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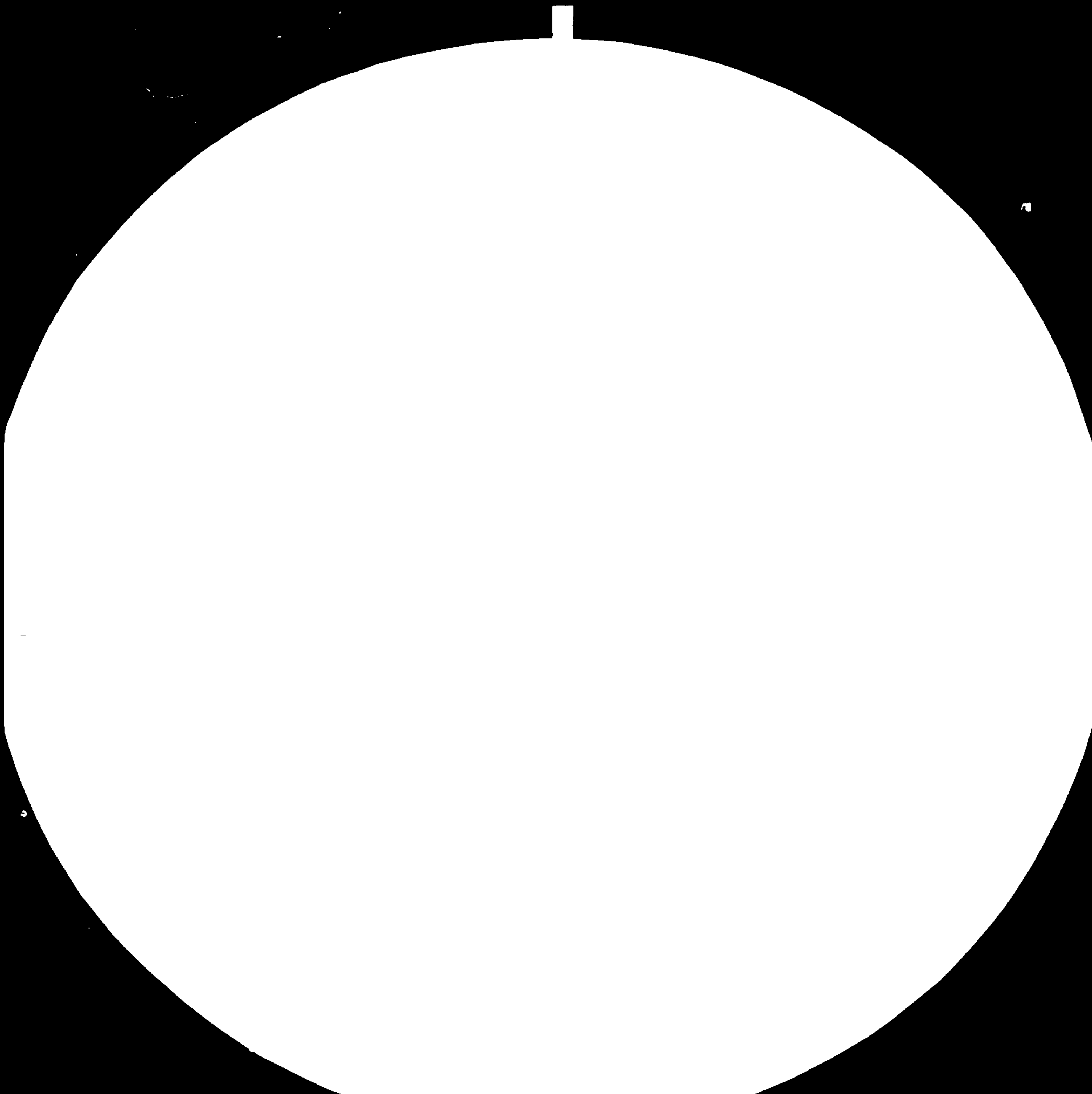

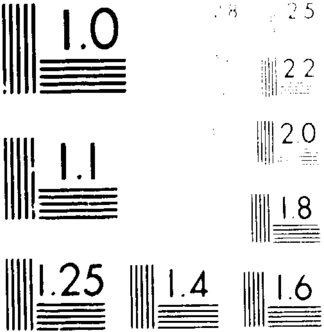
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8 August 1980
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ESTABLISHMENT OF MATCH FACTORY IN WESTERN SAMOA

SI/WES/75/003, SI/WES/76/806, SI/WES/77/801, RP/SAM/79/001 and DP/SAM/79/003

SAMOA

Terminal Report: Production of matches in Western Samoa

Prepared for the Government of Samoa by the United Nations Development Organization, executing agency for the United Nations Development Programme

Based on the work of Srinivasa Ramachandran, expert in the production of matches

United Nations Industrial Development Organization
Vienna

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Summary

At the request of the Government of Western Samoa, UNIDO fielded a team of specialists comprising

- one Senior Consultant for 15 months,
- two Mechanical Technicians for 14 months and
- one Chemist for 8 months,

to build a match factory in Apia, Western Samoa. This was the logical follow-up of recommendations made by the consultant in a feasibility study commissioned by UNIDO in 1976.

The project was executed in 15 months (between May 1978 and July 1979). The objectives of UNIDO assistance to the project have been fully realized as evidenced by the following results:

1. Over 60 unskilled workers were recruited and trained in operating machinery and 5 apprentices from the local technical institute selected and trained in machinery maintenance and operation.
2. Only indigenous timber, the major raw material in match manufacturing is used for production.
3. The factory is now run entirely by local personnel at all levels.
4. The factory provides scope for development of a number of ancillary industries. Already the match factory is supplying beer crates and pallets to the adjacent brewery.

The factory is in successful operation and the company is investigating possibilities of exporting matches to other islands in the South Pacific and ready impregnated splints to countries in South East Asia and the Middle East. The only other match factory in the South Pacific is located in Suva, Fiji. So the prospects for the industry look bright.

There is need for assurance of continued technical assistance to this industry, by monitoring to improve quality and performance, expansion of production, modernisation of the plant and establishing exports.

1. Introduction:

In 1976 the Government of Western Samoa sought the assistance of UNIDO to examine the feasibility of setting up a match manufacturing industry in the country in view of the plentiful timber resources available. UNIDO assigned a consultant for a month to make the study[1/]. The recommendations were positive.

The Government decided to go ahead with setting up a match manufacturing plant and requested further assistance from UNIDO for the implementation. This follow-up project was approved[2/] and executed in three separate missions as follows:

1. A 3-months' mission for the consultant to plan and design the factory, prepare specifications for building, machinery and raw materials and send out enquiries for the equipment (from 27 February 1977 to 2 June 1977).

2. A second mission of one and a half months for the consultant to assist the Government in the selection of the factory site, analyse quotations received for machinery, prefabricated steel structure and materials and place the necessary orders.

3. A final mission of a team of 4 specialists, including:
   - the consultant for 15 months (team leader) from 21 April 1978 to 31 August 1979;
   - a chemist for 8 months from 14 May 1978 to 13 January 1979;
   - two mechanical technicians for 14 months, each from 31 May 1978 to 31 July 1979,

   to build the factory, install machinery, train local workers and commission the plant.

The factory has been built and is now functioning

Western Samoa imports a little over 5 million match boxes annually. Besides, there is a good market for export of matches in the South Pacific Islands, mainly Tonga New Caledonia, American Samoa, Cook

1/ Project no. SI/WES/75/003

2/ Project no. SI/WES/76/806

Islands and French Polynesia. The factory in Western Samoa can produce and sell 20 million boxes annually with some additional investment in machinery. There are good prospects for exporting splints as well. It would be difficult to put an actual figure of quantity of splints that could be exported since no information is available regarding availability of soft timber in Savaii Island, Savaii being much larger than Upolu. From Upolu island an annual output of 2.000 tons is obtainable. In the long term larger quantities could be produced since the Forest Department has substantial acreage growing Anthocephalus Cadamba, a timber ideally suited for production of splints. Small quanitites of this timber made available to the factory by the Forest Department were tested and found good. It would be a worthwhile exercise for the Government to investigate markets for splints in the Middle Eastern countries.

There is no doubt that large quantities of good soft wood are available in Savaii island, suitable for matches and splints production; but transport costs are high between the islands at present. The match factory can operate indefinitely from timber resources in Upolu. If an export market for splints is definitely established then it may be worthwhile setting up a splints processing unit in Savaii island.

There is good scope for developing ancillary industries in the match factory complex. Already beer crates are produced in the factory and supplied to the neighbouring brewery. The brewery has ordered pallets to handle the beer crates. The beer crates business inside the match factory provides employment for about 12 persons.

About 60 workers are employed in the match factory. The fact that the factory is run entirely by local personnel is clear evidence of their enthusiasm, energy, work aptitude and capacity.

2. Factory construction:

Site levelling started in June 1978. The work was difficult and slow since the plot was located on a slope with rocky outcrops all over the area. This was further compounded by incessant rains. Rains were particularly heavy between August and November.

A temporary work shed was constructed at the site to enable supervision of construction work and also for fabrication of factory inventory. This was planned from the beginning. Substantial savings were effected by local fabrication, roughly US$ 32.000. Two circular saws, one planer, one buzzer, one metal cutting bandsaw, two grinders and one drilling machine were procured and installed in the shed for the purpose. The following were designed and fabricated locally:

- Frame carrier trolleys on casters, made out of channel and angle iron	(16)
- Wooden trays of 3 different sizes with local board and imported plywood	(600)
- Wooden trolleys on casters	(20)
- Veneer boxes for outer, rim and bottom pieces	(50)
- Splint levelling trays	(50)
- Work benches for mechanics, with storage boxes	(3)

- Racks and bins for chemicals
- Bins for boxes, inner and outer
- Working tables for workers and stools
- Galvanized iron exhaust ductings from box and splint driers.
- Racks for machine spares and tools stores.

All these were ready by the time production started. This work provided an excellent opportunity to select and train suitable mechanical apprentices, and semi-skilled workers. Qualified carpenters are generally available locally but there is dearth of mechanics. 15 mechanical apprentices were tried from the local Technical Institute and ultimately 5 qualified for permanent employment in the factory.

Excavation of foundations and flooring was completed, vapour barrier sheeting laid and network of reinforcement rods positioned. Ready mixed concrete was supplied by SPDC, a wing of the Government PWD, by trucks. Concrete was poured and compacted by vibratory equipment. Special foundations for peeling and chopping machines were prepared as per machinery suppliers' specifications.

The prefabricated portal frame steel structure was supplied by an American firm whose quotation was the most favourable of 5 offers received. This was put up by a local contractor according to erection instructions supplied by the firm. There was a delay of 2 weeks due to short supply of bolts and nuts. The purlins, channels and sheets were pre-drilled and bolts of suitable size were not available locally or from Fiji and American Samoa. Changing to a different size would have involved heavy drilling work. The materials arrived by air cargo and the work was completed on 10 October 1978.

The main factory building was 120 feet x 80 feet, consisting of 7 portals spaced 20 feet apart. To economise cost of civil work, 4 of the portals were ordered with additional 15' extension roof beams on one side to enclose the office block as well. Partition walls for stores, chemical processing rooms, finishing section for matches, inspection room and office rooms were put up. A large water tank of size 80 feet x 40 feet x 5 feet was built outside the main factory building for storage of logs. Civil work was completed with construction of wash and change rooms and a septic tank.

While laying concrete flooring provision was made for bringing in the main incoming electric cable and sub-circuit, drainage lines from chemical processing rooms and dipping machine. The entire construction work was completed by beginning of December 1978.

The electrical distribution work was taken on hand. The system consisted of one main board and three sub-circuits, from which service lines were taken out to the motors, all distribution lines taken underground. The work was done in conformance with New Zealand regulations in respect of switching and protection. Considerabld delay occurred due to late delivery of materials ordered from New Zealand.

Water services were ready by this time and machinery installation was carried out as soon as the civil work was completed.

3. Installation and testing of machinery:

Machinery cases arrived in Apia in the first week of July. The cases were all opened and checked for any damage. Packing was good and no damage was noticed. Since the factory was not ready the cases were closed and stored in the brewery buildings, by courtesy of the management of the brewery.

The cases were moved into the factory compound during September/ October since the brewery had commenced operations. As and when roofing sections were completed, the cases were moved into the factory and installed. Most of them were floor mounted, secured with rawl bolts. Installation was completed by end of December.

Since the electrical installation work was progressing slowly, temporary connections were given one at a time to each of the motors for testing the machines. Machine testing was taken up commencing from the chain saw and it was soon obvious that considerable modifications to the machinery were required before they became operational. Sizes of box mandrels were incorrect and lancet settings in the lancet holders were wrong. The engineer representative of the machinery suppliers, pleaded inability to do anything on the spot and promised to send correct sizes from Japan. Since there was already a big demand from the market for matches, it was decided to execute the work locally by the UNIDO personnel and the machinery makers accepted the defects as claims by the factory management, to be adjusted from supplies of spares in the future. Some of the major modifications done are mentioned hereunder:

1. Lancet holders, box mandrels were supplied for box size of 53.5 mm x 37.2 mm x 16.2 mm and even then the sizes and tooling were quite incorrect. New lancet holders for size 53.5 mm x 37.2 mm x 13.0 mm were made locally. The mandrels were reduced in size from 16.2 mm to 13.0 mm by hand since no surface grinders were available in the local PWD workshops.

2. Knife carriage speed had to be reduced to enable peeling 0.65 mm veneer and a new gear had to be made locally in the PWD workshops for the purpose.

3. The knife bracket and fixtures in both peeling machines were redesigned and made in conformance with standard peeling practice. This arrangement facilitated adjustment of knife angle manually depending on quality of veneer delivered. The machine as supplied by the makers had no provision for such adjustment.

4. The veneer chopping machine had to be modified by fixing an attachement to the holder on the flywheel to move the link mechanism further towards the centre to facilitate chopping to width of 11.2 mm. The machine as supplied could chop only upto 15 mm width.

5. Since the company wanted to market a family size large box of size 100 mm x 75 mm x 25 mm, holding 250 match sticks, fresh lancet holders for outer, inner and bottom veneers were made locally. These matches are very popular in the market.

6. The inner box making machine was modified to take the reduced width veneer. The paper cutter knives were of brass and these had to be replaced with spring steel ones. These knives as well as veneer holders in the machines were made out of scrap motorcar spring flats.

7. The holes in the frame filling machine screens were non-uniform. Almost 8.000 holes had to be redrilled.

8. The splints levelling machine had to be completely modified to enable a reasonable quantity of levelled splints to be available in each tray and to ensure elimination of cross splints in the trays. This was done by reducing the gap at the back of the trays and the machine reciprocation speed.

9. In the dipping machine there was no provision to keep the paraffin dipped splints in frames heated after the dipping at temperature of 55°C to ensure penetration of paraffin into the fibres of the splints and eliminate the coating of paraffin externally. This was designed and executed locally. Otherwise all match heads would come off even on gentle pulling. Similarly there was no provision to cool off the chemical-dipped heads imme-

diately after dipping to facilitate gelling and thus ensure maintenance of shape of head. There was no provision to keep and maintain the chemical composition in the machine tank at the temperature of 35°C by thermostatic control of the jacketed water bath, to prevent gelling before dipping. All these modifications were made locally.

10. The box labelling machine had to be completely modified to enable delivery of boxes side by side and not end to end. In the latter case it would be impossible for the workers to pick up a dozen boxes at a time and this would necessitate running the machine at a much slower speed. The box magazine, paste and label cups and lifting cams had to be realigned and fixed. The machine is now running at normal speed.

11. In the side coating machine, the hair brushes were replaced by foam brushes made locally. The box carrier tracks were lotted to allow superfluous composition to drip back into the tanks. Feeder and discharge lines were extended to make it easy for workers to gather the boxes before and after the coating.

12. Besides the following equipment were fabricated locally:

(a) The original ball mill supplied by the machinery makers was made of porcelain and the capacity was very small. It was more a test laboratory type. It would have been necessary to weigh out phosphorus from the drum, a very risky process. Fortunately the mill broke into pieces at the first attempt to make chemical composition. So a completely new steel ball mill was made locally by:

- bending and welding a 1/4" thick steel plate,
- welding the two end pieces,
- inserting and welding 3" shafting at the centre on both sides,
- aligning and trueing in lathe,
- mounting the shafting in ball bearings,
- fixing a cover for the opening with one end rounded to the inner curve of the mill to enable feeding and discharge of chemicals,
- installinga shaft-mounted torque-arm speed reducer with tension rod,

- driving the input shaft of the speed reducer by V-belt with pulleys on the motor and the shaft. Speed of the mill was 30 RPM driven by standard speed motor for 1400 RPM.

The mill was mounted on a channel iron framework. It is running well. Capacity of mill per charge was 25 kgs and this enabled the full phosphorus drum to be fed into the mill for each charge. The phosphorus drum had a net capacity of 10 kgs.

(b) A paste making boiler, electrically heated, water jacketed for uniform heating was made locally. Such uniform heating would prevent formation of lumps in the paste. Paste is used for making outer and inner boxes and for packeting.

(c) A drier heated by infra-red lamps for drying packets of matches. The pneumatic transport systems for box and splints transport were designed locally and orders placed for the fans, injectors and ducting with a New Zealand firm. These had to be installed after the departure of the experts.

The machines were ready for operation in May 1979.

Annex I gives a sketch of the machinery layout in the factory. The layout was planned on the basis of flow or line production, the semi-manufactured products moving from one operation to the other in the right sequence. The layout is best suited for the match factory since materials handling is minimal. Machine utilization is good. Work-in-progress can be kept down and it would be easy to facilitate production control. Floor space required is minimum. The disadvantage of course is the possible disruption to production when one of the machines in the chain breaks down. This has largely been taken care of by stocking buffer stocks of boxes and splints in bins.

4. Machinery Operation and Production:

The factory commenced production and marketing of matches in May 1979. In fact the machines were ready for operation in March but delay in arrival of blue match paper held up work. Half a ton of paper was brought by air freight from Australia to start work. Shipping was the major cause of most delays.

During the planning of the factory, considerable time and thought were spent in determining the level of mechanisation of the plant, appropriate to conditions in Western Samoa. Several combinations and alternative plans for the best manual method of using existing factilities for each of the operations were compared and these were predieated on the return on investment. It was necessary to keep capital investment down to an acceptable level. The need for higher skilled workers for mechanised operations was another constraint. Safety was another paramount consideration. For instance mechanical fillings of boxes with sticks carries a high fire risk in low output plants. It was considered inappropriate in the early stages of factory operation to introduce these machines, even though manual filling was very much more expensive because of low worker productivity. It was finally decided to arrange the following operations manually:

- debarking,
- arranging layers,
- impregnating splints,
- filling sticks into boxes and closing,
- packeting, 10 boxes to the packet,
- packing 10 packets into larger packet of 100 boxes,
- filling 10 large packets into a carton and sealing, and
- internal transport of semi-manufactured products by trolleys.

All other operations were done mechanically.

For heavy jobs like log handling, crosscutting, loading peeling machine, men were employed. For all other jobs women were recruited. For cirtical work like box making, dipping, splint levelling, side coating, veneer and splint chopping, over 50 workers were tested and finally 20 selected. Normally it takes 6 to 9 months to reach a reasonable level of operating skills and deliver normal production. It was indeed heartening to observe the workers selected picking up skills fast and within a period of 3 months attain a production of 50% of the normal level. It is also interesting to observe here that most of the workers had no more than primary school education.

It was now necessary to test various timbers for output and quality and to establish their suitability for match production. The Government Forest Department was very helpful in supplying most of the samples. Among various species tested, the following were found suitable:

Common name	Botanical name	Suitable for		Availability
		Splints	Boxes	
Fagaio	Pterocymbium Beccarii	Excellent	not good	Reported to be plentiful in Savaii Small quantities in Upolu island
Kadam	Anthocephalus Cadamba	Excellent	Excellent	Large acreages planted.Will be available after 5 years.
--	Octomeles Sumatrana	Good	Good	Again under plantation. Will be available after 5 years.
Mango	Mangifera Indica	Not good	Good	fair quantities available
Pulu Vau	--	Very good	good	plenty available
Pulu Mamoe	--	Not good	good	plenty available

Some other species under plantation were tried as well. But inadequate quantities provided for testing and low girth made it impossible to draw a meaningful result. There is no doubt that some of these varieties are promising.

Since Pulu Vau was readily available near the factory site, production commenced using the timber for boxes and splints. Barring the need for routing mechanical adjustments there were no serious machine problems. Two sizes of boxes were produced. The standard size box with stick contents of 50, and a family size containing about 250 sticks, size 120 mm x 75 mm x 25 mm. The large size boxes were produced manually, initially to be given free to visitors, marketing agencies etc. to establish confidence in the market and to introduce the factory to the people. It had a very favourable market and so was produced for sale as well later on. The market response to the matches was very good indeed. The main problem was to meet the demand. The limitation was naturally the question of training workers fast enough.

The main bottlenecks were splints levelling, frame filling and box making and later on, filling of boxes with sticks. The methods employed for training the workers was to place a number of them together to work on the same machine, observe them closely and find out which of them picks up the skills fast. Then slowly the number of workers at that particular work station is reduced and by this process of elimination the best one is selected as machine operator. To take the example of the inner box making machine: the work of the machine operator consists of

- sorting out box rim veneer. This is done by fanning out a bundle each time, pick off and reject those with faint scoring lines and defective grains, turn over and do the same thing from the other end and feed machine magazine with the right leading edge forward,
- take a bundle of bottom pieces and sort them out rejecting pieces of incorrect size,those having other defects as well,
- check paper feeding all the time to ensure adequate paste application and correct cutting,
- check delivery of boxes and the paper overlap. Overlap of over 10 mm is just waste of expensive paper.

This work should be done at speed to match the speed of the machine. The rim and bottom magazines should be kept topped up all the time. Naturally the machine speed is initially slow during the training period and is progressively increased to correct speed. Normally a worker requires at least 9 months to be fully trained to operate the machine. The machine was run by 3 workers at the beginning and in 3 months time one worker was removed. These skills are acquired only by experience. No amount of oral instructions can expedite the process. The function of the UNIDO personnel was to instruct, supervise and monitor.

Three operators were selected and trained in chemical processing work. They picked up the work very well and were able to operate independently within 3 months. Initially a number of formulations were tried out to find out from users the sort of quality that was generally acceptable. Finally two formulations were selected, one for color heads and one for black and brown heads. The factory manager and the workers were trained in making slight variations in the formulation if found necessary. The formulations in use are:

Chemical	Black + brown heads	Color heads
Potassium chlorate	52.5%	53.5%
Manganese dioxide	3.5%	--
Iron oxide	4.5%	--
Potassium bichromate	1.0%	1.0%
Glue	10.0%	10.0%
Zinc oxide	3.5%	4.5%
Sulphur	3.0%	4.5%
Glass powder	17.97%	21.92%
Kiesulghur	3.5%	4.5%
Gum tragacanth	0.03%	0.03%
Lamp black	0.5%	0.05%
Total	100.0%	100.0%

The factory is equipped with thermostatically controlled glue melter, a FRYMA chemical grinder with adjustment for fineness of grinding. Supplies of chemicals are adequate for 12 to 15 months of operation. The quality of raw materials imported is as per specifications mentioned in Annex II. Complete operating instructions have been provided to the factory, see Annex III. Troubleshooting information has been provided, see Annex IV. If these are scrupulously followed there will be no need to change processes. If chemicals of different specifications are imported then changes in formulation and processing will become necessary. They will depend on the nature of the new specifications, particularly particle size of chemicals and technical specifications of glue. These cannot be generalized. The factory manager is competent to effect minor changes in formulation.

Some aspects of factory operation require to be investigated and action taken to improve them. These are discussed in a later chapter of this report, under recommendations.

Operating instructions for the machines are given in Annex VI A specimen machinery maintenance card is given in Annex VII, a machinery maintenance programme is given Annex VIII.

5. Quality control, testing laboratory:

There has never been a standardized system of quality control in the match industry. Methods of testing have been mainly arbitrary, developed independently by different factory operators. Most of these testing methods are not meaningful, are quite irrational and very often not really relevant to determining quality of matches produced. To give a few instances: splint breaking strength is tested by placing it across two supports and dropping a weight from a height at the middle of the splint. The weight used and height from which it is dropped is arbitrary. What one should guard against is cross grained splints. This can be tested equally well by pressing between two fingers. The crushing strength of the match head is tested by dropping a weight from a height on to the head. Again the weight and the height are arbitrary. This method of testing is not indicative of the match quality. It is important that the head should not come off on pulling, or break up into pieces on firing. The former depends on paraffin temperature and absorption, the latter on the quality of glue, the actual formulation, the porosity of head and the particle size of chemicals used or rather the specifications.

The only test of great relevance, done with an instrument is the flame height test. This instrument has been developed by Swedish Match company and they were willing to sell them to factory operators, in the last 5 years. This instrument was ordered for the Samoa Factory by UNIDO and was due for delivery in October/November 1979.

The quality control measures suggested in this report are adequate for the production of good quality matches by the Samoan factory. They are mostly arbitrary and visual but certainly adequate for making a fair assessment of quality. In very large manufacturing units, statistical methods of analysis are employed for assessing dimensional accuracy of boxes and splints. They are necessary for successful operation of high speed machinery and are not necessary for the Samoan factory. Annex V provides a form for monitoring the quality in the factory daily.

An air conditioned testing laboratory has been built in the factory for housing the various expensive instruments provided by[1/] UNIDO to the Western Samoa factory to assist mainly in chemical process control and control of quality of output. Unfortunately, many of the instruments like flame height tester were due for delivery in October/November 1979. The UNIDO team was unable to give proper training to the laboratory assistants, particularly in instrumental methods of process control and quality control. Two laboratory assistants have been recruited and they have been trained in visual and manual test procedures as well as routine testing of specific gravity, ash content, etc. It is absolutely essential to provide them intensive training in use of viscometers, Ph-meters and flame height testing equipment. It will be necessary for a consultant to spend a period of 3 months to do this training as early as possible.

6. Recommendations for future:

The factory is now in successful operation. There is urgent need to undertake some development work as soon as possible. The following are some technical problems as well that require early attention:

(a) Drying of boxes and splints in the driers is effected by direct heating with the hot gases of combustion of kerosene. In spite of adequate excess air, combustion is incomplete and a certain extent of soot deposition takes place. Boxes should be dried at temperatures not higher than 75°C since otherwise excessive shrinkage of paper will take place with boxes becoming quite brittle. Splints can be dried at 90 to 100°C. The temperature of hot gases can be adjusted to a limited extent by setting the thermostat fixed at the gas inlet to the drier. This is

1/ Total equipment expenditure for project UF/SAM/78/169 was US$ 17,056 and for project RP/SAM/79/001 US$ 9,310.

effected by regulating the kerosene burner while air supply is maintained constant. While this control was satisfactory for splints drying, box drying was unsatisfactory, partly because of low wet box loading, about 25% of drier capacity. There is no way this can be increased unless bigger market for matches is established. Further, there are no baffles inside the drier to force the gases to take tortuous movement through the drier to enable better abstraction of the heat from the fuel. While this can be done locally, it will not be of immediate help due to the low loading. Smaller capacity driers are not marketed but can be fabricated locally.

Fuel consumption is excessive, costing almost WST 2,- per carton of 1.000 boxes which is about 6% of the selling price. This has to be rectified as soon as possible. The best possible way is to install a small horizontal steam boiler suitable for burning waste wood fuel, with provision for an auxiliary oil burner to assist during rainy days and when steam pressure drops. Even a good second hand boiler would serve the purpose.

Steam requirements should be, per carton of 1.000 boxes:

- box drier	7.5 kg
- splint drier	9.5 kg
- paraffin heating	1.0 kg
- drying match sticks + frictioned boxes	1.8 kg
- paste making, impregnation, etc.	6.0 kg
- total	25.8 kgs per carton.

For maximum production of 20 million boxes per year, steam requirements will be 260 kgs per hour. A small boiler delivering half a ton of steam per hour at a pressure of 5 kgs per cm^2 will be ideal for the purpose. Cost of such a small boiler would be about WST 12.000,- ready installed in the factory. Operating costs would be:

- Fuel for auxiliary oil burner to be used when waste wood fuel is inadequate or if it is too wet, 200 gallons per year, Diesel or heavy oil	WST 1.500,-
- Wages, one operator WST 10,- per day	WST 2.500,-
- Depreciation 12 1/2%	WST 1.500,-
- Maintenance 3%	WST 360,-
	WST 5.860,-

This works out to 30 Sene per carton on production of 20.000 cartons per year. On lower production this will be variable, since fuel consumption will be low and probably nil since waste fuel would be adequate. The advantages of steam drying are:

- better control of drying temperature,
- drier can be easily redesigned for re-circulation of air to enable extraction of as much heat as possible from steam,
- consumption of fuel can be matched to load,
- waste wood which is now sold cheap can be utilized.

If a market is established for export of splints, steam drying will be very economical.

(b) Manual filling of boxes with sticks is a bottleneck to production because of low worker productivity. It is expensive as well. The main problem is collection of sticks from the frames with heads in the same direction, to fill into boxes. A box filling machine can fill 50.000 boxes in 8 hours. But fire risk is high in operation of the machine. The sticks should be supplied to the machine in trays filled with sticks properly levelled and all heads in the same direction. This require a spill sticks machine which delivers the sticks properly levelled in trays. So the best thing to do initially would be to buy a spill sticks machine and give the levelled trays to workers for hand filling. After a year or two a box filling machine can be purchased. By that time workers will be accustomed to fire risks and will have learnt to handle machines and matches with great care. This may improve productivity.

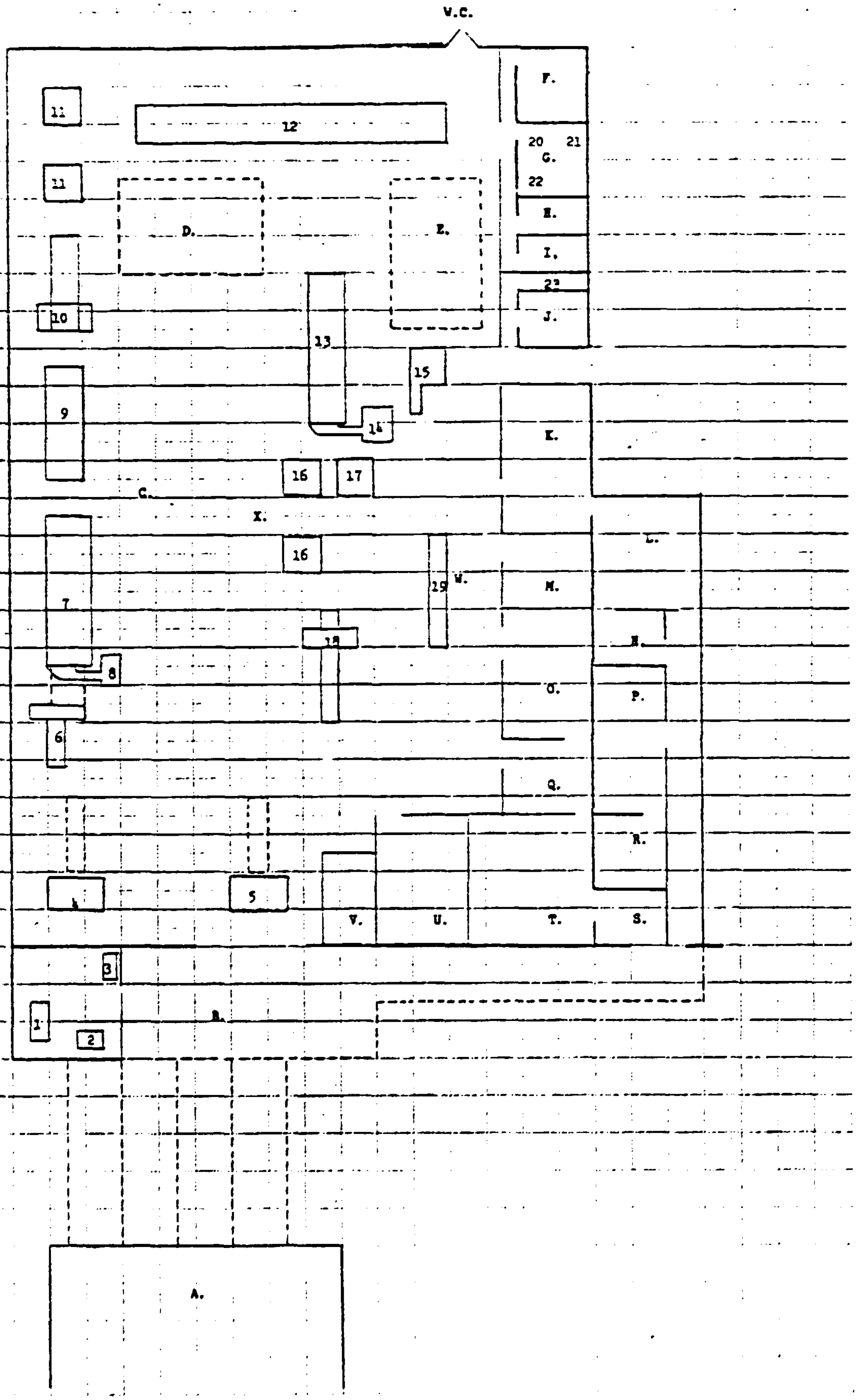
(c) Frame filling is somewhat unsatisfactory. This is partly due to uneven chopping of splints in the chopping machine and partly due to the clumsy, inefficient design and operation of the frame filling machine itself. The principle of the machine is to vibrate mechanically splints in the splints magazine and guide them into holes in the screen through which they drop in between the frame pieces. This mechanical vibration is cam actuated, undirectional and inefficient. The noise level is unacceptable. It is necessary to vibrate the splints magazine in 2 directions at right angles to each other to enable cross movement of splints and better guidance to screen holes. This will definitely ensure better filling of frames. This can only be done by electromagnetic vibrators. This work should be given high priority. Assistance could be provided in this regard.

(d) The splint chopping machine will require replacement as early as possible. Chopping is non-uniform and causes a good percentage of splints to drop out from frames on tightening. Unfortunately, the good splints drop out, understandably, since thicker splints are held. This non-uniform chopping is because of a number of reasons. Although the movement of the splint veneer layer is positive, the rack at the bottom holding plank being driven by a pinion, there is considerable slackness and play. Furthermore, the layer itself is 'boxed in' and due to friction, subjected to considerable movement disturbing the layer. Apart from these, collection of thin ribbons of veneer and arranging them into layers having a uniform depth is slow and difficult. The chopping knife descends at an angle and so full layers cannot be collected and arranged. Modification to vertical chopping will be expensive and a new machine would cost about the same. Production is low in spite of the high speed of the machine, because of the problem of arranging ribbons. Chopping is a batch operation now. If vertical chopping is arranged, then the cutting of wide layer to splint length can be built into the knife bracket itself. This is normal practice. In any case, if demand for splints increases, the machine has to be replaced.

Continued technical assistance to the industry in Western Samoa is absolutely necessary. The Wilkinson Match Group of companies offered to provide technical and managerial assistance and desired to participate in substantial percentage of the company's share capital. While they are certainly qualified and competent to offer such services, thier terms of collaboration were very expensive for such a small factory to afford. It would be necessary to provide assistance from time to time.

For the period 1980/82 it might be necessary for a consultant from UNIDO to visit Samoa twice a year for short periods of one or two months at a time, to monitor the performance, study problems, provide assistance and help in development of the factory.

ANNEX I.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MACHINE TYPE

1. Knife Grinder
2. Lancet Grinder
3. Chain Saw Tooth Grinder
4. Splint Peeler
5. Veneer Peeler
6. Splint Chopper
7. Splint Drier
8. Burner
9. Polishing Drum
10. Cleaning, Sieving, and Leveling Machine
11. Frame Filler
12. Dipping Machine
13. Box Drier
14. Burner
15. Labeling Machine
16. Inner Box Machine
17. Outter Box Machine
18. Veneer Chopper
19. Side Coating Machine
20. Fryma Grinder
21. Glue Melter
22. Paste Boiler
23. Ball Mill

SPACE ALLOCATION

A. Water Tanks for Logs
B. Cross Cutting
C. Splints Processing Line
D. Splints Storage Bins
E. Boxes Storage Bins
F. Potassium Chlorate Stores
G. Chemical Making Room
H. Chemicals
I. Stores
J. Chemicals Stores
K. Control Lab
L. Manager
M. Tools and Spares
N. Secretary
O. Finishing Room
P. Accounts
Q. Inspection
R. Time Keeping
S. Despatch
T. Matches Go Down
U. Chemicals Stores
V. Main Switch Board
W. Finishing Section
X. Boxes Processing Line

ANNEX II

Raw materials specifications:

Match head composition chemicals:

Bonding agents and thickeners:

Animal glue - match grade:

Particle size	100% to pass 8 mesh 90% to pass 20 mesh
Color	Light amber
Odor	Nonobjectionable
Moisture, Wt	14% max.
Ash, Wt	3.5% max.
Ph	6.9 to 7.1
Grease content	1.0% max.
Jelly strength, bloom grams	390 ± 3%
Viscosity, millipoises	140 for higher Jelly strength glue 110 for lower jelly strength glue
Melting point	32 ± 1°C for higher jelly strength glue can be lower for lower strength glue
Isoelectric point	5.4
Chlorides	0.3% max.
Foam ratio	1.8
Foam stability, half life	40 minutes

Natural gums - Tragacanth, Karaya:

Particle size	100 - 150 mesh

Synthetic gums - methyl cellulose, carboxy methyl celluloses:

These are available in different viscosity ranges and may be purchased to suitable grade which would give the right viscosity of chemical composition, usually 80 poises.

Oxidisers

Potassium chlorate:

Purity	99.5% minimum
Sodium, Wt	0.2% max.
Water insoluble portion,Wt	0.01 % max.
Chloride, Wt	0.03% max.
Moisture, Wt	0.05% max.

Color	White powder
Sieve analysis	Minimum 99.5% to pass 60 mesh 92.0% to pass 200 mesh Maximum 20.0% to pass 230 mesh

Combustibles

Sulphur:

Particle size	100% to pass 100 mesh 50% minimum to pass 200 mesh

Only ground sulphur should be used. Sublimed flowers of sulphur should not be used due to acidity.

Purity	99%

Rosin:

Particle size	100% to pass 140 mesh

Ash formers

Class powder:

Particle size	100% to pass 50 mesh 75% to pass 140 mesh

Should be free of free alkali, Maximum allowable alkalinity is 0.2% calculated as NaOH.

Color	White

Kiesulghur:

Particle size	100% to pass 200 mesh

Water absorption to be about 175 to 225% of its own weight.

Neutralisers

Zinc oxide:

Particle size	99% to pass 325 mesh
Lead content	below o.5%

Calcium carbonate:

Purity	98% minimum
Particle size	90% to pass 100 mesh minimum 50% to pass 200 mesh.

Sensitisers

Potassium bichromate:

Particle size	96% to pass 30 mesh 75% to pass 50 mesh
Purity	minimum 99%

Iron oxide, black, Fe_3O_4:

Pigment grade material used	
particle size	99% to pass 325 mesh

Manganese dioxide:

Purity	Minimum 90%
Particle size	100% to pass 100 mesh 50% to pass 200 mesh

Phosphorus sesquisulphide (for strike anywhere matches):

Melting point	Minimum 170°C
Moisture, Wt	0.5% maximum
Acidity of a 5 grams sample expressed as 0.1N NaOH solution	10 maximum
Free phosphorus	nil
color	lemon yellow
sieve analysis	90% to pass 80 mesh 80% to pass 100 mesh
Coloring agents	--

Inorganic pigments like titanium dioxide:

Particle size	99% to pass 325 mesh
Water dispersible grade	--

Organic pigments:

Particle size	99% to pass 325 mesh

Should be readily dispersible in water.

Organic dyes:

Mixing of acidic and basic dyes should not be done for getting different colors. Dyes with reactive groups which are capable of reducing the hexavalent chromium in chromate will tan the glue. So only very small quantities of such dyes can be used.

Flame transfer agents	--

Paraffin wax:

Double refined wax preferred

Grade	crude scale
melting point	$52^{o} \pm 1^{o}C$
Flash point	$218 \pm 10^{o}C$
Fire point	$240 \pm 10^{o}C$
Oil content	0.5% preferable

Side coating composition:

Bindres	--

Animal glue:

jelly strength	207 to 236 bloom grams
viscosity	78 to 87 millipoises

Casein and Soybean protein:

Minimum viscosity ranges used.

Defoamers must be employed to suppress the natural foaming qualities.

Urea-formaldehyde resin:

Grade	55 to 65% weight soluble used.

Acidic catalyst like ammonium chloride should be added to the resin to assure its polymerisation after drying.

Red phosphorus:

Purity	99.5%
Moisture	Maximum 0.2%
Acidity as H_3PO_4	0.1% maximum
color	red
Particle size	99.9% to pass 50 mesh 99% to pass 100 mesh

Only stabilised variety should be used.

Glass powder:

Particle size	100% to pass 80 mesh 85% to pass 200 mesh

Otherwise same specifications as for match heads.

Extenders and Sensitisers	--

Antimony sulphide or iron sulphide:

Should be used in fine powder form.

Splints

Wood:

Only straight grain splints should be used. Interlocked or cross grained splints should not be used.

Match board:

Basic weight	690 grams/square meter ± 10 grams per m^2
Thickness	1 mm ± 0.03 mm
Moisture	Maximum 7%
G.E.brightness (white board only)	62 min.
Water drop, seconds	120 max.
Splint strength, gms. minimum	150
Internal bond, minimum	no. 8 Dennison wax
Cutting quality	no hair formation while cutting.

Wax Vestas:

Strong, thin highly absorbent kraft paper should be used, of basic weight 40 to 60 grams per square meter.

Glow inhibitors	--

Mono- and di-ammonium phosphates:

These can be used separately or mixed. Mixed is preferred to give neutral solution.

Grade	Technical grade
Purity	90% min.
Moisture content	below 2%
Water insoluble portion	below 5%

ANNEX III

Operating instructions for chemical composition making:

Match head composition:

Glue:

1. Soak in double its weight of water for 12 hours, after kneading well by hand.
2. Melt in water jacketed vessel at maximum temperature of 60°C. Never exceed this temperature for grinding
3. Remove just before final addition to chemicals for grinding

All chemicals except potassium chlorate:

1. Soak gum tragacanth in water after mixing well by hand for 6 hours. (for 25 grams tragacanth powder, use 15 litres water).
2. Mix all the chemicals after pouring gum tragacanth emulsion. This mixing is preferably done with a high speed mechanical mixer.

Potassium chlorate and glue:

1. Add glue solution to the mixed chemicals
2. Now add properly powdered potassium chlorate.
3. Mix well for 3 or 4 minutes.

Grinding:

1. Start circulation of cooling water to the Fryma mill.
2. Adjust and check clearance of stationary and rotating grinding stones in mill.
3. Feed the entire mix to the grinder and start.
4. Pass discharged composition once again through the Fryma mill.
5. Check specific gravity of composition. This should be between 1.35 and 1.38.
6. If it is over 1.38, pass the composition a third time through the mill.
7. Now, homogenise the entire composition to blow in air and bring the specific gravity down to 1.33.
8. Check viscosity of composition. This should be 90 poises $\pm$ 5 poises.
9. Keep temperature of water jacket in the machine chemical tank at 38°C by setting the thermostat.
10. Feed composition to the dipping tank.

Now dipping can commence.

Specific gravity control is critical in ensuring right shape and size of head. This is controlled by the formulation of the composition and water quantity. For instance right percentage of Kielsulphur will lower the weight of composition. This should be well adjusted. Water should be 33 1/2 to 36% of the dry weight of all chemicals including glue and gum tragacanth. This will include water used in glue making and gum Tragacanth solution. The formulation should ensure that the potassium chlorate content will have 15 to 20% oxygen more than is actually required by the fuels namely glue, sulphur, rhodamine, etc.

Safety:

1. Potassium bichromate solution is highly acidic and will cause harm to the eyes and skin, if, accidentally dropped or spilled.
2. When red head composition is being made, great care should be taken to avoid inhaling rhodamine powder, since it is toxic.
3. It is always preferable to use a wet cloth over the nose while mixing glass powder and dry chemicals.
4. In case of composition catching fire, the Fryma mill should be stopped and water should be used to extinguish the fire.
5. Care should be taken to avoid spilling water on the Fryma mill's motor.
6. Never use fingers to pick up pieces from the Fryma mill while running. It is dangerous.
7. After use, the Fryma mill,machine tank,dipping belt and surrounding area should be thoroughly cleaned with water. No chemical composition must remain. On drying the mix can catch fire and on occasions explode on hard contact.
8. While cleaning the machine tank, do not use brush, or cleaning materials between rollers.
9. While going into the potassium chlorate room, remove shoes to avoid carrying oil, carbon and other materials. They can start a disastrous explosion. Great care should be taken in handling potassium chlorate.

10. Any balance composition remaining may be kept covered for the next day. • should be heated to 60°C the next day to melt the mass and then mixed with fresh composition, its specific gravity checked and then used.

Friction composition:

There are three grinding sequences to be followed:

1. First grinding:

   Antimony sulphide, glass powder are mixed with -% of their total weight of water to be fed to the ball mill. Grinding should preferably be for 24 hours.

2. Second grinding:

   A full tin of 10 kgs red phosphorus is added, preferably by washing it down with -% of its weight of water into the mill. The ball mill is closed and further grinding is done for 12 hours.

3. Third grinding:

   The required quantity of synthetic glue is added and the mill run for 1/2 an hour.

   The composition is now ready for use.

4. Since the composition is usually made in bulk, only the required quantity is taken out each time. The mill is then closed tight. Whatever composition remains at the end of a day's work should be fed back into the mill and the mill tightly closed.

Safety precautions:

1. Opening phosphorus tins must be done extremely carefully. Insert a large screw driver under the metallic lid overlap and rotate the screw driver to turn up the cover. Do this right round the tin opening all the way, till the lid can be removed by hand. Never force the lid. This can start a fire.
2. Phosphorus fires are quite dangerous. Water cannot stop the fire. Only a bucket or buckets of sand thrown over the fire area can put out the fire.
3. Never ladle out phosphorus with a spoon. Always tip the entire tin into the funnel over the ball mill. It would be best to wash it down with water. The formulation has been adjusted to ensure that one tin at a time is fully used up and not part of the tin of phosphorus.

4. Phosphorus tins should be opened by placing them on the ground and on a metallic table to prevent static electricity setting fire to the phosphorus.
5. Always wear a mask over the nose and eyes. Inhalation of red phosphorus dust is a hazard to health.
6. While working with phosphorus, no metallic materials should be used. Violent or hard action like hammering the tin should always be avoided. Work must be done as gently as possible.

ANNEX IV

TROUBLE SHOOTING INFORMATION

TROUBLE	REASON	CORRECTIVE ACTION
Match Sticks:		
1. Burning too slow	Low flame speed	Increase percentage of zinc oxide
2. Burning sluggish	Excessive impregnation	Control impregnation by reducing dipping time ash content should be 12% for correct impregnation.
3. Flame height poor	Paraffin absorption low due to moisture in splints and flame transfer effective.	Increase paraffin dipping time.
4. Match fizzles out	Oxygen inadequate in mixture	Increase percentage of potassium chlorate
5. Break easily	Splints cross grained	Investigate timber quality used for splints making.
Match head:		
1. Spitting over 1%	1. Inadequate glass powder to soak products of composition	i. Control specific gravity between 1.33 and 1.35
	2. Head too solid and compact and porosity inadequate.	ii. Add a little foaming agent to composition take up matter of conformity to specifications with supplier of glue.
	3. Glue not adequate foaming type	iii. Increase specific gravity to 1.38 and Homogenise to 1.33 iv. Increase glass powder %

2. Heads deformed	1. Specific gravity too high	i. Homogenise to bring down specific gravity.
	2. Head gelling too slow	ii. Composition temperature too high. Because: cooling of fryma mill insufficient. Temperature of water bath of composition tank too high. It should be only 2 to 3° above glue gelling temperature.
		iii. Cool match heads with fan immediately after dipping.
		iv. Investigate with suppliers about glue gelling temperature.
3. Heads come off easily	1. Cold paraffining	i. Temperature of paraffin should be between 135 and 150°C. It should never fall below 135°C.
	2. Post heating improper	ii. Soon after dipping, the frames should be kept warm at termperature of about 50°C for 10 to 15 seconds to enable paraffin to get fully absorbed with the wood.
	3. Moisture in splints	iii. Moisture in splints may be over 20%. If so splints must be passed through drier before dipping.
4. Match heads break to powder on pressing hard	1. Specific gravity too low	i. Add a little defoaming agent and bring specific gravity upto 1.35. Glue is excessively foaming type. Take up with supplier of glue.
	2. Glue melting temperature too high	ii. Glue melting temperature too high. It should never be allowed to go above 60°C.
5. Head shoots flame and burns uneven	Mixing and grinding of composition inadequate, resulting in non-homogenous mixture.	i. Mix composition for longer time. ii. Check grinding to see that it is free of small aggregates and lumps.

Side Coating:

1. Coating surface burns	Stratification of batch takes place leading to excessive concentration of red phosphorus in the coating.
2. Surface wears off fast	1. Glue poor quality 2. Moisture resistance poor 3. Inadequate grinding of mix.
3. Striking hard	1. Inadequate % phosphorus 2. Glue % too high
4. Coating uneven	1. Box shape not regular 2. Application rollers worn out and do not pick up composition evenly.

i. First grinding should be for 24 hours and second grinding for 10 hours.

ii. Check balls to see that they are not unduly worn out. Spherical shape of balls is important for good grinding.

iii. At any particular time 80 kgs weight of balls should be in the mill for grinding.

i. Good quality glue should be used.

ii. Percentage of glue may be increased upto 18%

iii. Proper grinding will ensure homogenity of surface and will eliminate wear off of surface.

i. Phosphorus should not be below 52% nor above 54%.

ii. Reduce glue percentage

iii. Grinding period very important.

i. Application of chemical should never be below 35 grams /m^2. Check boxes for shape. They have to be folded square.

ii. Change foam brushes

iii. Ensure that roller picks up enough composition from tank and transfers to brushes by adjusting feed.

ANNEX V

Daily quality control chart

1. Splints assessment:

   1.1 Dimensions:

      1.1.1 Length, mm Standard 42.0mm

      Average of 100 splints checked: -- mm

      Variation: -- mm %: -- Acceptable:0.5%

      1.1.2 Veneer thickness, mm Standard: 1.85 mm

      Average of 10 pieces checked every 5 layers: -- mm

      Variation: -- mm %: -- Acceptable 5.0%

      (The 10 pieces are taken from top, middle and bottom of the layers.)

      1.1.3 Chopping thickness, mm Standard: 1.85 mm

      Average of 20 splints checked, every 10 layers: -- mm

      Variation: -- mm %: -- Acceptable 3.0%

   1.2 Breaking strength:

   100 splints selected at random are tested twice daily.

   No. broken: -- %: -- Acceptable: 5.0%

   (This testing will be done initially by placing each splint across first and second finger and pressing the middle with thumb. Excessive pressure should not be used. All cross grained splints will break. An instrument is in use by the cottage factories in India replacing this test done by hand. In this instrument the dropping weight is varied by shifting the sliding weight along the dropping lever. The right position can be easily found by trial and error, for the particular species of timber under use.)

   1.3 Faults:

   100 splints selected at random, twice daily are tested visually:

Broken: --	%:--
Crossgrained: --	%:--
Sliver: --	%:--
Split: --	%:--
Crooked:--	%:--
Bruised end: --	%:--
Taper: --	%:--
Misshapen: --	%:--
Rough: --	%:--
Good: --	%:--

2. Boxes assessment

2.1 Dimensions:

2.1.1 Length: mm Standard: 53.5 mm

Average of 50 boxes tested: -- mm

Variation: -- mm %:-- Acceptable 2.0%

2.1.2 Width, mm Standard: 37.2 mm

Average of 50 boxes tested: -- mm

Variation: -- mm %:-- Acceptable: 0.5%

2.1.3 Height, mm Standard: 13.0 mm

Average of 50 boxes tested: -- mm

Variation: -- mm %:-- Acceptable: 0.5%

2.2 Fit:

The correct nesting of the inner box into the outer box depends on accurate chopping of inner box skillets and scoring and grooving of inner and outer box veneer. Otherwise the boxes may be fit too tight making it difficult to open the box. Or they may be too loose resulting in the inner box sliding out easily spilling sticks on the floor. So the regular measurements of chopping width of inner and outer box veneer is necessary. Shrinkage is usually high across the grain. It also varies between different species of timbers. If outer box is too long, it will result in uneven packeting of tens or dozens. If it is short the inner box with match heads will project outside the outer box. Samples of chopped skillets are taken from top, middle and bottom of every 5 layers chopped and examined for width, and variations are recorded.)

2.2.1 Outer skillets chopping width, mm Standard 56.3 (for Pulu timber)

Average 15 strips taken from test layer: -- mm (Test layer will be every 5 layers)

Variation: -- mm %: -- Acceptable 1.0%

The standard figure given is only for Pulu timber. Shrinkage across the grain of 5% was measured between air-dry and fully dry conditions and the standard figure computed to give overall dry length of box as 53.5 mm. When different timber is used, the shrinkage should be tested and standard figure adjusted to give the final dimension of box which is 53.5 mm).

2.2.2 Inner skillet chopping width, mm   Standard: 10.8 mm

Average of 15 strips taken from every test layer: ..mm

(Test layer will be every 5 layers chopped)

Variation: -- mm   %:--   Acceptable 2.0%

3. Matches assessment:

3.1 Sticks contents: Standard: 50 ± 4%

5 boxes are checked every 2 hours.

Boxes	9 a.m.	11 a.m.	1 p.m.	3 p.m.	5 p.m.
A	--	--	--	--	--
B	--	--	--	---	--
C	--	--	--	--	--
D	--	--	--	--	--
E	--	--	--	--	--
Average	--	--	--	--	--

(In a full box if the sticks content is low, then evidently the match head diameter and length are too high and they should be reduced, by reducing depth of dipping. If contents are too high then the heads are too small and should correspondingly be made bigger.)

3.2 Functioning:

100 match sticks are tested every hour.

Match head size - length: -- mm   Standard:4.5 to 4.8 mm

diam.: -- mm   Standard:2.8 to 3.0 mm

Shape: deformed -- %

Sticks spitting on firing: -- %

Loose heads: --%

Strength of head, poor: -- % (Reckoned by pressing heads hard)

Flame height: -- mm   Standard: 20 mm ± 3 mm

Impregnation: -- % failures

Defective matches are totally unacceptable.

3.3 Side coating: (100 Sticks are tested every 4 hours)

Ease of firing: -- % good   This has to be 100%.

Application: Good/poor   Standard: 35 gm/m^2

Moisture resistance: Good/poor (This is tested by keeping boxes exposed at the window sill overnight or by placing them in air ovens set at 35°C and 70% relative humidity. This equipment with thermostatic and hygrostatic controls is very expensive).

3.4 Packeting:

10 packets are tested every two hours to check tightness of packing, shape and size uniformity and general presentation. The test is visual.

ANNEX VI

Operating Insturctions for Machines:

Veneer peeling machines;

1. Check oil level in reduction gear first thing in the morning and top it if necessary.
2. Check both drop feed lubricators of the machine bearings and top with oil.
3. Apply a little grease to knife carriage gear train and worm drive.
4. Fix freshly ground knife on machine, align with gauge provided and tighten bolts.
5. Fix lancet holders for outer box, inner box or bottom veneer as necessary. Check all lancets for sharpness and tip centre.
6. Center billet and tighten chucks.
7. Start the machine at slow speed. When veneer delivery is steady and continuous stop machine. Lower lancet holder and move it into position. Peel a little. Check cutting, scoring and grooving by folding pieces over mandrel gauge supplied, check tightness of movement over gauge, fibres projecting and accuracy of lines. Adjust laterally and depth of scoring if necessary. If veneer comes out right quality, start peeling.
8. Build up layer. Ensure that bottom and top 10 layers veneer are continuous length strips, 3 meters long. Pack bits and pieces in between uniformly. Once layer is of right height, say 20 cm, remove layer and place fresh wooden plank to receive new layer.
9. Check cutting, scoring, grooving for every billet loaded on machine.
10. Keep good watch on quality of veneer delivered. Adjust angle of knife by adjusting two screws at the two ends of knife bracket, as diameter of billet gets reduced. When veneer gets soft, remove billet from machine.
11. Always stop machine and retract knife carriage as soon as billet diameter reduces to 80 mm. Otherwise, machine may get damaged, breaking worm drive and peeling knife.

12. Always check uniformity of thickness of veneer using gauge provided, as well as accuracy of lines scored or grooved. If not tight and loose boxes will result in production.
13. At the end of the day's work, remove lancet holder and knife for regrinding of knives and lancets, oiling and keeping ready for next day's work.
14. Clean machine before leaving work.

Splint peeling machine:

1. Complete all checks nos. 1 to 4, as mentioned under veneer peeling machine.
2. Centre billet and tighten chucks.
3. Start machine at slow speed and when veneer delivery is steady, stop machine.
4. Move pressure bar bracket forward till it is almost touching the billet.
5. Adjust vertical clearance between pressure bar and knife edges is 0.5 mm.
6. Check horizontal clearance between edges to the thickness of veneer peeled, 1.85 mm for splints used in factory.
7. Run machine, check sharpness of cutting and build up layer. Always ensure that bottom and top have at lease 10 continuous strips. Pack bits and pieces in between. When layer height is about 20 cm, remove layer and place fresh plank for receiving next layer.
8. Constantly check veneer delivered for cracks at the tension side i.e. bottom side and if cracks are evident, adjust pressure bar slightly forward to increase pressure. The pressure bar should be ground from time to time depending on wear and finished by rounding off the edge by hand filing.
9. At the end of a day's work, knife must be removed for regrinding. Lancets should be reground once every 10 layers.
10. Clean machine before leaving.

11. Stop peeling billet as and when veneer delivered is too soft and rough.
12. Knife carriage should be retracted when billet diameter reaches 80 mm. If care is not observed, damage to worm drive or knife carriage and to knives will result.

Splint chopping machine:

1. Oil all bearings and grease gears before starting work.
2. Fix fresh ground knife, bring knife bracket down to lowest position and level knife. Thighten bolts.
3. Check ratchet spring and ensure that it engages pinion well. Otherwise tighten spring.
4. Arrange veneer ribbons uniformly over the plank with rack underneath. Always arrange about 10 full lengths veneer top and bottom to ensure even pressure. Close box, feed forward by hand till pinion engages rack. Chop and remove first veneer block. Start machine.
5. Check splints for uniformity of chopped thickness which should be 1.85 mm.
6. At the end of a day's work, remove knife for regrinding, clean machine.

Veneer chopping machine:

1. Follow checks 1 and 2 as under splint chopping machine.
2. Transfer layer from plank to machine table and level top and sides well.
3. Clamp milled roller tight on to the side of layer.
4. Release weight on top to sit on layer. Check uniformity of layer. If necessary shift pieces in the middle to ensure uniform pressure by the pressure plate on top.
5. Chop once and remove the bundle. This can be used for packing into a fresh layer later.

6. Chop second time and check width of chopping from top to bottom. If width is consistant (± 0.5 mm), then continue chopping and receive the skillets on to the wooden box provided. If there is excessive variation in width, rearrange layer, adjust pressure by milled roller at the side and chop again for checking. If still width varies, the layer must be removed and rearranged outside, cleaning off wood dust in between veneer rows.
7. For chopping outer skillets, inner skillets and bottom skillets, the position of block on the flywheel should be adjusted for varying the forward feed by the milled rollers. In the case of inner skillets, the extension should be fitted on before adjustment.
8. At the end of day's work remove knife for regrinding and clean machine.

Peeling and chopping machines:

There should always be ready ground knives for the machines, well ground and oiled in stock in the knife and lancet grinder room. At least 6 knives each should be kept ready.

Peeling knives should be removed from machine and ground after every 20 billets are peeled. Chopping knives should be removed for regrinding once in the morning and once in the afternoon.

Box making machine:

1. Oil the journal bearings and grease gears first thing in the morning before starting.
2. Feed paper roll and pass it through the paste cup. Adjust paste so that there is adequate paste cover on the paper.
3. Feed inner rim veneer and bottom pieces into the respective magazines.
4. Turn machine by hand and check if paper is cutting properly and rim feed is correctly aligned to machine mandrel.
5. Check paper folding and pasting. Paper overlap should be not more than 10 mm in the case of inner boxes. In the case of outer boxes gap between ends should be 15 mm and not over 18 mm. This can be regulated by adjusting paper feed.

6. Engage clutch and run machine. Check boxes coming out. Ideal speed for outer boxes is 130 per minute and inner boxes 115 per minute.
7. Always keep boxes of well sorted skillets ready, one each of rims and bottom for inner boxes and one for outer boxes. Rim and outer skillets should be sorted out by taking a bundle each time, fanning them out from one end first and then from the other end and each time check and remote skillets with faint scoring or grooving, broken ends, excessively cross-grained ones. If this work can be done fast enough to keep pace with speed of machine, then good production is possible.
8. At the end of a day's work machine must be cleaned well with water and oiled. There should be no paste in the paper cutting knives or over rollers.
9. Clean paste cup thoroughly.
10. Examine paper cutting knife daily and if cutting is not clean, ask mechanic to file tips sharp or replace knife.

Labelling machine:

1. Oil journals and grease gears before starting machine.
2. Check label magazine for holding labels by using a little paste at the tip of the forefinger and pulling the bottom label from the magazine by mere adhesion of paste. If label does not come off easily ask mechanic to file the holding teeth and rectify. If too many labels come off, then, the teeth have to be redone and fixed.
3. Check paste cup holes for easy flow of paste but only in droplets.
4. While running machine feed boxes always full into the magazine. Boxes should be fed right side up for labelling.
5. Clean paste cup well at end of day's work. Clean machine and oil before leaving.

Splint cleaning and splint sieving machines:

These machines should be kept oiled and greased well at the beginning and end of day's work. They do not require any special attention for operation. The place of work should be kept absolutely clean.

Splint levelling machine:

1. Grease all bearings before starting machine.
2. Fix the splints receiving false bottom plate on to the slider and move up and down a number of times to make sure it moves smoothly. Very often wood dust will clog and hinder smooth movement.
3. Start machine and adjust splints feed by regulating flow from the splints magazine. This can be done by blocking out some of the grills through which splints move out from magazine.
4. Check tray of levelled splints after machine stops automatically. If levelling is good, the machine can be run. Otherwise if splints are poorly levelled or disturbed, polishing may not be enough. In such a case polishing drum should be run for longer time ensuring more splints retention time in drum.
5. Clean machine and place around well before leaving work.

Dipping machine:

1. Oil and grease all chain conveyors and machine gears before starting machine.
2. Switch on paraffin heaters at 6 a.m. daily. It takes over an hour to raise temperature to 140°C.
3. When temperature of paraffin reaches 140°C, adjust thermostat temperature to the same temperature.
4. Switch on all the pre-heaters and post heaters.

5. Fill chemical tank water jacket with water at 35°C and set thermostat to the same temperature.
6. Fill up tank with chemical composition and run dipping belt. Adjust feed level using two set screws on either side of the levelling bar bracket. Height of chemical on belt should be 4.5 mm.
7. Feed frames one by one through the splints levelling rollers and run over the pre-heaters.
8. Pick up frame over the paraffin tank and dip by hand in paraffin for 5 seconds. The dipping tray has overflow arrangement so that dipping height is 5 mm.
9. Feed dipped frame on to conveyor over the post-heaters, where they pass over the heaters for about 15 seconds, exposed to temperature of 60°C. This is to ensure penetration of paraffin into the wood.
10. The frame passes over dipping belt where it sits on the moving belt for 2 seconds. The frame is now received and held with heads down in the cooling air stream for 10 seconds to assist gelling of glue in the chemical composition.
11. The frame is now loaded into the trolley for drying.
12. As soon as all frames are dipped,switch off all heaters.
13. Clean dipping table and area around thoroughly with water and make sure no chemical composition is left. If cleaning is not good, dry chemical composition will start a fire the next day.
14. The chemical tank is emptied out into waste composition bucket which can be used next day after melting and mixing with fresh composition.
15. Always use CO_2 gas for extinguishing small fires that may start near the paraffin dipping station. WATER SHOULD NEVER BE USED, near paraffin tank.
16. All chains, gears are wiped clean of water, oiled and greased before leaving work.
17. Clean area around the machine well with water and ensure that no dry chemical composition remains anywhere. These are always a source of fire.
18. Check paraffin thermostat every day for accuracy by using a thermometer. The thermostat should be calibrated once a month by the factory chemist.

Side coating machine:

1. Oil all journals and grease gears before starting machine.
2. Switch on all heaters and hot air blower to warm up drier.
3. Fix up ready set of foam rollers on machine, top and bottom.
4. Feed chemical composition to level marked to both top and bottom tanks.
5. Start machine and allow to run idle for a few minutes to enable brushes to pick up uniform layer of chemical composition.
6. Now feed boxes into machine and hold them by hand till they are picked up by the pressure rubber rollers.
7. Check uniformity of friction chemical application to the two sides of the box.
8. If application not adequate run a wooden bar provided with paper stuck on and weigh out paper for application. It should be not less than 30 gm per m^2 and not more than 45 grm per m^2. Chemical pick up by foam rollers can be adjusted to regulate feed and consequently application. Wooden bar is repeatedly run and tested till application is adequate.
9. Check margins on either side and adjust as necessary.
10. Clean machine thoroughly after day's work and make sure no chemical composition remains anywhere.
11. Clean foam rollers in hot water and leave them covered with wet cloth for next day's work.
12. Switch off all heaters and blower. When the drier cools down, clean the box conveyors thoroughly of dry chemical composition.
13. Change foam rollers once a week. Keep two sets of rollers with fresh foam brushes always ready.
14. Keep place around machine absolutely clean and tidy.

ANNEX VII

Specimen machinery maintenance card:

Machine:----------------

Type: ------------------ Factory Serial No.:--------------

Date purchased:--------- Date Installed:------------------

Value Installed:--------

Electric Motor Name plate Particulars:

HP:-------------- Speed:-------------

Voltage:------------------------------

Other relevant information:-----------

Date	Nature of repairs done	Parts replaced			Local fabrication		
		Code No.	No. of Pieces	Cost	Factory No.	No. of Pieces	Cost

ANNEX VIII

Machinery maintenance programme

Machine	Check every:	Replace every:	Fabrication	Minimum Stock required:	Remarks
Outer box					
Veneer holder	week	when broken	in factory	3 pieces	can be made from scrap car springs
Paper cutting knife	week	6 months	in factory	2 pieces	file and sharpen every fortnight can be made from scrap car springs
Paper cutting roller	week	3-4 months	PWD workshop	3 pieces	only brass rollers advisable
Mandrel	3 months	liners after one year	in factory	1 set liners	after 6 months place shims under liners and finish to gauge by filing
Springs	month	15/18 months	import	1 set	check tension every 6 months and adjust
Cams	year	when necessary	import	1 set	cams can be repaired by welding liner and finishing by filing to templet profile. can be fabricated locally as well.
Feed rod	3 months	2 years	in factory	1 piece	rod in use can be filed periodically to present sharp edge to ensure feeding one skillet at a time.
Pushing plates	3 months	year	in factory	1 set	
Bushing	6 months	year	PWD workshop	nil	This is done during annual overhaul

Machine	Check every:	Replace every:	Fabrication	Minimum Stock required:	Remarks
<u>Splints levelling</u>:					
Separators	6 months	year	in factory	nil	they tend to bend and get distorted, thus disturbing splints while levelling
<u>Frame dipping</u>:					
Paraffin pump	6 months	overhaul annually	in factory	one	due to high temperature the pump wears out fast
Dipping belt	daily	year	import	two	check tension every month and keep absolutely clean
Gears	daily	2 years	PWD workshop	1 set	keep clean from chemicals. belt and gears to be oiled daily
Paraffin tank	6 months	--	in factory	nil	clean every 6 months
Chain conveyor	6 months	2 years	import	50 feet	links can be removed as they stretch
<u>Peeling</u>:					
Journals	year	when necessary	PWD workshop	nil	
Gears	6 months	when necessary	PWD workshop	1 each	
Pressure bar	6 months	when necessary	in factory	nil	grind and finish every 6 months

Knives should be checked constantly and every time knife is changed, alignment of knife and pressure bar should be checked. Gauges have been made and provided for the purpose. Lancets should be checked daily and ground.

Machine	Check every:	Replace every:	Fabrication	Minimum Stock required:	Remarks
Inner box:					

Schedule of maintenance will be exactly the same as under Outer box machine. Minimum stock required will double the quantities since there are two machines in operation. There are no other additional machinery components involved.

Machine	Check every:	Replace every:	Fabrication	Minimum Stock required:	Remarks
Labelling:					
Label cup	6 months	Indefinite life	In factory	nil	holding teeth should be filed periodically and remade when necessary
Cams	year	2 years	import	nil	can be repaired and used indefinitely
Friction:					
Pressure rollers	6 months	2 years	locally	nil	can be rerubberised and used
Frame filling:					
Cam(vibrator)	3 months	6 months	PWD workshop	4 pieces	they break often. so it is better to replace every 6 months.
Frames	3 months	year	in factory	500	They need replacement every year since grooving starts due to constant pressure and filling is affected. waste would increase.

Machine	Check every:	Replace every:	Fabrication	Minimum Stock required:	Remarks
Veneer chopping:					
Milled rollers	3 months	when necessary	PWD workshop	1 set of 2	Every 6 months the rollers should be remilled in the workshop and the teeth sharpened.

Change top pressure plates and bottom plates to correct size each time the machine is adjusted for chopping outer, rim or bottom skillets. It will be necessary to change top pressure plates with pressure rollers to reduce friction and ensure uniform chopping. This has been explained to the factory manager. PWD workshop can fabricate this. The workshop foreman is also informed of the exact nature of work to be done.

Machine	Check every:	Replace every:	Fabrication	Minimum Stock required:	Remarks
Splint chopping:					
Ratchet feed	fortnight	6 months	PWD workshop	1 set	The pressure plate gets slack often. So constant checking is necessary to prevent slipping.

ANNEX IX.

ASSISTANCE TO THE SAMOA MATCH FACTORY UNDP/UNIDO INPUTS

PROJECT NO: SI/WES/75/003

		Period Covered
10.	Project Personnel	
11	Experts/Post title	
11-01	Expert in match production	6 March 1976 - 5 April 1976
02		
03		
04		
40	Equipment	
49.00		

PROJECT NO: SI/WES/76/006

		Period Covered
10.	Project Personnel	
11	Experts/Post title	
11-01	Expert in match production	27 February 1977 to 2 June 1977 and 18 October 1977 to 7 December 1977
02		
03		
04		
40	Equipment	
49.00		

PROJECT NO: SI/WES/77/801

		Period Covered
10.	Project Personnel	
11	Experts/Post title	
11-01	Chemist in match production	14 May 1978 to 13 October 1978
02	Technician in installation and start-up of match factory	31 May 1978 to 30 September 1978
03	Technician in maintenance of equipment	31 May 1978 to 30 September 1978
04	Expert in match production	21 April 1978 to 20 April 1979
40	Equipment	
49.00		

	PROJECT NO: SI/SAM/77/801		Period Covered
10.	Project Personnel		
11	Experts/Post title		
11-01			
02	Technician in installation and start-up of match factory		1 October 1978 to 31 October 1978
03	Technician in maintenance of equipment		1 October 1978 to 31 October 1978
04			
40	Equipment		
49.00			

	PROJECT NO: UF/SAM/78/169		Period Covered
10.	Project Personnel		
11	Experts/Post title		
11-01	Chemist in match production		14 October 1978 to 13 January 1979
02	Technician in installation and start-up of match factory		1 November 1978 to 31 January 1979
03	Technician in maintenance of equipment		1 November 1978 to 31 January 1979
04			
40	Equipment	Allotment (US$)	Actual Expenditure (US$)
49.00	Quality control and laboratory equipment	15,895.	17,056.

	PROJECT NO: RP/SAM/79/001		Period Covered
10.	Project Personnel		
11	Experts/Post title		
11-01	Expert in match production		21 April 1979 to 31 May 1979
02	Technician in installation and start-up of match factory		1 February 1979 to 30 May 1979
03	Technician in maintenance of equipment		1 February 1979 to 30 May 1979
04			
40	Equipment	Allotment (US$)	Actual Expenditure (US$)
49.00	Quality control and laboratory equipment	10,000.	9,310.

	PROJECT NO: DP/SAM/79/003	Period Covered
10.	Project Personnel	
11	Experts/Post title	
11-01	Expert in match production	1 June 1979 to 20 September 1979
02	Technician in installation and start-up of match factory	31 May 1979 to 30 July 1979
03	Technician in maintenance of equipment	31 May 1979 to 30 July 1979
04		
40	Equipment	
49.00