Safety pins have a different sequencing of operations up to electroplating, as follows:

straighten and cut
point both ends of a double length
chop in two pieces
twist spiral onto pin wire

stamp the safety closure from sheet
press the closure partly to shape
feed closures to the pin line

insert pin end onto closure
press closure around pin
fold closure around

electroplate, wash, dry, inspect, pack.

Technology sources:

The largest needle makers (hand and machine) in Uk is:

Henry Millward & Sons Ltd
Studley, Warwickshire, England, B80 7AS

A hand sewing needle maker and plant supplier in Germany is:

Jecker
Aachen
West Germany
Telex 832628 JECKER DE

Jecker have been helpful and are interested in developments in Ethiopia.

The Singer Sewing Machine Company makes sewing machine needles and also supplies machinery.

Safety pins are made in UK by:

Newey Goodman
Tel: Tipton 021-520-7661

The larger manufacturers also design much of their own machinery. There is no 'standard' needle and pin making machinery.

3. Machinery and cost

Plant and equipment is supplied by a know-how partner as a package. A contract may have a breakdown of items with a cost per item but essentially it is a lump sum. The capital costs are shown in Table 2. The heat treatment and electroplating are fairly standard items of equipment but the needle/pin making plant incorporates special features. Second hand needle making plant is now available from Europe.

4. Layout

The building for hand sewing needles is about 650m², split as follows:

	m^2
Needle forming and heat treating	210
Plating and inspection	230
Engineering	40
Storage	90
Administration	80
	650

The layout for hand sewing needles is shown in Figure 1. The building for machine sewing needles reflects the fact that there are about one third more work stations and nearly half again as many employees. Overall the area increases by about 37 percent, to 890m².

5. Operating Costs

Materials and other operating costs are shown in Table 3. The raw material is drawn steel wire, priced ex-Europe plus $200/tonne transport by container (or part container). The wire is normally high carbon (1.2% C, 0.2 Si, 0.5 Mn, P and S less than 0.01 each). Wire qualities vary, less with needle quality than with the type of eye (the stamping and punching operation).

There is no reason why a quality wire drawer in Ethiopia should not draw the wires but 2½ tonnes is too small a quality to consider drawing the wire at the needle maker.

Packaging is more costly than the price of the steel wire itself. All the packaging could be locally sourced.

Labour costs are based on the employment given in Table 4, with the cost weighted by the skill distribution.

In developing operating costs for machine sewing needles and safety pins the following comments may have:

* machine sewing needles

  a) Wires are of similar quality but losses are higher and overall the needles use 6 times as much steel

  b) quality is higher and it is likely that know-how fees and technical assistance contracts will cost more

  c) manpower is 40-50% higher in number with more skill needed

  d) maintenance materials will be related to the higher capital cost and building areas.

* safety pins

most costs will be pro rata with the 30 percent reduction in capital cost, safety pins on average weight about twice as much as needles. In addition to the wire there is a need for steel sheet of about 0.25mm thickness for making the closure. Often the plant makes brass and steel pins.

7. Employment and training

Employment is shown in Table 4 and amounts to 46 of whom 37 percent are professional, technical or skilled.

Start-up would need to be undertaken by two skilled expatriate staff remaining for up to a year. They would undertake the necessary training.

8. Concluding Comments

Production at the scale described is not economical. Total costs (excluding duties) are likely to be three times the import prices. The introduction of a second shift would reduce this to 2½-3 times.

With hand sewing needles in industrialised countries labour is typically up to 70 percent of costs.

A plant cannot compete with imports until it produces several hundred million needles per year.

TABLE 1 - PRICES (NEEDLES AND PINS)

---

1. Hand sewing needles:

Sewing needles (Sharps) $4.7/1000
Heavy mending needles (Darners) $14.0/1000
Weighted ⅔ sewing ⅓ mending = $7.8/100

Ex-works price of 15 million = $116,000
Transport cost to Ethiopia is low in percent terms because cost/tonne very high
Hence add 1% cif and port cost
Border price = $117,000

---

2. Machine sewing needles:

Domestic machine type needles	$18.6/100
Add 1 percent cif and port cost: then 15 million needles	$282,000

---

3. Safety pins:

25mm pins	$3.3/1000
mixed 15-60mm	same
Add 2% cif and port cost =	$3.4/1000
then 15 million safety pins	$51,000

TABLE 2 - CAPITAL COST (NEEDLE AND PINS)

		$ Thousand
1.	Hand sewing needles (15 million/year)	
	Plant and equipment	140
	Ancillary plant	30
	Spares	15
	Cif and port costs	20
	Erection	37
	Mecnanical and electrical services	98
	Vehicles	13
	Design and engineering	24
		377
	Buildings 650m^2 x $460	299
		676

This plant can make 15 million needles on 1 shift and 25 million on two shifts. To double the output increase plant and equipment by $40,000* and assume all other items increase pro-rata.

2. Machine sewing needles

Plant costs about 50% more for same number of needles.

3. Safety pins

Plant costs only about 70% of the hand sewing needles plant.

* Extra lines for forming needles but little change in heat treatment or plating.

TABLE 3 - MATERIALS AND OTHER COSTS (NEEDLES)

	Hand sewing $ thousand	Machine needles $ thousand
Hand sewing needles materials		
Steel wire 2½ tonnes at $1950	5	30
Tooling consumed	3	5
Electroplating chemicals and neutralisers	2	3
Printed packets (3 million) and other packing	13	30
Hand sewing needles other investment:		
Technical assistance say	40	50
Start-up cost	25	40
Conversion costs (hand sewing needles):		
Labour 46 x 3965	182	270
Maintenance materials and spares	20	32
Electricity 30,000 kWh	2	3
Water 600 gallons/day	1	1
Administration expensees	55	77
Vehicle operations	8	8
Technical assistance (1 visit)	10	15
Working capital:		
6 months material		
3 weeks stock		
4 weeks debtors		

TABLE 4 - EMPLOYMENT (HAND SEWING NEEDLES)

	Number
Process line:	
Machine operators and plating	11
Testing inspection, packaging	10
Trainees	3
Foreman	2
	26
Stores	2
Maintenance	2
	30
Labourers	8
Administration:	
Manager	1
Sales	1
Finance	1
Secretaries/clerks	3
Drivers	2
	46

Skill distribution	number	%
Professional/technical	6	13
Skilled	11	24
Semi skilled	21	46
Unskilled	8	17
	46	100

In the case of machine sewing needles the total number of employees increases by nearly 50 percent, with large increases on the process lines. The skill distribution also changes, with a higher proportion of technical and skilled workers.

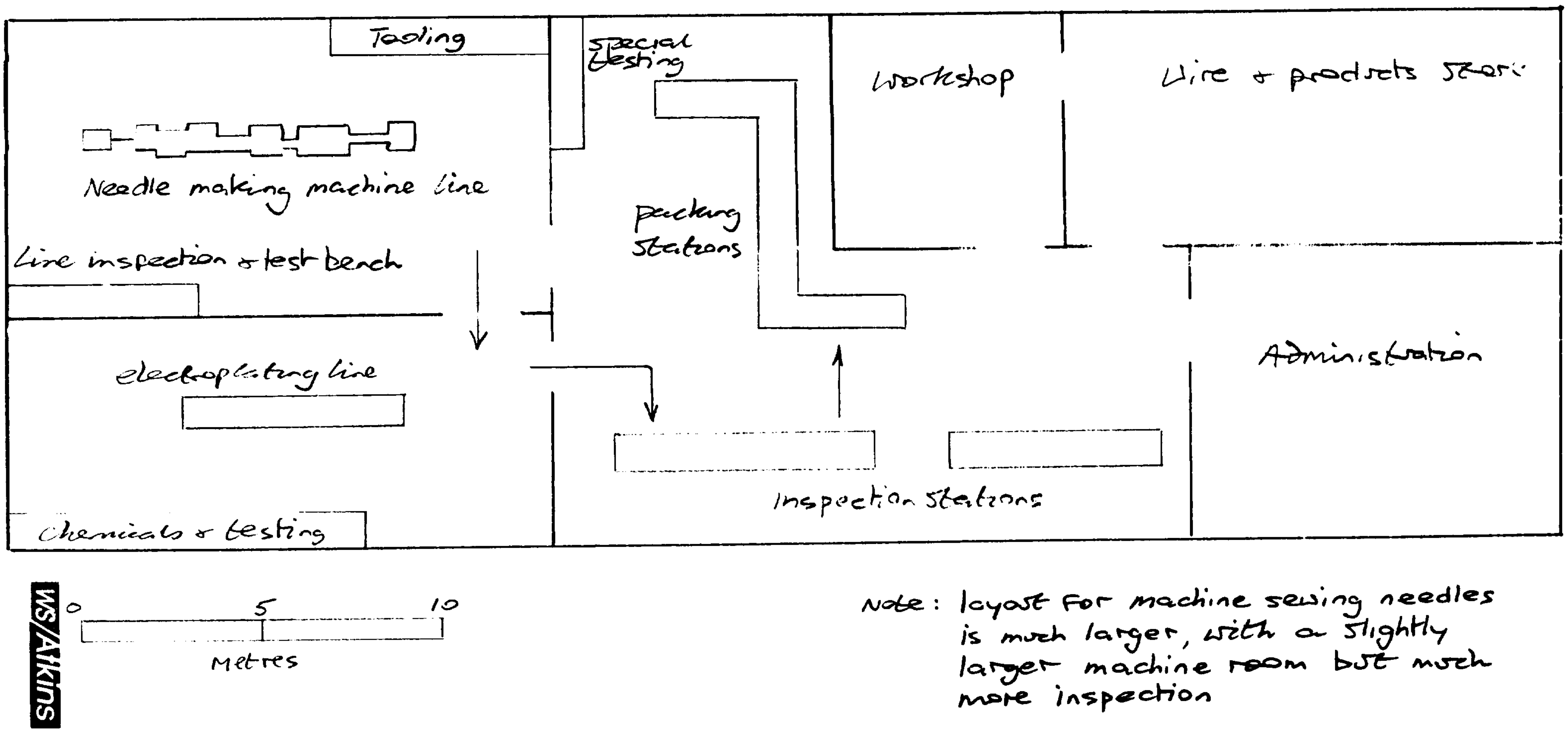

FIGURE 1 - HAND SEWING NEEDLES LAYOUT (INDICATIVE)

ABRASIVE PAPER

Flexible sand and emery paper for smoothing wood and metalic surfaces is considered at a production level of 100t per annum in 9' x 11" sheets

1. Product, Volume and Price

Product

Abrasive paper and cloth is used for smoothing, finishing and cleaning wooden and metallic surfaces. It consists of a base layer onto which is glued abrasive grit. The size of the grit and its composition determine the properties of the product with larger grit sizes being suitable for softer materials. The abrasives themselves are selected for the surface they are to treat. Emery is a natural and impure form of carborundum (aluminium oxide) and has largely been superseded by synthetic products because of its inconsistency. Aluminium oxide abrasives are tough while silicon carbides tend to be hard and brittle. The output is expected to be sold as sheets 9 x 11 inches. Opportunities should arise later to sell economy rolls and possibly abrasive bands.

Volume

The demand in Ethiopia has been specified by IPS as follows:

	tons
1986	63
1990	71
1994	101
1998	111

Price

The assumed volume split and the price structures are shown in Table 1.

2. Process and Technology

Process

To make the abrasive paper or cloth a layer of adhesive is laid upon the base layer and then abrasive, such as silicon carbide or aluminium oxide, is spread on top and passed through an electrostatic field to make the abrasive grains stand upright. This maximises their effectiveness and ensures that the distance between the grains is constant. Another layer of glue is spread on top of the grit and the product is then looped over rolls and passed through a drier before being re-rolled. This part of the process is continuous and the capital investment high. With a throughput of 100 tonnes per year and a typical 1.5 metre wide line working at about 4 metres/minute the plant can complete the 213,000m^2 (Ethiopian requirement) in about 600 hours. Assuming a normal machinery utilisation of about 60 percent the plant will require 1150 operating hours out of the available 1900 hours (one shift).

Faster lines can be purchased but are more costly. Many operators use slow lines.

Technology

There are eleven manufacturers of flexible abrasive cloth and paper in the UK, all of whom have been contacted. None were prepared at this stage to make commercial quotations for plant and technical support in Ethiopia.

A technical assistance contract with a larger manufacturer will be necessary to establish the plant. The largest UK manufacturer is:

English Abrasives Ltd
Marsh Lane
London N17 OXA

3. Machinery and Cost

Machinery

Paper and cloth in a number of grades, depending on the end use, will arrive at the plant in jumbo rolls around five feet wide. These are fed as continuous web onto the coating machine where the substrate is covered with a thin layer of glue. The cheapest, simplest and yet one of the best coaters uses the rigid knife method. The glue is mixed before being pumped, or even hard ladled, into a trough. This is of variable width and is supported at the bottom by the web. It has end dams on either side and a precision metering knife at right angles to the web. The coat weight is controlled by adjusting the clearance and pressure between the knife and the web which runs over a supporting roll. This driven back-up roll is usually made of precision metal for heavy coat weights or covered with resilient material for low coat weights.

The base layer then enters an electrostatic spreader which deposits the grit in regular upright form across its whole surface. For optimum performance the grit should be rice shaped so that it will give a uniform consistency across the paper. A continuous belt of semiconducting material passes over a group of rolls and is in contact with the upper and lower electrostatic plates. The glued face of the web passes through the electrostatic spreader facing downwards. A dc voltage of about 100 kV is applied across the two plates (one below the web and one above it).

The abrasive material, agate, sand, aluminium oxide or silicon carbide, is carried through the spreader on a second belt moving parallel to the glued web but just below it. The ground abrasive particles being asymmetric in shape become charged and align their long axis with the electromagnetic field. When the force becomes sufficient they fly up to become embedded in the glue. As the coated web leaves the spreader plates it is mechanically vibrated so that unglued abrasive falls back to the bottom belt. The substrate is then glued again to hold the grit in place before being dried.

Once a coating has been properly applied to a substrate it must be conveyed, dried and cured before the coated side can be touched again. The drying method chosen is dependant upon the available fuel source, strength and stability of the coated substrate and the maximum rate at which it can be accomplished without a detrimental affect on the end products. For drying flexible abrasive products hot gases, usually dehumidified steam, are circulated over or against a moving sheet in a festoon dryer. The web is festooned in loops over bars that are carried on a moving chain through a heated chamber.

Gas movement must be sufficiently moderate not to tangle the adjacent loops of material. One advantage of this method is that it can take place in a tall thin enclosure and not take up too much floor space. This floating method increases the drying rate by 25% because it allows for both sides of the substrate to be dried at the same time.

After drying the web may be rerolled before being passed onto the slitting machine or it may be split into long sheets prior to standby slitting. In any case the papers must be rerolled through a series of rollers which make the produce more flexible by breaking up the hard glue matrix.

The slitter converts the strip into 9" x 11' pieces of sandpaper or emery cloth. First the web passes through a set of vertical knifes which slit it horizontally and then the slim strips are cut be a reciprocating blade at right angles to their direction of flow. The cut retangles are moved by a conveyor and deposited in a hopper from where they are taken by hand for stamping with the relevant grade and grain size of the abrasive, and packed into cardboard bands in groups of 3-8.

The capital costs are listed in Table 2.

4. Materials and Other Costs

Table 3 presents the other costs. Materials can be separately sources. The paper and cloth are in any case made separately from the glues and abrasives.

The abrasive quality papers weigh 80-220 gms/m^2 and they are 100-290 microns thick. Such papers have high tear strength. A typical specification for a No. 1 quality paper of 150 gm/m^2 is:

thickness	200 micron
bulk	1.3
burst kPa	950
tensile MD N/15mm	240
CD	110
stretch MD %	2
CD	6
double tear MD mN	2000 (2700)
CD	2200 (3000)
Cobb (1 min) g/m	20/25
porosity sec/100 ml	69
smoothness	500/700

75 tonnes of finished abrasive paper, with an area of about 170,000m^2 contains approximately 26 tonnes of paper. The remaining two thirds of the weight being made up of abrasives and glues. Across a range of papers the weights of glues and abrasives are about the same, the abrasives being heavier but rather less volume.

The 26 tonnes of paper will be required in a range of qualities making the requirement of any one quality not more than about 3 tonnes. Some qualities will be less than 1 tonne. If the papers are to be purchased at intervals less than one year the purchase orders will be small and the unit prices high.

Materials price estimates may vary widely as a result small scale of purchasing.

5. Layout

The plant requires a covered space of 640m^2 as follows:

	m^2
Coating, slitting and packing	280
Stores	180
Services	80
Offices	100
	640

It is probably advisable to have an EOT crane running through the stores area and across the main line. The layout is shown in Figure 1.

6. Employment and Training

The business will employ some 37 people as shown in Table 4.

Skill levels are low. The plant could be started by a single technician working for around one year. Hardly any special skill is needed on the shop floor. Nearly all staff can be trained at work during the first weeks of operation although a dozen or so will need machine/general process familiarisation. The workers who will need to have acquired full practical skills before joining the business are:

Foreman	1
Coating plant/drier	1
Slitting plant	1
Stores	1
Maintenance	2
Testing	1
	7

7. Concluding Remarks

A line producing 100 tpy of abrasive papers is small by normal standards but plants of this size do exist. At 150 tpy a suitably designed and fully utilised line should become economic but much depends on being able to purchase the raw materials at a good price. These make up over half the cost at full output.

The line costed in this profile has an ex-works cost of around $700,000. This is a budget estimate. It might be possible to purchase a simple line more cheaply than this but it is unlikely that the total cost could be brought below $1 million.

TABLE 1 - ABRASIVE PAPER VOLUME AND PRICES

	m^2	
Overall volumes:		
25 tonnes cloth abrasive =	42,000	
75 tonnes paper abrasive =	171,000	
	213,000	
Paper substrates:	%	$/m²
Cheap grit open coat finishing papers	30	1-62
Cabinet papers	25	2.84/4.05
Silicon carbide	20	2.97
Aluminium oxide production papers	20	2.88/4.10
Waterproof papers	5	4.55/7.25
* Second prices are typical for coarser grades which are assumed here to be one-third of volume of that grade	100	
Weighted price/m² $2.82/m²		
Cloth abrasives		
Aluminium oxide		7.11/8.73
Weighted price/m²	$7.67	

Exwork price of 42,000m² cloth and 171,000m² paper is $804,000

Add $ 18,000 for transport and $10,000 for port cost

Total border price $832,000

Based on UK prices. Cheaper papers may be available elsewhere

TABLE 2 - CAPITAL COSTS (ABRASIVE SHEETS)

	$ Thousand
Roller/handling)	
Glue handling)	125
Abrasive handling)	
Coating section)	190
Abrasive application)	
Drying and steam raising	270
Softening, run out line and slitter)	115
Secondary slitting)	
Spares	80
Mobile plant	80
Maintenance	45
Vehicles (3)	29
	934
Cif and port costs	50
Erection	105
Mechanical and electrical services	195
Design and project management	80
	1364
Building 640m² @ say $ 460 =	294
cranes	55

TABLE 3 - MATERIALS AND OTHER COSTS (ABRASIVE SHEETS)

	$ Thousand
Annual materials (cif prices):	
Substrate papers 26 tonnes	39
Substrate cloths 8 tonnes	36
Abrasives 35 tonnes	47
Glues 35 tonnes	70
Packing sleeves and boxes	12
	204
Transport and port costs	24
Other investment costs:	
Technical assistance contract estimate	30
Start-up labour and expenses	55
Conversion costs:	
Labour 37 at $3900	144
Maintenance materials and spares	55
Administration expenses	58
Technical assistance (annual visit plus literature)	5
Electricity 51,000 kWh	4
Water 1500 gallons/day	2
Oil 50 tonnes	10
Vehicle running	6
Miscellaneous plant costs, lubricants, solvents for cleaning, etc.	15
Working capital:	
6 months average materials	
4 weeks product	
4 weeks debtors	

TABLE 4 - ABRASIVE PAPER AND CLOTH: EMPLOYMENT

	Number
Foreman	1
Coating plant	5
Slitting	4
Print, inspect, packaging	5
Stores (material, product)	2
Cleaners/labourers	3
	20
Maintenance	2
Testing	1
Trainee	1
Administration (GM, sales (2), Finance (2), clerks and secretaries (3), drivers (2), site (3)	13
	37
* for second shift add 18	

Skill distribution:	number	%
Professional/technical	4	11
Skilled	9	24
Semi skilled	18	49
Unskilled	6	16
	37	100

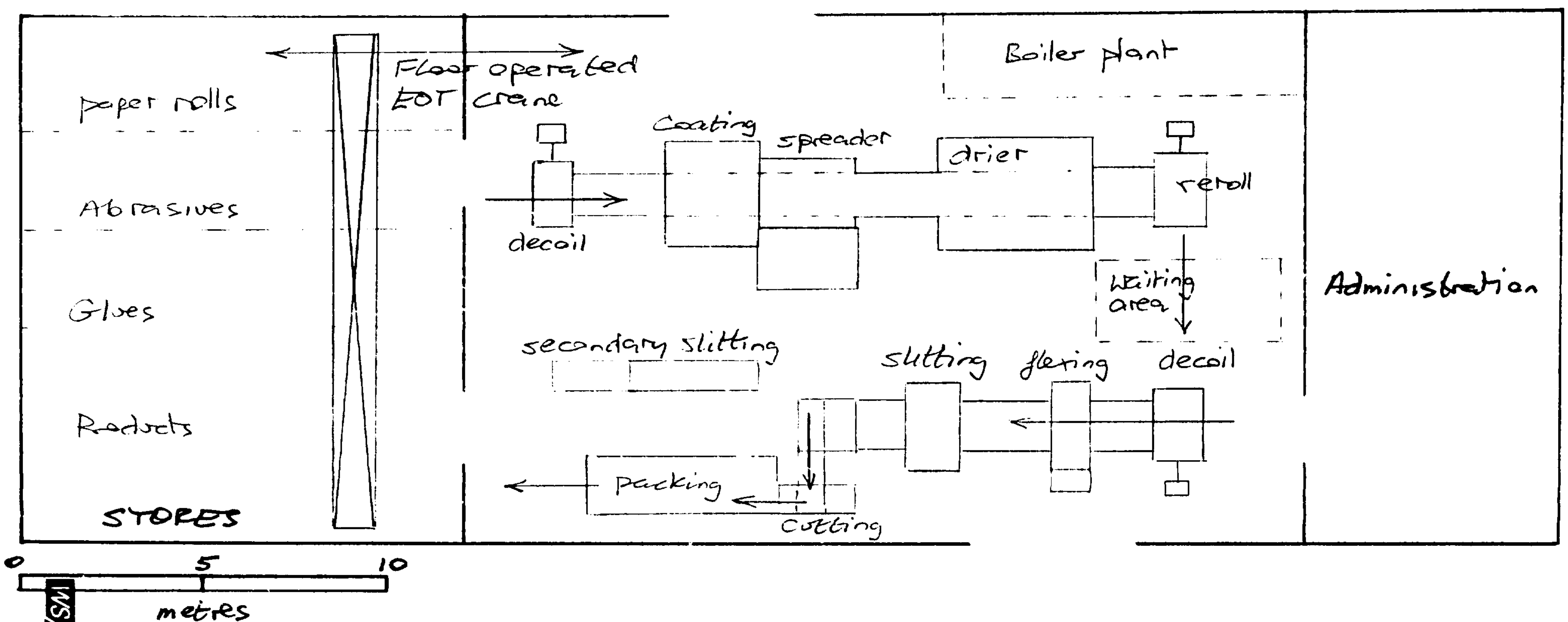

FIGURE 1 - ABRASIVE PAPER LAYOUT

SAW BLADES

This project looks at a standard plant for the production of hand and machine hacksaw blades. A full costing is given for 44 tpy (1 million blades) on single shift working

1. Product Type, Volume and Price

Product

Saw blades are usually made from hardened, tempered, bright and polished steel although hacksaws start out being black soft strip and are subsequently work hardened and tempered. The manufacturing process for each type of blade varies but they are all pieces of steel with teeth on one edge which are used for cutting wood and other material. The teeth are made so that the path they cut is wider than the blades itself, to reduce friction. This means the steel must be tough enough to allow shaping of the teeth without cracking, and yet hard enough to allow good wear resistance.

Volume of production

The market demand for all kinds of saw blades has been identified by IPS as 68 tonnes per year increasing to 123 tonnes by the year 2000. An appropriate division between the different kinds of saw blades, by weight, would be as follows:

	%
Wide band saws	4
Narrow band saws	5
Circular saws	23
Machine hacksaws	37
Hand hacksaws	31
	100

If the factory is to produce about 70 percent of the demand in the early 1990's then these percentages are representative of the following number and weight of blades:

	number	weight tonnes
Hacksaws-machine	35,000	24
-hand	950,000	20
		64

Price

12 inch hacksaw blades of medium to low quality are available from SE Asia (eg Taiwan) at around $0.18 each with better quality blades at about $0.22. From the industrialised countries the cost increases to $0.26 (much of the supply is actually imported and repackaged).

In this profile of hacksaw manufacture a mean price of $0.2 ex-works is used. Adding 2½ percent for cif and port costs this gives a border price of $205 per thousand.

950,000 hand hacksaw blades have a border price of $195,000.

The machine hacksaw blades cost about $118/hundred at border price so 35,000 cost $41,000.

The border price of the total 985,000 hacksaw blades is therefore about $236,000.

2. Process and Technology

Process

Ordinary hacksaw blades are made from carbon or alloy steel strip, already slit to width or in the case of circular saws steel plate, by cutting teeth along the edge and shaping them to specific designs. The machinery described in this profile will consist of one hacksaw production line with a capacity of about 1 million blades per year per shift.

Technology

Automatic blade making is not a skilled operation but some overseas training will be necessary for key personnel. This could be provided, as could all machinery, by Original Vollmer of Nottingham. This is the UK subsidiary of a West German firm which has supplied saw blade manufacturing equipment all over the world.

Original Vollmer
Middle Street
Beeston
Nottingham
England.

3. Machinery and Cost

Machinery

The process for hacksaw blades is outlined below.

Strip such as that used for narrow band blades arrives in flat boxes and is pulled out through a hole in the casing. Hacksaw blade material is purchased in the annealed condition and is hardened later.

The blade material is fed into the press to be blanked where necessary and then the teeth are pressed. A perfectly ground and honed punching tool with well balanced clearance and tight guides will give the best result. Otherwise there will be an excessive amount of burr and the toothed edge will be strained, resulting in a wavy and curved blade. Waviness causes excessive friction and overheating in operation, resulting in distortion of the blade. Punching machines should have an automatic mechanism which feeds accurately, without slipping, an equal length of strip at each stroke.

After punching the strip is cut to length. Hacksaws with holes punched in each end are placed together to form a block and are then milled by a hob. Bandsaws are joined to form endless bands. Wide band saws are joined by oxyacetylene welding and heat treated to maintain a constant composition for the blade. The blade is then retensioned, usually by hammering, and filled to leave a seamless circle of metal. Narrow band saws are flash welded and filed to leave an invisible join.

Hacksaw blades are milled in batches clamped together hydraulically. They are then unpackaged and fed through a setting machine. After setting the blades are hung up and passed through a hot salt bath, blast cooled to harden them and cleaned by boiling water before being painted.

Selected batches of all kinds of blades must be washed and inspected with a magnifying glass to allow cracks and scratches to be distinguished from each other. The blades are then packed for despatch.

The costs capital are outlined in Table 1.

4. Layout

The layout of the hacksaw blade plant is shown in Figure 1. It shows a total covered area of 370 square metres, including offices and storage. This is split as follows:

	m^2
Factory	250
Stores	60
Administration	60
	370

5. Materials and Other Costs

The materials and other costs for hacksaw blades are presented in Table 2. The steel strip has a price of about $850/tonne in Europe. Losses are small, around 2 percent. A major part of the other material cost is for packing the blades in 5 packs. Some savings could be achieved by selling the blades separately from commercial boxes.

There is a requirement to discard very small sources of toxic salts from heat treatment. This can be done by deep burying on a rubbish tip, by agreement with the city authorities.

6. Employment and training

Employment

A single shift can be manned by eight operators together with foremen, labourers, maintenance, etc. The operators can be semi skilled in hacksaw making although a high degree of machine familiarity is needed and normally at least two operators (milling and heat treatment) would be skilled.

Training

A specialist technician would be needed but for 3-6 months if only hacksaws are produced.

Training in the foreign manufacturer's factory is needed for 3 months for the manager and foreman.

7. Concluding Remarks

The plant will be highly utilised on single shift working but the single shift regime will disadvantage both capital and labour costs. Since cheap imports are available the plant will probably not be competitive. Such a plant should be nearly competitive on two shift working.

TABLE 1 - CAPITAL COSTS (SAW BLADES)

	$ Thousand
Hacksaw requirement:	
Cut to length line and tools	26
Engraving and dies	7
Teeth milling machine and cutters	32
Grinding of teeth	13
Wave setting machines and rolls	14
Hardening machine	13
Oil bath and deoiling equipment	12
General plant, painting, jigs, racking	20
Maintenance shop	25
Spares	15
Testing equipment (hardness etc)	10
	187
Office equipment	10
Vehicles	19
Cif and port cost	9
Plant erection	10
Mechanical and electrical services	36
Project management	29
	300
Building for hacksaw blades $370m^2$ at $460/m^2	

Excluding all duties and all site costs - land, fencing, roads, landscaping.

TABLE 2 - MATERIALS AND OTHER COST (SAW BLADES)

	$ Thousand
Hacksaw making materials:	
Steel strip $1050/t, 45t	47
Lubricants, paints, heat treatment salts	16
Other investment costs (hacksaws):	
Technical assistance contract	60
Start-up costs	39
Conversion costs:	
Labour 28 at $3740	105
Electricity 40,000 kWh	3
Water 650 gallons/day	1
Maintenance materials and spares plus trading	28
Administration expenses	42
Vehicle maintenance	10
Technical assistance	15
Working capital:	
3 months materials	
4 weeks stock	
4 weeks debtors	

TABLE 3 - EMPLOYMENT (SAW BLADES)

		Number
Hacksaw blades only:		
Foremen		1
Cut to length and blank		1
Milling and setting		2
Heat treatment, clean, paint		3
Inspect and pack		2
Trainee		1
Helpers and cleaners		3
		13
Maintenance		2
Stores		1
Administration:		
Manager, accountant, sales manager		3
Clerk, sales assistant, secretaries		4
Drivers		2
Site		3
		28
Skill distribution (hacksaws):	number	%
Professional/technical	4	14
Skilled	7	25
Semi skilled	11	39
Unskilled	6	22
	28	100

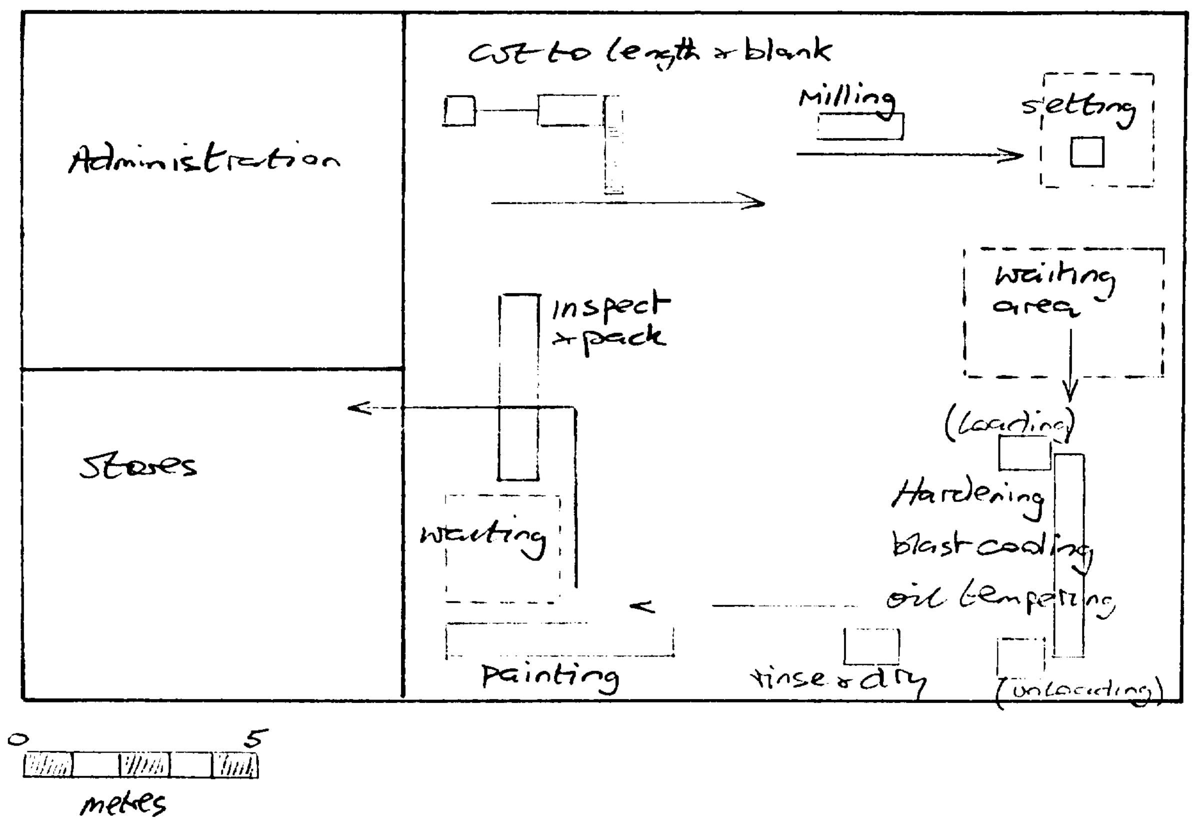

FIGURE 1 - HACKSAW BLADES LAYOUT (INDICATIVE)

WS/Atkins

APPENDIX 1

IPS comments on the Draft Report
and the responses by Atkins
in this Final Report

IPS Comment	Treatment of Comments
1. **Welding electrodes** no comment	-
2. **Mortice locks** layout required	now included
3. **Padlocks** layout required	now included
4. **Razor blades** high cost - review	second hand plant available. See Section 8 and footnote to table 1 for extra comment
5. **Grinding wheels** layout required	now included
6. **Water meters** high cost - review	subcontracting to foundries and plastics firms in Ethiopia would greatly reduce costs. See Section 7 for extra comment
7. **Adhesive tapes** cheap Indian plant is available	Atkins draft report noted the availability of slow speed lines. It is assumed that the Indian estimate will not cover total investment. All-up cost of plant is more than the Indian estimate of 'several hundred thousand dollars' and is hopelessly uneconomic - see section 4 for extra comment
utilities consumption not indicated	now included
layout required	layout not justfied for very small building with a single machine. Space requirement is stated.
8. **Sewing needles** include data for machine sewing needles	now included in Sections 4 and 5, and tables 2, 3 and 4
9. **Abrasive paper** layout required	now included
high cost - review	see extra comments section 7

IPS Comment		Treatment of Comments
10.	**Saw blades** focus on hacksaw blades	comments on circular and band saw blades removed (these products are uneconomic)
	layout required	now included