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sults (April - Sept. 1949)

Power consumption of every branchs (per month)

ting	Sulphuric Acid	Transportation	Maintenance	Research & Analysis	Business etc	Total
.6	164,675	20.897	15.651	26.907	29360	467,108

days of every branchs (per month)

r ting	Sulphuric Acid	Transportation	Maintenance	Research & Analysis	Business etc	Total
.6	2694.3	2872.7	3679.9	983.7	3657.7	17645.9

f every branchs / Total Expenses

ting	Sulphuric Acid	Transportation	Maintenance	Research & Analysis	Business etc	Total
0 %	16 3 %	9.0 %	6.2 %	3.6 %	25.9 %	100 %

tal ratio of Total expense of Hibi Smelter

	Expense of ore	Expense of material (except ore)	Labour cost	Expense of welfare	* general Expense	Total
%	64.8	9.0	13.5	1.6	11.1	100 %

luding selling expenses & debts

alization

l operating of Copper Smelting
lization of Suspending apparatus
dy of Converter operating
~~tics~~ Researches

anufacture of Calcium Superphosphate
ctro-thermic Smelting

hanization of Transportation

very of Sulphuric Acid from Waste gas.

The end.

DECLASSIFIED E.O. 11652 SECTION 3 (E)(1)(B) NLS

HEADQUARTERS
CHUGOKU CIVIL AFFAIRS REGION
ECONOMICS SECTION

CCAR 319.1 (D-Lo) 28 September 1950

SUBJECT: Report of Field Trip, Okayama City, 20 September 1950

TO : Chief
Economics Section

PREPARED BY: Robert P. Lord, Distribution & Industry Division

1. REFERENCE:

O.D. 11

2. PURPOSE:

Inspection of Kurashiki Rayon Company.

MANUFACTURING AND INDUSTRY FILE

3. BACKGROUND:

Routine

4. DISCUSSION:

August production was as follows:

Rayon Staple Fibre	224,461 lbs.
Vinylon Fibre	21,330 lbs.

At present Vinylon is supplies to this plant from Kurashiki Rayon Plant in Kurashiki City. The Vinylon manufacturing plant which was scheduled to open here at the Okayama plant in September was delayed due to late delivery of needed machinery. Company officials are anticipating opening the Vinylon plant in November. When placed in operation initial production is slated for one (1) ton of vinylon per day. This figure is expected to be increased to five (5) ton per day one month after plant is opened.

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Electric Power

August Allocation	August Consumption
175,000 KWH (Plus 14,000 KWH additionally allocated) (Plus 30,000 KWH sent from Kurashiki City Plant)	227,680 KWH

Company officials are negotiating for a larger power allocation due to the fact that Vinylon plant will be opened soon.

5. CONCLUSION:

Vinylon products seem to be well received on the Japanese market. Printed advertisements and show window displays of department stores in the larger cities are proving very successful in keeping the general public interested.

6. RECOMMENDATIONS:

None

RPL

R. P. Lord

R. P. LORD
Distribution & Industry Division

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TEKTILE

RCA file

Outline of Kurashiki Rayon Co., Ltd.

Nov. 1, 1948

Address of Main Office: 4-chome, Imabashi, Higashiku, Osaka

Representative : Soichiro Ohara, President

Establishment date of company: June 24, 1926.

Capital: ¥50,000,000 (Paid-up)
(To be increased to ¥250,000,000 in this year)

Main products: Rayon filament
Rayon staple
Staple yarn
Synthetic fiber (Vinylon)
Plastic moulding powder

Production in the past:

Before the War, this company has had four rayon plants in the cities of Kurashiki and Okayama in Okayama Pref. and Niihama and Saijo in Ehime Pref. and has kept the production capacity of 88.157 ton/day for rayon filament and 84.50 ton/day for rayon staple. (approximately 10 % of the whole capacity in Japan)

Production at present: (capacity)

Kurashiki Plant: Rayon filament: 5 ton/day (Rehabilitation is almost completed)

Synthetic fiber: 200 kg/day (Under operation)

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h. Granted permission from HQ, I Corps in Kyoto on May 3, 1946 to produce the synthetic fiber.

i. Granted permission from GHQ on July 21, 1947 for rehabilitation fund to produce 200 kg/day of synthetic fiber.

j. Granted permission from GHQ on April 13, 1948 for the rehabilitation fund to produce 5 ton/day of viscose rayon filament.

k. Commenced operation to produce synthetic fiber on April 27, 1948.

l. Stopped production of prefabricated house at the end of December, 1947 and plywood at the end of June, 1948.

6. Production before the war:

	Capacity
Rayon filament:	26,212 kg/day
Rayon staple :	12,600 "

7. Production after the war:

Product	Quantity (month)	Total quantity produced For U.S.Army	For BCOF	Others
Plywood	60,000 sheets	14,250 shts	90,379 shts	1,164 shts
Door		1,000	3,992	
Sash		2,998	9,713	
Box			10,000	
Transom			8,370	
Flash door		1,653		
Prefabricated house	60 houses		For Japanese 268 houses	
Plastic moulding powder	30 tons			

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8. Production at present & future plan:

a. Rayon filament:

We are now rehabilitating the production equipments of 5 ton/day of rayon filament and will commence to operate partially in this month.

After the completion of the rehabilitation work, we plan to manufacture 10 ton/day production of rayon filament.

b. Synthetic fiber:

We have now the production capacity of 200 kg/day of synthetic fiber, (Vinylon staple) and are producing about 1.5 ton of vinylon staple per month.

And now we are experimenting synthetic rayon filament production and so after the completion of this experiment, we plan to manufacture 1 ton/day production of vinylon filament, and 1 ton/day production of vinylon staple.

c. Plastic moulding powder:

We are now producing about 20 ton of plastic moulding powder per month and will produce 30 ton/month if the allocation of materials will be given enough.

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General description of Kurashiki Plant

Kurashiki Rayon Co., Ltd. Nov. 1, 1948

1. Location: 1621 Sakazu , Kurashiki City, Okayama Pref.
2. Area of site: 386,685 Sq. meters (96 acre)
3. Area of building: 72,776 Sq. meters (18 acre)

   Capacity of dormitory: Male dormitory: 300 persons

   Female dormitory: 600 persons

   Employees' quarters: 320 houses

4. Number of employees: Male: 1,549

   Female: 532

   Total: 2,081 (At the end of Oct.,1948)

5. History of the Plant:

   a. Began construction of the plant in May, 1927.

   b. Completed construction on December 31, 1927.

   c. Commenced operation on May 9, 1928.

      Quantity of rayon filament production: 2 ton/day.

   d. Expansion of production equipments has been done in 1939.

      Production capacity of rayon filament: 26.312 ton/day.

      Production capacity of rayon staple : 12.600 "

   e. Converted to the wood working and electrolysis metallic manganese production in 1943.

   f. Upon termination of war, stopped operation.

   g. Granted permission dated Dec. 13, 1945 for producing plywood, prefabricated house and plastic moulding powder with the equipments and materials which have been kept during the war.

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Saijo Plant: Rayon filament: 11.8 ton/day (under operation)

Rayon staple : 30.6 ton/day (under operation)

Okayama Plant: Staple yarn : 5.7 ton/day (23,400 spindles) (Under rehabilitation)

Niihama Plant: was sold by the Government order.

Future Plan: This company is now planning to increase the production capacity of rayon filament to 10 ton/day and synthetic fiber to 2 ton/day in Kurashiki Plant and to construct the rayon staple yarn weaving equipments equipped with 500 weaving machines in Okayama Plant.

Note: Ratio of actual result of production against the registered capacity: (Sept., 1948)

1. Rayon filament:

Average in Japan:	36.5 %
Our company :	75.3 %

2. Rayon staple:

Average in Japan:	17.5 %
Our company :	13.4 %

DECLASSIFIED E.O. 12065 SECTION 3 (E)(2) NARS DATE

B. On the Viscose Rayon Plant

1. Production process - flowsheet

2. Manufacturing condition

3. Production equipments

4. Characteristics of installation

5. Researches

6. Raw materials and chemicals

7. Employees for rayon production

8. Training for operation

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(1) Production process of rayon filament at Kurashiki Plant

Pulp → Open the bale → Punching machine (cutting and punching) → Dryer room (control the moisture content 6 %) → Weighing machine → Elevator (transfer pulp to steeping room of upstairs) → Steeping press → Crusher → Apron conveyer → J.S. Shredder → High speed fan → Cyclone → Wagon → Weighing machine (weigh alkali cellulose with weighing machine) → Vacuum conveyer → Vacuum kneader (short ageing, xanthating, cellulose xanthate dissolving) → Mixing → First filter → Second filter → Third filter → Spin tank → Pot spinning machine → Cake →

Skein: Reeling machine → Bleaching machine → Hydro extracter → Dryer → Air conditioning → Sorting → Grading → Packing

Cake: Backing machine → Bleaching machine → Pot hydro-extracter → Dryer → Air conditioning → Finding → Sorting → Grading → Packing

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Rayon manufacturing condition

Kind of product: Semi-dull lustre 120 D

A. Viscose section:

1. Steeping and shredding:

Conc of steeping solution	230 g/L
Quantity of steeping solution	4,100 L/one batch
Temp of steeping solution	12°C
Conc of hemi-cellulose of steeping solution	Below 6 g/L
Number of section of steeping press	47 sec
Weight of pulp for one batch	200 kg
Steeping hour	120 min
Pressing hr	30 min
Pressing ratio	2.7
Percentage of cellulose in alkali cellulose	31.0 %
Percentage of alkali in alkali cellulose	16.5 %
Shredding hr	50 min
Temp at shredding	25°C
Weight of alkali cellulose for one batch	540 kg

2. Ageing, xanthating and dissolving:

Temp of ageing in the beginning	35°C
Highest temp of ageing	45°C
Temp at cooling	23.5°C
Cooling hr	120 min
Temp at xanthating	23.5°C- 25.0°C
Xanthating hr	150 min

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Dissolving hr	180 min
Temp at the end of dissolving	15°C
Transfe hr of viscose	20 min
Percentage of adding CS2	36 %
Vacuum degree of kneader	500 m.m.
Percentage of adding Na2SO3	5 %
Quantity of additional solution	3,000 L/2 batches
Alkalinity of additional solution	28 g/L
Percentage of adding TiO2	1.01 %
Total quantity of viscose	3,720 L/2 batches
Percentage of cellulose in viscose	8.0 %
Percentage of alkali in viscose	6.3 %

3. Mixing:

Receiving hr of viscose	40 min/4 batches
Mixing hr of viscose	240 min/4 batches
Transfer hr of viscose	40 min/4 batches
Temp at the end of mixing	18°C
Viscosity at the end of mixing	160 second

4. Ripening:

Ripening hr	45 hrs
Ripening temp	18°C
Pressure at 1st filter	3 kg/cm2
First filtration hr	3 hrs
Cloth of 1st filter	One sheet of calico and one sheet of flannel
Pressure of 2nd filter	3 kg/cm2
Second filtration hr	3 hrs

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Cloth of 2nd filter	2 sheets of flannel
Pressure of 3rd filter	2 kg/cm2
3rd filtration hr	3 hrs
Cloth of 3rd filter	3 shts of calico & 1 sht of flannel
Pressure of spinning tank	5.0 kg/cm2
Viscosity at the beginning of spinning	130 sec.
Ripening degree in the beginning of spinning	9.0 c.c.

B. Spinning section:

Number of nozzle per one spinning machine	100 nozzle
Spinning speed	80 m/min
Output per day per one spinning machine	260 lb/day
Quantity of viscose flowing out by gear pump	9.6 c.c./min
Immersion length	100 m.m.
Size of spinnerette	50x0.08x12x17x5
Dia of pot	160 ø
Doffing hr	4 hrs
Traverse	20.0 times
Sp.gr of coagulating bath	1.290
Acidity of bath	138 g/L
Concentration of ZnSO4	23 g/L
Concentration of Na2SO4	250 g/L
Temp of bath	48°C
Bath supply quantity per one spinning machine	2,000 L/h

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Temp at spinning room	22°C
Moisture degree of spinning room	85 %
Ventilation time of spinning room	45 times/hr

C. After-treatment Section:

1. Reeling room:

Revolution time of reel hanks	300 r.p.m.
Meter manifestation	4,300
Knitting method of skein	4 x 4
Temp in reeling room	22°C
Moisture in reeling room	60 %

2. Skein bleaching & drying:

Speed of belaching machine	70 min
Number of reel per one bleaching rod	40 s
Conc of Na2S	11 g/L
Temp of Na2S bath	55°C
Conc of bleaching liquor	0.4 g/L
Alkalinity of bleaching liquor	0.46 g/L
Concentration of oiling bath	1.5 g/L
Temp of oiling bath	50°C
Dehydration hr	15 min
Dryer speed	260 min
Number of skein per one dryer rod	12 s
Output per one dryer per hr	2,600 s
Highest temp in dryer	83°C

3. Cake bleaching, drying and winding:

Speed of bleaching machine	400 min

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Number of cake per one bleaching rod	12 cakes
Output of cake per day per one bleaching machine	11,300 cakes
Revolution time of dehydration pot of cake	2,700 r.p.m.
Dryer speed	24 hrs
Number of cake per one dryer rod	5 cakes
Output of cake per day per one dryer	6,630 cakes
Speed of winder	160 m/min
Winding hr for one cone	10 hrs
Weight of one cone	1,260 kg

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3. Production equipments

Production equipments, number of machines installed and operable machines as at Nov. 1 are as follows:

Machinery equipments	Time	Total No. of machine	Operable machines on Nov.1	Remarks
Alkali dissolving tank	10 ton/day	1	1	
Alkali solution stock tank	45,000 L	3	3	
"	19,5000 L	15	15	
Conc alkali stock tank	45,000 L	4	4	
Stock tank of setting alkali	12,500 L	3	3	
Additional alkali stock tank	45,000 L	2	2	
Recovering alkali stock tank	45,000 L	2	2	
Mixed alkali stock tank	45,000 L	1	1	
Adjusted alkali stock tank	45,000 L	4	4	
Underground tank of returned alkali	16,000 L	2	2	
Underground tank of pressed solution	12,000 L	2	2	
Hard water softening equipments	11 m3/h	3	2	
Soft water tank	3,000 L	4	4	
Alkali evaporator	500 L/h	1	1	
Alkali dializer	3,000 L/day	15	1	
Pulp punching machine	Pulp 8 ton/day	2	2	Nov.30 4 Dec.31 5 Jan.31 10 Feb.28 15

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Steeping and pressing machine	Pulp 440 lb/batch	6	6	
Temp adjusting tank of normal alkali	12,000 L	2	2	
Shredder	Pulp 484 lb/batch	3	3	
Alkali cellulose fan	2460 m3/h x 90 mm	3	3	
Vacuum kneader	5,500 L	10	10	
Vacuum tank	5,000 L	4	4	
Viscose mixer	13,000 L	2	2	
Viscose tank	13,800 L	22	22	
Filter press	580x820x45 frame	12	6	Dec.31 -12
Washing machine	38" ϕ x 46"L 2 HP	3	2	Dec.15 - 3
Hydro extractor	800 ϕ x 350 H 5 HP	2	1	Dec.15 - 2
Carbon disulphide stock tank	25,000L	2	2	
Measuring tank of carbon disulphide	8,000 L (1,700ϕx3,500 L)	3	3	
Air conditioning equipments	75,000 m3/h	4	4	
Bath tank	8,000 L	2	2	
Bath collection tank	65,000 L	4	4	
Pot liquor stock tank	3,500 L	2	2	
Zinc oxide dissolving tank	1,000 L	2	2	
Sulphuric acid adjusting tank		2	2	
Bath heater	410 ϕx1,500 x 2	4	2	
Bath evaporation equipments	7,000 L	5	3	Dec.15 - 5

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Bath crystalizer	Vertical 1,000 ϕ x 2,000 H	3	3	
Glauber salt dehydration tank	Na2SO4 3 ton/day	3	2	Dec.15 - 3
Spinning machine	100 nozzle centrifugal type	45	9	Nov.9 - 9 Nov.30-14 Dec.30-19
Sulphuric acid stock tank	40,000 L	4	4	
Air conditioning equipments	175,000 m3/h 50 HP	3	3	
Exhaust fan	100,000 m3/h 20 HP	6	6	
Reeling machine	2 skein x 8$ swift	6	6	
Na2S circulation tank	7,500 L	2	2	
Bleaching liquor circulation tank	7,500 L	2	2	
Sulphuric acid circulation tank	7,000 L	2	2	
Soap liquor circulation tank	6,250 L	2	2	
Saponification vessel	436 L	2	2	
Na2S dissolving tank	4,200 L	1	1	
Na2S precipitation tank	13,000 L	5	5	
Liquid chlorine synthetic dissolving tank	9,120 L	2	2	
Skein bleaching machine	9,700 skein/h	2	2	
Skein hydroextractor	1,200 ϕ x 500 h	3	3	
Skein dryer	2,955 skein/h	3	3	
Bundling machine	300 bundle/day	3	3	

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Baling machine	100 bale/day	1	1	
Cake bleaching machine	10,776 cake/day	2	1	Dec.15 - 2
Cake hydroextractor	240 cake/h	4	4	
Cake dryer	6,630 cake/day	2	2	
Reeling machine for cone	72 henks	1	1	
Cone winder	56 spindle	36	24	Dec.20 - 36

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4. Characteristic of installation:

Compared with that of Saijo Plant, we mention here the special features of Kurashiki Plant in its installation as follows:

(1) Moisture control of pulp:

In order to keep the content of moisture in the punched pulp within 6 % (mainly home-made pulp) we installed the pulp dryer next to the pulp ware house. Inserting the pulp of 14 sheets in one section, pulp is gently dried by the steam pipe on the floor by 40°C for 18 to 20 hrs.

Moisture control is to be done by the following order:

Open the bale of pulp, cut it into one half, punch it and insert it in the dryer in each section of 14 sheets to decrease the content of moisture and then is carried over to the next weighing room where the pulp is left for 24 hrs for adjustment of moisture and then after weighing it is carried over to the steeping room of upstairs by pulp elevator.

(2) Filter of CS2:

Due to the mixing of dust in CS2, the cock with which CS2 is weighed and inserted to vacuum kneader is sometimes damaged, therefore, we put the filter press of CS2 next to the weighing tank of oil. Filter press is dipped in the water while using, and in case of cloth exchange, the water is discharged from the tank.

(3) Purification of water used for viscose and caustic preparation:

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Water is cleaned by ordinary Zeolite Filter, and then cleaned through manganese Zeolite Filter in order to decrease the content of Fe in the watrer and the dust in the water is extracted through the filter press.

(4) Purification of conc caustic soda solution:

In case of diluting of liquid caustic soda of 500 - 700 g/L into conc solution of 350 g/L, we take the measure of settling by circulating the steam heater by pump by 30°C and accerelate the precipitation.

(5) Purification of dissolving alkali liquor:

After adjusting the dissolving liquor for xanthation in the soft water and conc soda solution, we transfer it to the additional alkali temp adjusting tank through the filter press in order to extract the dust from the liquor.

(6) Installation of air conditioning equipments for alkali cellulose plant.

We installed the air conditioning equipments for weighing pulp room, steeping room, shredding room and alkali cellulose weighing room in order to control the moisture content of pulp, to prevent the drying of alkali cellulose and also to inify the temperature.

(7) Vacuum transport of Alkali cellulose:

On steel belt conveyer at Saijo Plant, alkali cellulose touches to the air too much and it causes the carbonation and drying of alkali cellulose and in order to prevent this, alkali cellulose which comes out from J.S. Shredder and is received by the wagon through cyclone and sent to

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vacuum kneader through the pipe by vacuum after weighing.

(8) Adjustment of cooling and heating of vacuum kneader:

In order to make the kneader uniformly cooled and heated, we make the passage of cold and hot water more efficient than that of Saijo Plant.

(9) Uniform temperature of viscose dissolving:

We installed the cooler and temp adjusting tank next to the vacuum kneader room to make the viscose dissolving in low and uniform temperature.

(10) Installation of the completely temp-controlled ripening room:

As the ripening room of Saijo Plant is not satisfactorily constructed in its temp adjusting equipments and building, Kurashiki Plant paid the special attention to the temp adjusting equipments and temp maintenance of building.

(11) Conduction equipments of spinning machine:

We separate the driving system to the high speed part (godet) and the low speed part (gear pump and cam) at the starting point and therefore, inside of gear box is simple and appropriate.

(12) Screen of spinning machine:

Screen of Saijo Plant is not easy for opening and closing with the cutting of the rope several times, therefore, we made it working by spring.

(13) Double godet:

In order to make the uniform yarn from spinning machine, we experimetally constructed one spinning machine

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with double godet. All others are also planned capable to be changed into double godet.

(14) Reeling machine:

We made the construction to be stable so as to make the opening and close of the swift exactly.

(15) Cake bleaching:

Paying attention to the oiling in cake bleaching, we installed oiling bath tank separated from skein oiling.

(16) Air conditioning in after-treatment section:

We installed the air conditioning equipments in the conditioning room where the skein and cake are left after drying, and also in the winder room and sorting room.

(17) Test room:

Fiber testing room is always kept in the same condition with temperature of 20°C and 65 % humidity.

5. Researches: Items of research which we are going to take up are as follows:

(1) Decrease the hemi-cellulose in the steeping liquor.

(2) Temperature control of alkali cellulose in J.B. shredder.

(3) Temperature control of heating and cooling in vacuum kneader.

(4) Utilization of electric high vibration apparatus for the removal of air bubbles in mercerization.

(5) Determination of the operation condition of the double godet spinning machine to produce the uniform yarn.

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Production Schedule

Kind of product: Skein and cone
Semi dull lustre
120 D (50 filament)

Production plan is estimated as follows considering the progress of the construction work and the equipments of raw chemicals.

Month	Charge per day	Number of spinning machine operated	Production quantity of cone (lb)	" of skein (lb)	Total (lb)	Remarks
Nov.	4-10	3-14		60,000	60,000	start of spinning: Nov. 6
Dec.	10-14	14-19		30,000	100,000 130,000	

6. Raw materials and chemicals:

We submitted the application for the special allocation for the second quarter as the running stock, but no ticket has been given and so we have to wait for the regular allocation for the 3rd quarter. It gives much obstacle to the commencement of operation and therefore, we submit the application for approval of transferring the stock in our Saijo Plant. We wish the regular allocation for the 3rd quarter shall be issued as quickly as possible and upon receiving it we will do our effort to materialize the coupon. (allocation ticket)

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Necessary quantities of principal raw materials & chemicals

Unit: Ton

Material	Quantity in stock	November	December
Pulp	0	35	75
NaOH (purity 97 %)	25.0	25	53
Cl2	0	11	22
TiO2	0	0.3	0.6
Na2S2O3	0	1.6	3.4
H2SO4 (purity 65°Be)	30	37	79
ZnSO4	5.0	3.0	6.2
Na2SO4	60		
Na2S (purity 55 %)	3.0	2.3	4.6
Bleaching powder (Act.Cl 24 %)	10	0.7	1.4
Pensofter	0.5	0.4	0.8

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7. Employees for rayon production:

Production plan and draft (recruition) plan of necessary persons in the rayon manufacturing section.

Necessary persons to carry out the afore-mentioned production plan are as follows:

Month	Production quantity	Female	Male	Total
Nov	60,000 lbs	400	200	600
Dec	130,000 "	450	300	750

Total listed employees in the rayon manufacturing section on Oct. 30 are 730 (Female: 410 and Male: 320) and there is no obstacle for the operation of the plant in November. From the smooth recruition in the past, we can expect the rose future regarding the employement of workers after December.

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8. Training for operation:

Training plan of rayon manufacturing section:

Kurashiki Plant started the viscose rayon filament production in 1926 and continued the production until 1944 and therefore, all the stuffs and foremen are experienced in viscose production. Accordingly, we carried out gradually the rayon production plan from the beginning of this year and completed the actual planning up to April 20. Engineering and technique are being learned by the installation of machinery and through text book and we sent the employees to Saijo Plant for practical learning according to the under-cited schedule and the final group came back from Saijo on Sept 27 and here we have completed the organization of employees for the operation of rayon filament production of 3,000 lbs per day from Oct. 1.

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Number of employees by their living quarters

Period		Total number	Dormitory		Employees quarters		On foot	Remarks
			No.of accomodation	No.of occupied	No.of house	No.of occupied		
At present	M	1531	300	274 34 (clerks)	272	272	951	Oct.20
	F	539	500	311		43	185	
End of Dec.1948	M	1725	540	540	268	268	917	Accomodation for 240 male increased
	F	678	600	391		57	250	
End of Mar.1949	M	1977	540	540	368	368	1069	~~100~~ houses increased
	F	875	600	563		37	275	

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On the Synthetic Fiber (Kuravilon) Plant

1. Introduction:

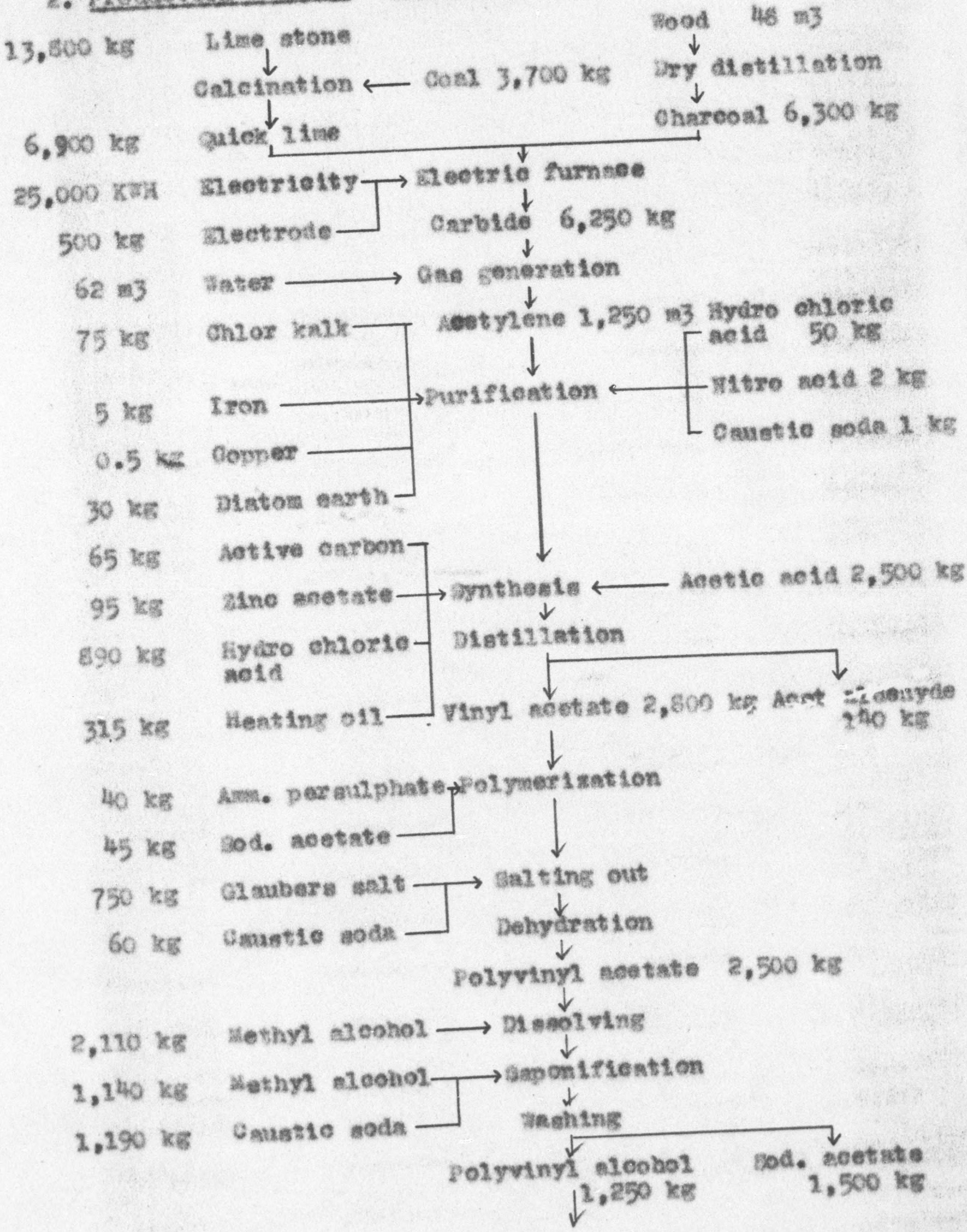
Research on the production of Kuravilon was being carried on in the laboratory of our Okayama Plant before the war and we completed the intermediate test production equipments but during the war, these equipments in the plant were partially burnt out. Upon termination of the war, we planned to rehabilitate the equipments in Kurashiki Plant, got the permission from HQ, I Corps in Kyoto on May 3, 1946, got the formal approval from GHQ on July 21, 1947 and was granted approval from Finance Ministry of Japanese Government for finance of fund. Furtheremore, we got the approval of loan from RFC for the additional fund due to the price raise of construction materials.

Charcoal production equipments were completed on Nov. 3, 1946.
Calcium carbide equipments were completed on March 20, 1947.
Production equipments of polyvinyl alcohol and polyvinyl alcohol fiber (Kuravilon) were completed on April 27, 1948.
All these are being operated but the charcoal production was stopped temporarily due to the change of situation. Production equipments of polyvinyl acetate were completed excepting the acetic acid and began to operate on Oct. 20, 1946.

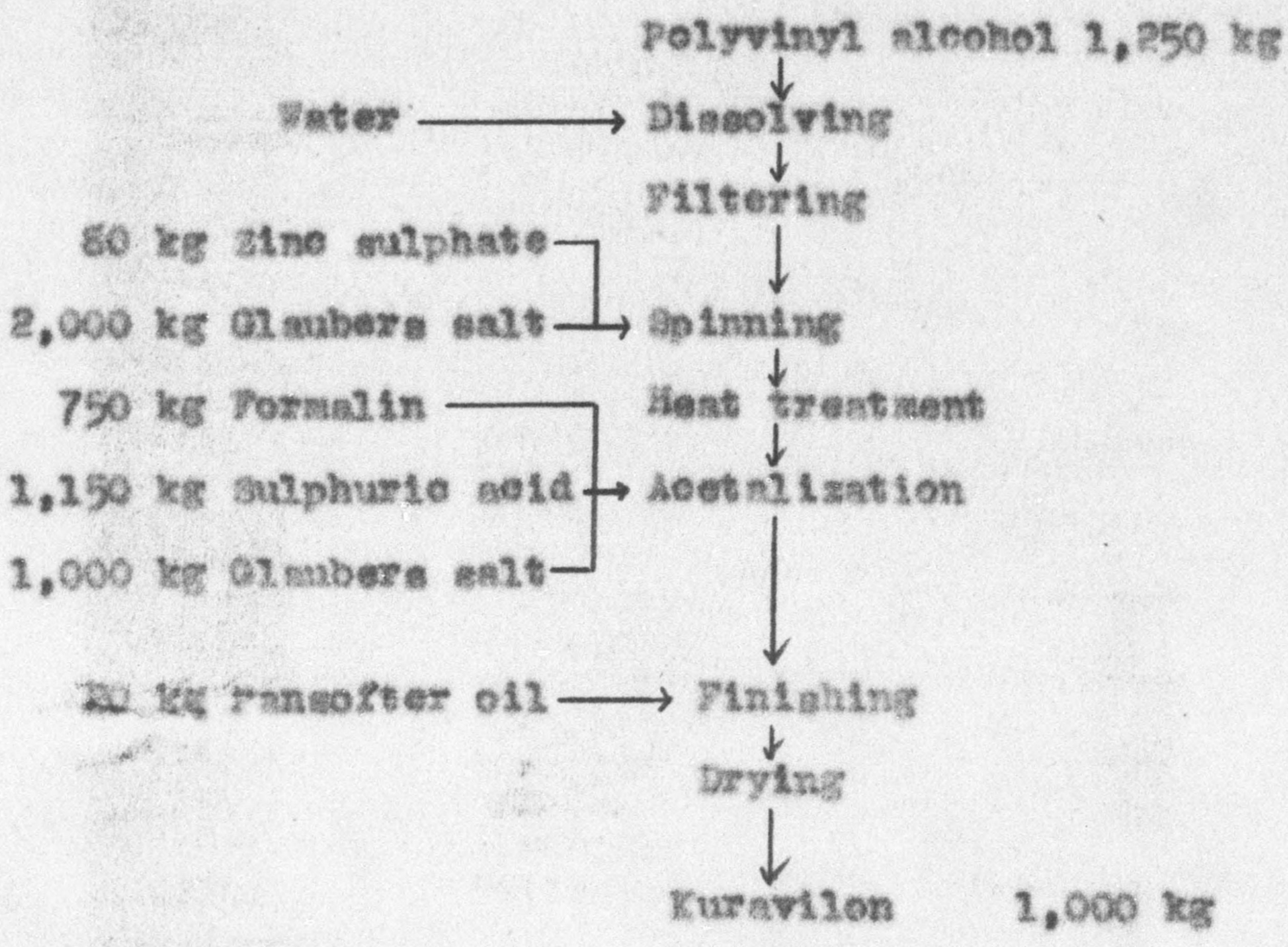
We set up the production technique by using these equipments, and at the same time, we examine the function of each equipment. After acquiring the exact expectation for the quality of the product and its use, we wish to materialize the 2nd plan of 2,000 kg/day production of Kuravilon. The products at present are staple and tow and in the near future we are preparing to produce the filament yarn.

DECLASSIFIED E.O. 12065 SECTION 3 402/NNBS NO:

2. Production process: Flowsheet



DECLASSIFIED E.O. 12065 SECTION 3 402/MNDS NO: [illegible]



DECLASSIFIED E.O. 12065 SECTION 3 402/NNBS NO:

3. Production equipments:

The main equipments are as follows:

	Item	Type	Quantity
Charcoal production	Circular saw	40"	2
		20"	1
	Dry distillator	300 kg/day	20
	Wye product treatment		1 set
Calcium carbide production	Lime kiln	7.5 ton/day	2
	Electric furnace	6 "	1
	Transformer	2,800 KVA	1
Polyvinyl acetate production	Acetylene generator	2,750 ϕx6,200H	1
	Gas holder	50 m3	1
	Acetylene purifier	1,200 ϕx900H	4
	Acetylene preheater	600ϕx4,500H	1
	Acetic acid evaporator	700ϕx4,500H	1
	Gas preheater	900ϕx4,000H	1
	Reaction vessel	1,300ϕx3,100H	2
	Heat exchanger	300ϕx3,700H	1
	Distillation of vinyl acetate		1 set
	Polymerization vessel	1,700ϕx2,200H	1
Polyvinyl alcohol production	[illegible]-solver of PvAC	1,100ϕx2,000H	2
	Saponificator	750ϕx1,000H	3
	Vacuum dryer	Closed	1
	Washer	1.5 m3	2

DECLASSIFIED E.O. 12065 SECTION 3 402/NNDS NO.

	Item	Type	Quantity
	Distillator of methanol		1 set
Kuravilon production	Dissolver of PvA	1.6 m³	2
	Spinning machine	10 nozzles	3
	Heta treatment app.	14 m L	2
	Aftertreatment app.	21 m L	2
	Dryer	Roller type	2
	Bath evaporator		1 set

k. Products:

We commenced the production of Kuravilon on April 27, 1948 and the quantity up to this day is cited as follows:

Month	Calcium carbide	Kuravilon (staple or tow)	PvA	VAC (monomer)
Apr. 1948	96,797 kg	100 kg	1,240 kg	0
May	95,940	148.2	1,272	0
Jun	95,695	366.03	2,552	0
Jul	110,002	1,457	1,310	0
Aug	93,880	2,071.17	1,367	0
Sept	88,350	1,592	2,180	0
Oct	102,500	2,449	1,028	0

Calcium carbide is now being sold through the allocation system. PvA is being self-consured for production of fiber and some part for film and others. Fiber is now under spinning test. The reason of the low production quantity than an estimate (6,000 kg/day) is due to the re-construction of equipments, the delay

DECLASSIFIED E.O. 12065 SECTION 3 402/NNDS NO.

the delay of making the product into complete articles and the shortage of the raw materials.

Equipments for acetic acid is not yet completed and so we purchase it from others.

5. Necks for operation of the plant:

As this is the enterprise undertaken for the first time, there are many bottlenecks which are described as follows:

a. Difficult finance of fund.

Fund supply is difficult as it takes long to make the products into complete articles.

b. It takes a long time to make the products into complete articles. Difficulties to make the product into complete articles are described as follows:

i. When spinning, it is easy to generate the static electricity, therefore moisture adjustment of operation room is necessary.

ii. Because of the difficult nature of dyeing, when spinning, be careful not to mix with other fibers. (When used by mixing, it is other matter.)

iii. At present, textiles are very busy with full operation. for the reason mentioned above, it takes a long time to spin them into yarn and make them into textiles.

c. It is hard to secure the raw materials.

It is hard to secure the VAC monomer and good active carbon. Accordingly, the operation is not running smoothly

DECLASSIFIED E.O. 12065 SECTION 3 402/NNBS NO:

related with each other and therby make the uniformity of the product very hard. Consumption of chemicals increases and efficiecy of operation lowers. However, since VAC monomer began to be produced in this plant from this October, this problem will be solved.

d. High production cost.

It is natural that 200 kg/day is only a small quantity as this is the pilot plant but we should do the full operation to decrease the loss and to raise the efficiency of operation.

e. Others.

So as to make the prodcut easy to be the complete articles, we should prevent the static electricity of the product, make crimping, make good dyeing, increase the strength and make it good looking, etc. All these points are being improved gradually.

Coal is also the neck for smooth operation, but we are doing our efforts to solve this question.

DECLASSIFIED E.O. 12065 SECTION 3 402/NNBS NO:

Explanation on the Plastic's Production

Outline of plastic's production in the plant.

1. Production of bakelite moulding powder.
   a. Manufacturing process.
   b. Equipments.
   c. Production of bakelite moulding powder.
   d. Present enlisted employees for the production.
2. Research on the plastics from vinyl resin.
   a. Water proofing agent for textile fiber.
   b. Film from the bye-product of vinyl fiber.
   c. Urea resin using for rayon plant.

DECLASSIFIED E.O. 12065 SECTION 3-402/NNDG NO.

Outline

After the war, through the permission granted by HQ, I Corps in Kyoto on May 3, 1946, we are now manufacturing the bakelite moulding powder for textile industry, and on the other hand, we are making a research on the production of resin and films, etc. for textile processing by utilizing the bye-product of polyvinyl fiber production.

At present, we produce the bakelite moulding powder of about 20 tons per month which are used for the production of accessories and parts of spinning machines and telephone apparatus for export and on the other hand, we are making an experimental production of resin and film, etc.

To make the development of rayon industry easy, we wish to continue the plastic industry with the power remained for us.

1. Production of bakelite moulding powder.

(a) Manufacturing process:

We produce the bakelite moulding powder with 2 step process, that is, we synthesize the bakelite resin using phenol, cresol, formalin and hydrochloric acid and then evaporate, crushes it into the solid resin, dissolve it in the alcohol, mix it with wooden powder, dye, hexametylene tetoramin and stearic acid, dry and crush. The flowsheet of production is as follows:

DECLASSIFIED E.O. 11652 SECTION 3 (E), MRS NO.

Phenol
Cresol
Formalin
Hcl
→ Synthesizing → Concentrating → Crushing →
Dissolving → Mixing → Crushing → Drying →
Alcohol
Wood powder
Dye
Hexametylene tetoramin
Stearic acid
Packing → Product

(b) Equipments

Description	Capacity	Number
Reaction kettle	500 L	4
Concentrating kettle	400 L	4
Mixing machine	800 kg/day	4
Crusher	200 kg/hr	3
Dryer	800 kg/day	2

(c) Production of bakelite moulding powder.

Year	Production quantity	Note
1945	0	
1946	135.996 ton	
1947	263.383 "	
1948	150.360 "	From Jan to Oct

(d) Present enlisted employees.

Male: 52 Female: 3 Total 55

DECLASSIFIED E.O. 12065 SECTION 3-402/NNDG NO.

2. Research on the plastics from vinyl resin.

(a) Water proofing agent for textile fiber.

To give the water-proof to rayon and silk textile, we make a research on the polyvinyl resin and we use the vinyl acetate for the 1st bath and polyvinyl, acet-acetar, alcohol solution for the second bath and steep the textile and we obtain the good result. Still we are now making a research.

(b) Film from bye-product of polyvinyl alcohol fiber.

To utilize the bye-product in the process of Kuravilon production, we are now making a research on the production of film followed by the experimental production of 5 kg per day.

(c) Urea resin using for rayon plant.

We are now making a research on urea-formalin resin for the use of rayon plant. (For example: Fiber box, paper pipe, reel rod, etc.)

DECLASSIFIED E.O. 12065 SECTION 3 (b), NARS NO.

Stoppage of electric power supply and plan for self-generation of electricity.

Stoppage of electric power supply at Kurashiki District happens very frequently, especially when the hydro-electric power in Chugoku Province decreases in dry season and the shortage is supplemented by receiving electrification from Kansai Province by Sagoshi electric transmission line along the seaside which becomes out of order very often. Therefore, we can not produce the rayon of good quality, so we wish to operate the equipments of self-generation of electricity (maximum power: 2,300 KW) after the middle of November to supply it for viscose and spinning operation for which non-stoppage of electric power supply is absolutely necessary.

(1) Record of stoppage of electric power supply:

June	22 times	52 min
July	35 "	4 hr & 14 min
August	14 "	52 min
September	10 "	2 hr & 1 min

(2) Plan of self-generation of electricity.

	Generation KWH	Power purchased KWH	Total KWH	Quantity estimated to be consumed: Rayon	Quantity estimated to be consumed: Synthetic fiber	Output of rayon estimated	Necessary quantity per 1 lb of rayon KWH
Oct	0	350,000	350,000	210,000	140,000		
Nov	150,000	533,000	683,000	543,000	140,000	60,000	11.4
Dec	500,000	600,000	1100,000	960,000	140,000	130,000	7.4
Total	650,000	1483,000	2133,000	1713,000	420,000	190,000	Average 9

DECLASSIFIED E.O. 12065 SECTION 3 (E)(1)(D) NO. [redacted]

Note:

1. We need coal of 1,300 ton (4,500 Kcal/kg) for generation of electricity of 650,000 KWH.

(3) Necessary quantity of coal:

	Necessary quantity of coal for electric generation	Necessary quantity of coal for steam		Total (ton)	Rayon output estimated
		Rayon	Synthetic fiber		
Oct	0	0	300	300	0
Nov	300,000	1,400	400	2,100	60,000
Dec.	1,000,000	2,000	500	3,500	130,000
Total	1,300,000	3,400	1,200	5,900	190,000

DECLASSIFIED - E.O. 12065 - SECTION 3 - 6(B) MAY BE

KURASHIKI RAYON

Co. Ltd.

OKAYAMA PLANT

DECLASSIFIED E.O. 11652 SECTION 3 (E)(2), MISC NO.

Kurashiki Rayon Co
Okayama Plt.

20 July 49
Plan 1 file

NOT REPARATION

9600 spindles at present operating for rayon.

23,400 spindles expected to be operating by end of August.

450 people now working.

600-700 will be ~~working~~ expected to be working by end of August

This plant has its own reservoir on the Asahi River and the water is used both for drinking and industrial use and it furnishes water for 1/5 the needs of Okayama City.

They have no plans for producing its own power.

Mr Diehl and Diebold of ESS, SCAP, Production Section on ~~visit~~ inspection here.

DECLASSIFIED E.O. 12065 SECTION 3 402/NNBS NO:

20 July 49

Plw 1 file

NOT REPARATION

Kurashiki Rayon Co
Okayama Plt.

9600 spindles at present operating
for rayon.

24,400 spindles expected to be operating
by end of August.

450 people now working.

600-700 will be ~~working~~ effected to be working by
end of August

This plant has its own reservoir
on the Asahi River and the water
is used both for drinking and industrial
use and it furnishes water for 1/5
the needs of Okayama City.

They have no plans for producing
its own power.

Mr Diehl and Diebold of ESS, SCAP,
Production Section on ~~visit~~ inspection
here.

DECLASSIFIED E.O. 12065 SECTION 3 402/NNBS NO:

Okayama Plant

Kurashiki Rayon Co., Ltd.

A. General Description:

1. Location: Kaigan-dori, 1-chome, Okayama City.

2. Area of site: 452,195 Sq. meters.

3. Area of building: 69,970 Sq. meters.

4. History:

a. Established on the 11th of January, 1935 as the Okayama Plant of Chugoku Rayon Co., Ltd., capitalized at ¥ 20,000,000 (paid-up), amalgamating to Kurashiki Rayon Co., Ltd. on the 26th of November, 1935.

b. Commenced to produce rayon filament yarn on August 27, 1936. Production capacity of rayon filament was 16.7 ton per day (14,400 nozzles) at the maximum.

c. Stopped production of rayon in November, 1943 as it was obliged to convert for military purpose.

d. Procured by the Brindiv in August, 1946 and was released in September, 1947.

e. 23,427 spindles of rayon staple spinning was allocated by the Director of Textile Bureau of Commerce and Industry Ministry.

f. The approval by G.H.Q. dated May 24th 1948 was informed by SHUHAI SHONIN KI No. 1086 dated May 28th 1948.

5. Staffs: Plant Manager: I. Miyagawa.

Asst. Manager: T. Nakahara.

Chief of Labour Section: H. Mori.

DECLASSIFIED E.O. 12065 SECTION 3-402/NNDS No.

B. Rehabilitation of Rayon Staple Spinning:

1. Spinning counts: Average: 30's (20's - 80's)

2. Spinning process: Cotton system, 13,427 spindles.
Draft break system, 10,000 spindles.

3. Process:

a. Cotton System

Cotton mixer - Lap machine - Carding engine - Drawing frame - Fly frame - Ring frame - Doubling frame - Twisting machine - Winding machine - Reeling machine - Baling machine.

b. Draft break System

Draft cutter - Drawing machine - Fly frame - Ring frame - Doubling machine - Twisting machine - Winding machine - Reeling machine - Baling machine.

4. Main Equipment:

A. Cotton system	Number	Type or capacity	Number received	Number Operable
Hopper bale breaker	2	42"	2	2
Hopper opener	2	42"	2	2
Hopper feeder	2	42"	2	2
Single lap machine	2	42"	2	2
Carding engine	51	40"	51	15
Drawing frame	5	2 H x 80	5	1
Fly frame	6	122 sp	6	2
Ring frame	34	2.5/8" x 400 sp	34	9

DECLASSIFIED E.O. 12065 SECTION 3-402/NNDG NO. [redacted]

Cotton system	Number	Type or capacity	Number received	Number operable
Doubler	4	160 drum	4	2
Twister	10	2.3/4" x 400 sp	10	0
Winder	20	160 drum	20	5
Reeler	13	50 cap	13	13
Bundling machine	4	1 bundle	4	4
Baling Machine	1	20 - 40 bundle	1	0
B. Draft Break System:				
Draft break machine	48	Delivery 8 D x 6 H	48	48
Drawing frame	16.8	D x 1 H	16	8
Fly frame	7	112 sp	7	5
Ring frame	25	400 sp	25	18

5. Quantity of rayon staple consumed: 339,000 lb/month.

6. Quantity of rayon staple yarn produced: 319,800 lb/month.

7. Schedule of installation work & production quantity expected:

Cotton system	Draft break system	Total	Production quantity expected
July	3,200 sp (8)	6,000 sp (15)	9,200 sp (23)	40,000 lb
Aug.	4,400 "(11)	7,600 " (19)	12,000 " (30)	60,000 "
Sept.	4,800 "(12)	9,600 " (24)	14,400 " (36)	100,000 "

8. Quantity of electricity consumed:

Ordinary time: 720 KW

239,000 KWH per month.

DECLASSIFIED E.O. 12065 SECTION 3-402/NNDS NO. [redacted]

9. Employees: (June 30, 1949)

	At the time of full operation	At present
Staffs	42	66
Male worker	154	129
Female worker	501	222
Total	697	387

DECLASSIFIED E.O. 12065 SECTION 3 402/NNBS NO:

Working Condition

Endless staple fiber

One rope 360,000 Denier

(1) Draft cutter

Supply sliber: 360,000 x 3 = 1,080 Denier

Draft : 26

Delivery sliber: 350 grain/6 yard

(2) Drawing frame

Supply sliber: 350 grain x 6 = 2,100 grain/6 yard

Draft : 7.3

Delivery sliber: 290 grain/6 yard

(3) Fly frame

Supply sliber: 290 grain/6 yard

Draft : 6.74

Twist : 0.57/inch

Delivery sliber: 215 grain/20 yard

(4) Ring frame

Supply sliber: 215 grain/20 yard

Draft : 25.5

Twist : 14/inch

Yarn weight: 23.6 grain/120 yard

Yarn dry strength: 110 lb/120 yard

Spinning counts: 30's

DECLASSIFIED E.O. 12065 SECTION 3 402/NNDS NO. [illegible]

EXTRA

RC/file

HEADQUARTERS
OKAYAMA MILITARY GOVERNMENT TEAM
APO 248

AFM/ht

Okayama Japan

386.3

24 May 1949

SUBJECT: Approval of 'Authorized Use' reparation items of Kurashiki Cotton Spinning Co., Ltd., Masu Mill, Okayama Prefecture.

TO: Commanding Officer
Chugoku Military Government Region
APO 248

3 4 II

1. References:

a. OD 5 with its amendments, Headquarters Eighth Army, dated 18 January 1946, subject pertaining to "Reparation items".

b. OD 21, Headquarters Eighth Army, dated 30 March 1948, subject: "Japanese Industrial Reparation Facilities."

2. Permission is requested for written authority for the items identified in enclosure #1 attached as being in authorized use as of 30 March 1948. These items have been in continuous use, as verified by this team's inspections, and complies with reference 1b above paragraph 4d. In accordance to paragraph 4f of reference 1b above, this team is submitting these items in enclosure #1 for approval, even though they technically are not "additional items". This team has in the past apparently given verbal approval. Mr. E. C. Crafton, Reparations Section, ESS, SCAP, had requested of reparation plants in this prefecture on 22 and 23 March 1949, documentary proof of "authorized use" for machines that were used in manufacturing end products.

F. W. PRATT
Lt. Col., Infantry
Commanding

DECLASSIFIED E.O. 12065 SECTION 3 402/NNSG NO.

File

11 May 1948
Opening of this plant.
Ref file

Okayama Plant

Kurashiki Rayon Co., Ltd.

A. General Description:

1. Location: Kaigan-dori 1-chome, Okayama City.

2. Area of site: 452,195 Sq. meters.

3. Area of building: 69,970 Sq. meters.

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b. Commenced to produce rayon filament yarn on August 27, 1936. Production capacity of rayon filament was 16.7 ton per day (14,400 nozzles) at the maximum.

c. Stopped production of rayon in November, 1943 as it was obliged to convert for military purpose.

d. Procured by the Brindiv in August, 1946 and was released in September, 1947.

e. 23,427 spindles of rayon staple spinning was allocated by the Director of Textile Bureau of Commerce and Industry Ministry.

f. The approval by GHQ, dated May. 24, 1948 was informed by SHUHAI SHONIN KI No. 1086, dated May 28, 1948.

5. Staffs: Plant Manager: I. Miyagawa

Asst. Manager: T. Nakahara

Chief of Labour Section: H. Mori

DECLASSIFIED E.O. 12065 SECTION 3 402/NNBS NO:

B. Rehabilitation of Rayon Staple Spinning:

1. Spinning count: Average; 30's (20's - 80's)

2. Spinning process: Cotton system, 13,427 spindles.
Draft break system, 10,000 spindles.

3. Process:

a. Cotton System

Cotton mixer - Lap machine - Carding engine - Drawing frame - Fly frame - Ring frame - Doubling frame - Twisting machine - Winding machine - Reeling machine - Baling machine.

b. Draft break System

Draft cutter - Drawing machine - Fly frame - Ring frame - Doubling machine - Twisting machine - Winding machine - Reeling machine - Baling machine.

4. Main equipments:

A. Cotton system:	Number	Type or capacity	Number received	Number operable
Hopper bale breaker	2	42"	2	2
Hopper opener	2	42"	2	2
Hopper feeder	2	42"	2	2
Single lap machine	2	42"	2	2
Carding engine	51	40"	42	0
Drawing frame	5	2 H x 80	2	0
Fly frame	6	122 sp	0	0
Ring frame	34	2.5/8" x 400 sp	34	1

DECLASSIFIED E.O. 12065 SECTION 3-402/NNDS NO.

Doubler	4		160 drum	4	2
Twister	10	2.3/4"	x 400 sp	0	0
Winder	20		160 drum	20	4
Reeler	13		50 cap	13	0
Bundling machine	4		1 bundle	4	0
Baling machine	1	20 - 40	bundle	1	0

B. Draft Break System:

Draft break machine	48	Delivery 8 D x 6 H	24	24
Drawing frame		16.8 D x 1 H	16	8
Fly frame		7 112 sp	5	3
Ring frame		25 400 sp	15	12

5. Quantity of rayon staple consumed: 342,000 lb/month.

6. Quantity of rayon staple yarn produced: 325,520 lb/month.

7. Schedule of installation work & production quantity expected:

	Cotton system	Draft break system	Total	Production quantity expected
End of Feb.	-	800 sp (2)	800 (2)	Test production
"ofMar	-	3,200 " (8)	3,200 (8)	"
Apr	-	4,800 " (12)	4,800 (12)	3,000 lb
May	2,400 sp (6)	6,400 " (16)	8,800 (22)	23,000 "
Jun	4,000 " (10)	8,000 " (20)	12,000 (30)	74,100 "
Jul	8,000 " (20)	10,000 " (25)	18,000 (45)	120,000 "
Aug	13,427 " (34)	10,000 " (25)	23,427 (59)	325,520 "

DECLASSIFIED E.O. 12065 SECTION 3-402/NNDG NO. [illegible]

9. Quantity of electricity consumed:

Ordinary time: 720 KW

239,000 KWH per month.

10. Employees: (April 30, 1949)

	At the time of full operation	At present
Staffs	42	39
Male worker	154	133
Female worker	501	166
Total	697	338

DECLASSIFIED E.O. 12065 SECTION 3-402/NNBS NO:

Working Condition

Endless staple fiber

One rope 180,000 Denier

(1) Draft cutting machine

Supply sliber: 180,000 x 6 = 1,080 Denier
Draft : 27
Delivery sliber: 350 grain/6 yard

(2) Drawing frame

Supply sliber: 350 grain x 5 = 1,750 grain/6 yard.
Draft: 5.96
Delivery sliber: 290 grain/ 6 yard

(3) Flyer frame

Supply sliber: 290 grain/ 6 yard
Draft: 6.74
Twist: 0.57/inch
Delivery sliber: 215 grain/ 30 yard

(4) Ring frame

Supply sliber: 215 grain/ 30 yard
Draft: 27.1
Twist: 16/inch

Yarn weight: 33.6 grain/ 120 yard
Yarn dry strength: 110 lb/120 yard
Spinning counts: 30 s

DECLASSIFIED E.O. 12065 SECTION 3 402/NNBS NO.

Brief Outline of Kurashiki Plant

Kurashiki Rayon Co., Ltd.

Annex: Explanation on the polyvinyl synthetic fiber

DECLASSIFIED E.O. 12065 SECTION 3 402/MNSC NO.

General Description of Kurashiki Plant

1. Location: 1621 Sakazu, Kurashiki City, Okayama Pref.
2. Date of Construction: 31 December, 1927
3. Commencement Period of Operation: May 9, 1928
4. Area of Site: 386,685 Sq. meters
5. Area of Building: 72,776 "
6. Number of Employees: Male: 1,047
   Female: 191
   Total: 1,238
7. History:
   a. Began construction in May, 1927.
   b. Commenced operation on May 9, 1928.
      Quantity of rayon yarn production: 2 tons per day.
   c. Expansion of production equipments has been done in 1939.
      Quantity of rayon yarn produced: 350 tons per month.
      " of rayon staple fiber : 150 "
   d. Converted to the wood working and electrolysis metallic manganese production in 1943.
   e. Upon termination of war, stopped operation.
   f. Granted permit dated December 13, 1945 for producing Veneered panel (plywood), Prefabricated house and Plastic moulding powder with the equipments and materials which we have kept during the war.
   g. Granted permit from HQ, I Corps in Kyoto on May 3, 1946 to produce charcoal, calsium carbide, polyvinyl acetate, polyvinyl alcohol and polyvinyl alcohol fiber.
   h. Granted permit on July 21, 1947 for the rehabilitation fund to produce charcoal, calsium carbide, polyvinyl acetate, polyvinyl alcohol and polyvinyl alcohol fiber.

DECLASSIFIED E.O. 12065 SECTION 3 402/NNSC NO.

8. Production capacity and quantity before the war.

Capacity	Quantity
Rayon yarn: 26,212 kg/day	31,803 ton (1935 - 41)
Rayon staple: 12,600 kg/day	1,775 ton (1938 - 41)

9. Production after the war.

Product	Capacity (Month)	Production quantity Up to Dec 1947	Production quantity Average of Oct. Nov. & Dec.
Plywood	60,000 shts	1,075,560 shts	38,453 shts
Plastic moulding powder	30 ton	413 ton	19 ton
Prefabricated house	60 house	295	19
(This production has been abolished)			
Wood fittings	Door	118,072 shts	
	Box frame	8,600 "	
	Transom	8,370 "	
	Sash	12,713 sets	

Note: Almost all fittings were for Occupation Forces' use.

10. Future Plan of production.

a. Permission has been granted for the recovery of pilot plant of synthetic fiber production from Okayama Plant.

Refer to the annexed paper "On the enterprise of synthetic fiber production".

b. We are now planning to rehabilitate the production equipments of 5 ton/day of rayon yarn in this plant. We submit the application to GHQ for the permission to this plan. (Application- CLCO No. 571)

DECLASSIFIED E.O. 12065 SECTION 3 402/NNSC NO.

The enterprise of Polyvinyl Synthetic Fiber production

DECLASSIFIED E.O. 12065 SECTION 3 402/NNSS NO.

ON THE ENTERPRISE OF POLYVINYL SYNTHETIC FIBER

1. Outline of the enterprise

Under the circumstances of the new world, utilizing the nature through machinery, chemistry and synthetic chemistry, our company intends to develop the viscose rayon on one hand and on the other, to manufacture the vinyl resin fiber. In connection with this plan, 10 years ago, our company completed the research on the manufacture of the polyvinyl synthetic fiber through the vinyl resin from charcoal and water in the Laboratory of our Okayama Plant, located No. 3, 1-chome, Kaigan-dori, Okayama City and constructed the test production equipments. During the war, this pilot plant produced the polyvinyl alcohol but others were not developed into full production and on June 29, 1945, the equipments were partially burnt out due to the fire caused by air-raid and therefore this valuable experimental production was temporarily suspended when we came across the termination of war.

From the viewpoint that superior polyvinyl synthetic fiber will bring the welfare to the civilians, we planned to recover this production in October, 1945 by removing the equipments from Okayama Plant to our Kurashiki Plant located at 1621 Sakazu, Kurashiki City. We were sure that this would be easily realized at the earliest period by repairing and arranging the equipments damaged by the fire and those which were left not being actually used in our Okayama and Kurashiki Plants.

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We submitted the application for permission to HQ, I Corps in Kyoto on April 15, 1946 and was granted permit on May 3 in the same year. The production items permitted were as follows:-

Charcoal-	300 kg/day
Calcium carbide-	3,000 "
Polyvinyl acetate-	400 "
Polyvinyl alcohol-	200 "
Polyvinyl alcohol fiber-	200 "

Then, we submitted the application for the rehabilitation fund to GHQ-SCAP and the Japanese Government on February 17, 1947 and was granted the permit on July 21, 1947. We have done our best for the rehabilitation work:

The equipments for charcoal calcium carbide production have been completed and now are in operation. The construction of equipments for polyvinyl alcohol and polyvinyl alcohol fiber has been just finished and we have the ceremony for operation commencement to-day. Furtheremore, the equipments for polyvinyl acetate are expected to complete by the end of this June. On perceiving the completion of this work, we are going to realize the 2nd plan to have 2 tons/day of polyvinyl alcohol fiber.

2. Production Process

The plan of our polyvinyl synthetic fiber production is to utilize synthetically the wood and lime stone as the raw materials through the process shown in the following table.

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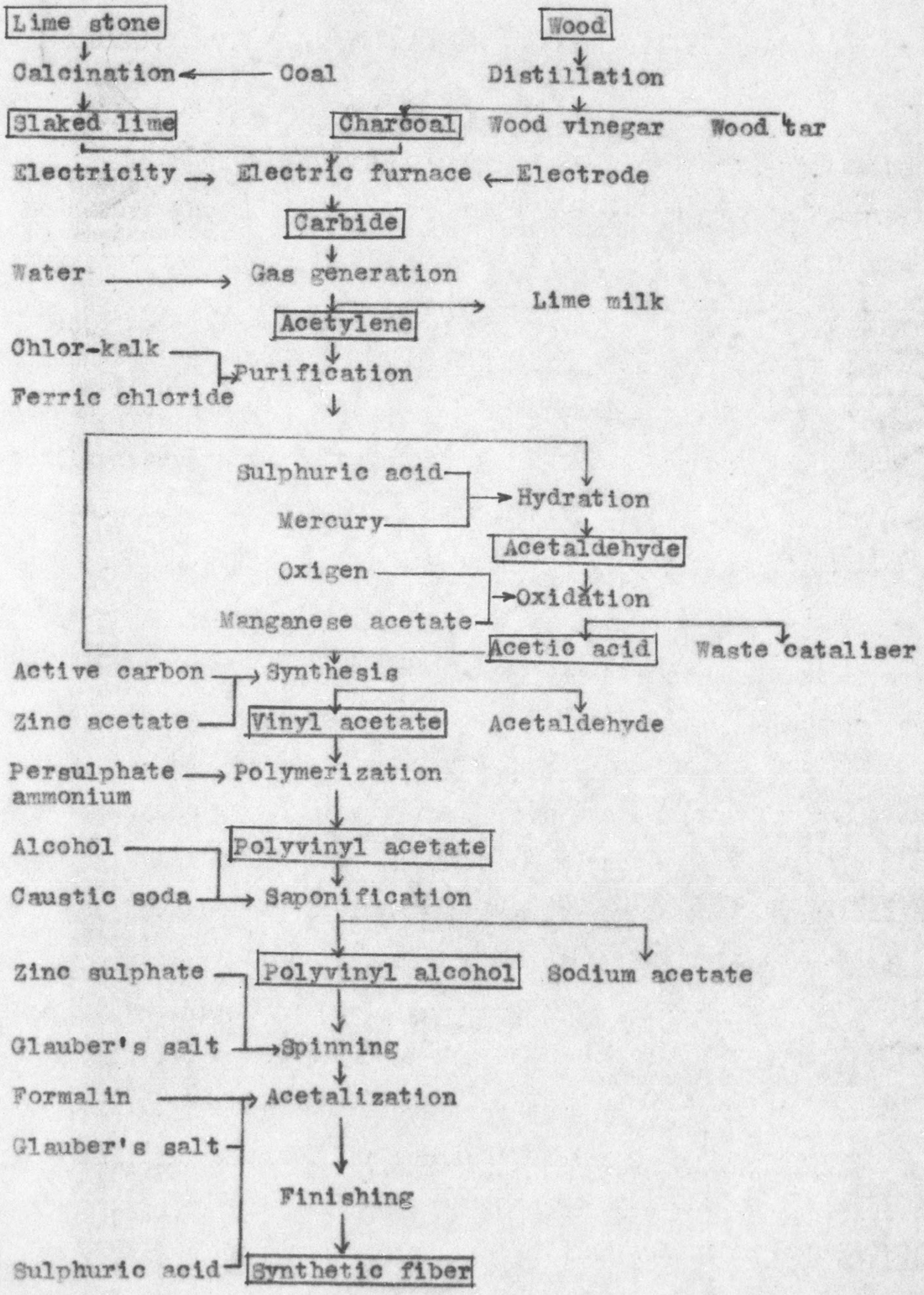

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3. Products and their use

The characteristics and the use of the products are as follows:-

(1) This fiber is proof against acid, alkali and oil and therefore, it is very much valuable as electrolysis diaphragm, filter cloth, packings, thread and also for industrial material and clothing at the chemical plant for which the natural fiber or viscose rayon can not attain.

(2) This synthetic fiber is superior in its mechanical property and the degree of its tensile strength, bending and rubbing is much higher than that of natural fiber. It has also a suitable elasticity and hygrocopicity and so good for the material of durable laborer's clothing.

(3) We are able to produce the curled fiber which preserves a suitable warmth and can compete with the wool with its special features of strength, elasticity and warmth preservation.

(4) We can spin this fiber into hard and elastic thread. We are now studying the synthetic hard hair, the characteristics of which are its strength, elasticity, waterproof and transparency and therefore we utilize it for fishing cord and net. It can be used as the substitute for wire gauge and brush.

These are the characteristics we can get from our research, the value of which can be determined by the realization of this plan and the future speciality will come out hereafter for its new use. To-day, we can not fix the production

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cost of this synthetic fiber but it is expected to be approximately five thousand Yen per kg in case the day production is 200 kgs. But it seems not to be difficult to reduce the cost by becoming skillful in the actual production and also by the future development of production scale.

It is worthy to mention that we can fully recover the waste and use it again as the material for resin plastics. Accordingly, the value of the waste should be considered together with the fiber itself.

This enterprise is planned for the manufacture of synthetic fiber only. However, the vinyl resin can be utilized as films, paint and paste, on which we are now making a research for its industrialization.

The characeteristics and use of synthetic films:-

(1) Utilizing the superiority in its elasticity, strength, alkali and oil proof, we can make the belt and packings as the substitutes or by iteself of the leather or rubber goods.

(2) This film is to be manufactured into rain-coat, umbrella and cover and on the other hand, we can make the table cloth and leather by spreading it on the cloth while manufacturing.

(3) This film is good for the material of fancy and sundry goods.

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We can develop the paint into water paint, clear lacquer, oil paint substitute, acid and alkali proof paint. Sizing material can be utilized as fiber sizing, emulsifier and rubber paste substitute.

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ON THE DEVELOPMENT OF SYNTHETIC FIBER "VINYLON"

By File

Dr. I. Tomonari,

Kurashiki Rayon Co. Ltd.

Okayama City

February, 1950

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On the Development of Synthetic Fiber "Vinylon"

February, 1950

By Dr. T. Tomonari.

Kurashiki Rayon Co., Ltd.

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I. Introduction

In the lapse of this century various kinds of chemical fibers have appeared and rapidly developed, adding all the more the colour of chemical fiber age to the textile field of the world.

Early in the present century, there were only two kinds of chemical fibers, nitro and cupra rayon, and their yearly output was as small as only about two million lbs. Since then in these 50 years, viscose rayon, acetate rayon, protein fiber, rubber fiber and glass fiber and furtheremore several kinds of other synthetic fibers have been born, so that the number of varieties has become more than ten and their annual output is amounting to as much as four thousand million lbs.

To-day, various kinds of chemical fibers are produced from various kinds of natural resources by several production methods, and among of them, viscose rayon has been most widely developed in 32 countries in the world, its output getting about 73% of the total amont of chemical fibers. Acetate rayon has

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appeared a little later than viscose rayon and steadily progressed in 11 countries in the world and its output gets about 22% of the total chemical fibers. On the other hand, cupra rayon which was most prosperous early in the present century has declined a little and its output in 6 countries of the world becomes less than 2% of the total chemical fibers.

Synthetic fibers were introduced ten years ago and have made a rapid progress with the output amounting 2 to 4 percent of the total chemical fibers and promise a remarkable expansion in the future.

How the textile world will be changed hereafter? The chemical fibers will surely make a further progress, especially the synthetic fibers will bring various kinds of new textiles and are expected to change the aspect of textile world by their development. Herein lies the reason why the civilized nations are doing their best for its development. In our country, vinylon as a synthetic fiber is now being produced in a large quantity and here we look after its past progress and for its future development.

Ⅰ. Development of Synthetic Fiber

(1) Synthetic fiber in the world.

It was only 20 years ago when the people dreamed of producing a synthetic fiber by spinning of high morecular compounds synthesized from low morecular compounds. In 1926, H. Staudinger in Germany started the research on the synthesis of polyvinyl compounds in a connection with the study to decide the structure of high polymeric compounds, and in 1929, W. H. Carothers in the United States entered in the research on the synthesis of polyester and polyamide compounds with the aim of synthesizing fiber thereof, and along with the progress of researches of other scholars the probability of its industrialization was gradually being ascertained. Soon after, in 1938, PeCe fiber of Germany and Vinyon and nylon of the United States were introduced to the surprise of the world and then Gosei-ichigo of Japan, saran of the United States, Perlon T and Perlon L of Germany and Amilan of Japan were made public successively.

During the war, some of the afore-mentioned fibers were developed in Germany and the United States for war and special uses. The actual status is yet unknown for us but we hear that the annual output of synthetic fibers in the United States during the year of 1942 to 1943 was estimated as much as 20 million lbs of nylon, 1.5 million lbs of Vinyon and 1.5 million lbs of saran and that of Germany was estimated as 4.5 million lbs of Perlon and 5.5 million

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lbs of PeCe fiber. After the war, the synthetic fiber has made a surprising development and in addition to the synthetic fibers before the war, in 1946 Terylene of Great Britain, in 1947 Velon of the United States and in 1948 Vinyon N and Orlon of the United States were introduced one after another, and thus the synthetic fibers are now making a remarkable development, promising a further expansion of uses with their excellent qualities as clothing materials, industrial materials and materials for daily necessaries and furniture. Snythetic fibers which have been introduced are more than 10 kinds and can be classified as in the following Table 1.

Table 1. Kinds of Synthetic Fiber

Series	Name	Country of invention	Year	Materials
Polyvinyl synthetic fiber	PeCe fiber	Germany	1938	After-chlorintaed product of polyvinyl chloride.
	Vinyon	U. S. A.	1938	Co-polymer of vinyl chloride & vinyl acetate.
	vinylon	Japan	1939	Polyvinyl alcohol.
	saran	U. S. A.	1940	Polyvinylidene chloride.
	Sinsen	Japan	1941	Polyacrylnitrile.
	Velon	U. S. A.	1947	Co-polymer of vinyliden chloride & vinyl chloride.
	Vinyon N	U. S. A.	1948	Co-polymer of acrylnitrie & vinyl chloride.
	Orlon	U. S. A.	1948	Polyacrylnitrile.
Polyamide synthetic fiber	nylon	U. S. A.	1938	Hexamethlene diamine adipamide.
	Perlon T	Germany	1940	〃
	Perlon L	〃	〃	Polylactamide.
	Amilan	Japan	〃	〃
Polyester synthetic fiber	Terylene	England	1946	Co-polymer of terephthalate & ethleneglycol.
	Perlon U	Germany	1940	Polyurethane
Polyurethane synthetic fiber	Polulan	Japan	〃	〃

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Looking at the world situation of textile production, one may see that in the United States, nylon, Vinyon and saran are scheduled for an increased production and Velon, Vinyon N and Orlon are also added for the production increase. In England, Canada, France and Italy, the production of nylon has been taken up and in Japan, vinylon and Amilan are making a rapid progress and in England, Terylene is undertaken for its production. The production of Perlon and PeCe fiber is reported as being recovered in Germany. In this way, synthetic fibers are developed in several countries in the world with an estimated output per year amounting to as much as one hundred million lbs.

After ten years since the synthetic fibers have been introduced in the textile world, they seem to have already passed the experimental age and have come into an age of rapid progress. To-day's situation of synthetic fibers led us remind of the situation of rayon 25 years ago after the First World War. In 1923, rayon acquired a steady position in the textile field of the world with the output exceeding one hundred million lbs and at that time the hopeful future of rayon was generally recognized and many rayon plants were erected in several countries of the world, so that the so-called golden age of rayon was recorded. It is then now in the dawn of the golden age of synthetic fiber, when it has become to be highly valued and its output is exceeding one hundred million lbs just equal to that of rayon output 25 years ago, isn't it? In any way, future development of synthetic fiber will surely bring a surprise to the public of the world.

(2) Synthetic fiber in Japan.

Under the world situation mentioned above, nobody can be unaware of the necessity and importance to breed the synthetic fiber industry also in our country. Already about 15 years ago, Japanese chemists and engineers entered into the researches on the production of synthetic fibers and in 1938 they were strongly encouraged by the announcement of PeCe fiber, Vinyon and nylon. Especially, as nylon was introduced for lady's stockings so much as to come into the sphere of silk, giving a strong shock to the Japanese people, the name of nylon was shortly and widely propagated and this fact served to excite much interest in the manufacture of synthetic fibers in our country. By the enthusiastic researches it was succeeded soon to master the fundamental principle about the synthetic fiber production and to understand the processes taken up in the United States and Germany and furthere to find out the way for new synthetic fiber production. Gosei-ichigo was made public by Kyoto University in 1939, Kanebian by Kanegafuchi Spinning Company and Amilan

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by Toyo Rayon Company in 1940 and Polulan and Sinsen by Tokyo Industrial University in 1941. It was at that time that in January, 1941 Synthetic Fiber Research Association (The Society of High Polymer at present) was established as an organization for promotion of the fundamental and applied research on synthetic fibers. But the research could not be successfully progressed and its industrialization was not realized during the war time.

After the war, the research on synthetic fiber was again actively taken up and the Toyo Rayon Company, Kurashiki Rayon Company, Kanegafuchi Spinning Company, Gosei-ichigo Company and Mitsubishi Chemical Industries Company rehabilitated or expanded their experimental equipments and have studied eagerly to set up the industrial technique. Toyo Rayon Company undertook the manufacture of Amilan (trade mark of Toyo Rayon Company), while Kurashiki Rayon Company, Kanegafuchi Spinning Company, Gosei-ichigo Company and Mitsubishi Industries Company undertook the manufacture of vinylon (synthetic fiber of polyvinyl alcohol such as Gosei-ichigo or Kanebian). On February 6, 1948, these companies formed the Synthetic Fiber Manufacturers Group in the Japan Synthetic Textile Assn and have been doing their efforts for the establishment of synthetic fiber industry in this country, being encouraged by the great concern and expectation of the nation.

(3) Development of vinylon.

Being much concerned by the textile field of the world, vinylon stands on its foot for its growth after the continuous researches for 20 years long. Vinylon is the synthetic fiber of polyvinyl alcohol series, the compound of which appeared for the first time in the world about 20 years ago. As mentioned before, H. Staudinger and his collaborators published the thesis on polyvinyl acetate and polyvinyl alcohol in connection with their study on the high polymeric compounds as early as in 1926. At that time, O. Hermann and his collaborators in Germany were also making a research on the production of polyvinyl alcohol and its application. O. Hermann carried out several researches on polyvinyl alcohol fiber and he examined the nature of the products. The greatest feature of this fiber lied in its being weak against water or readily soluble in water. To make use of this feature for special purposes was taken into consideration, but the weak water resistance can not but a defect of the fiber, and it was not possible to use such fiber for practical purposes without improving its water resistant property. Therefore, different researches were undertaken in Germany, the United States, Britain and France to improve the property of this synthetic fiber and other articles of polyvinyl alcohol. For

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example, the attempt has been actively made to render the products water resistant by esterification with various organic acid or acetalization with various aldehydes. It was also studied to make it insoluble in water by heat treatment but all these failed to produce any fiber of practical use.

Ten years passed since then and in 1939 to 1940 Japanese chemists succeeded at length to produce a highly water resistant synthetic fiber with great practical value by inventing a method in which the heat treatment of polyvinyl alcohol fiber was skilfully combined with acetalization. This success served to deepen general interest in this synthetic fiber, especially in this country. For its industrialization, various researches were executed by Kyoto University, Kanegafuchi Spinning Company, Kurashiki Rayon Company and many others, but the war stopped it to be realized. After the end of war, Kurashiki Rayon Company, Kanegafuchi Spinning Company, Gosei-ichigo Company have taken up this problem and continued their researhces and come to the present situation.

Polyvinyl alcohol was called in Japan as poval since 1943 and polyvinyl alcohol series synthetic fiber was given a generic name of "Vinylon" on May 20, 1948 at the Meeting of Synthetic Fiber Manufacturers Group and the name was introduced to the public.

The Kurashiki Rayon Company has carried out the industrial researches on vinylon manufacture most actively. We started investigation on synthetic fibers as early as in 1935 and concentrated the researches on the manufacture of polyvinyl series synthetic fiber in April 1938, anticipating its future development in view of the circumstance of natural resources of this country. At the end of following year when the research on synthetic fiber of polyvinnyl alcohol made an advance in this country, we took up this fiber and decided its industrialization. To establish the industrial technique for this fiber, we must extend the researches in wide range covering the production of carbide and then polyvinyl alcohol which was followed by the spinning into final product of the synthetic fiber.

In 1940, we installed the small pilot plant in the Research Laboratory located in our Okayama Plant and in October 1942 completed the basical research for the industrialization and set to work instantly for the erection of pilot plant for 200 kg vinylon per day which encountered several difficulties caused by the war and could not be completed until the termination of war. After the war, we recovered the equipments in our Kurashiki Plant and in April 1948 started to operate the plant of 200 kg vinylon per day and by the end of

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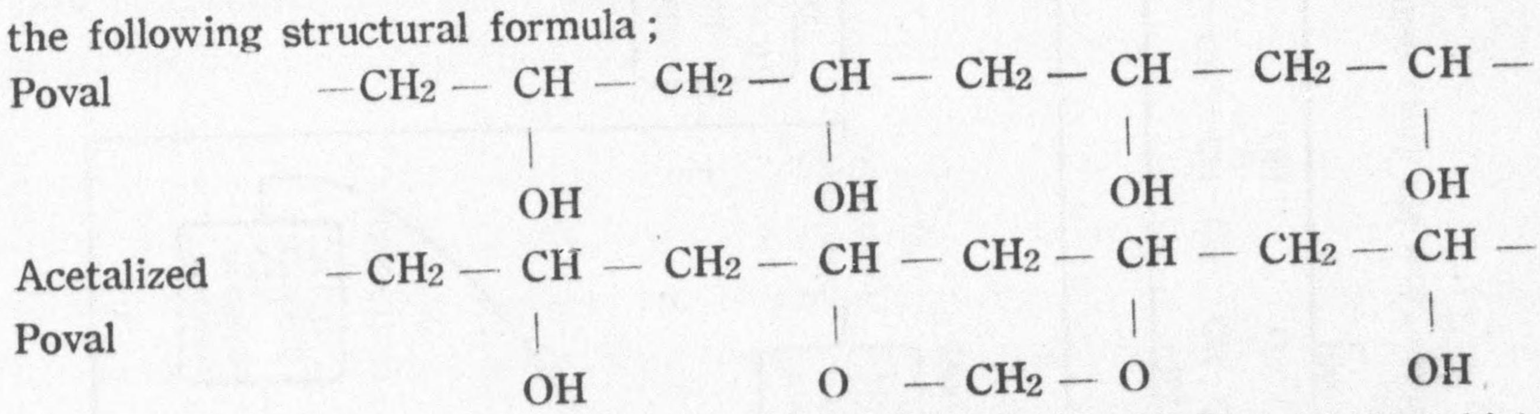
the year succeeded to arrange for the industrialization by the special technique of our company. In January of 1949, we began to plan the layout of a big plant and in October started the construction work of the Toyama Plant as poval plant and the Okayama Plant as vinylon plant with the scale of 20 tons per day, out of which the first part of that program for 5 tons/day production is expected to be completed by September, 1950.

After about 20 years since polyvinyl alcohol fiber was introduced in the world and 10 years since the practical value of the fiber was discovered, this fiber is now going to be produced in a commercial scale in both plants for the first time in the world.

Ⅲ. Process of Vinylon Production

Vinylon is obtained through the wet or dry system spinning of polyvinyl alcohol (poval) and is then made heat and water resistance through the processes of heat treatment and acetalization. In case of being acetalized by formalin, about 50 % of hydroxyl groups of poval is united by formaldehyde into the following structural formula;



The direct rawmaterial for vinylon is poval as obtained from carbide, which in turn is produced from limestone and coal. Therefore, the manufacturing process of vinylon may be divided into 3 divisions of carbide production, poval producton and fiber production. This process is shown on Table 2.

(1) Carbide

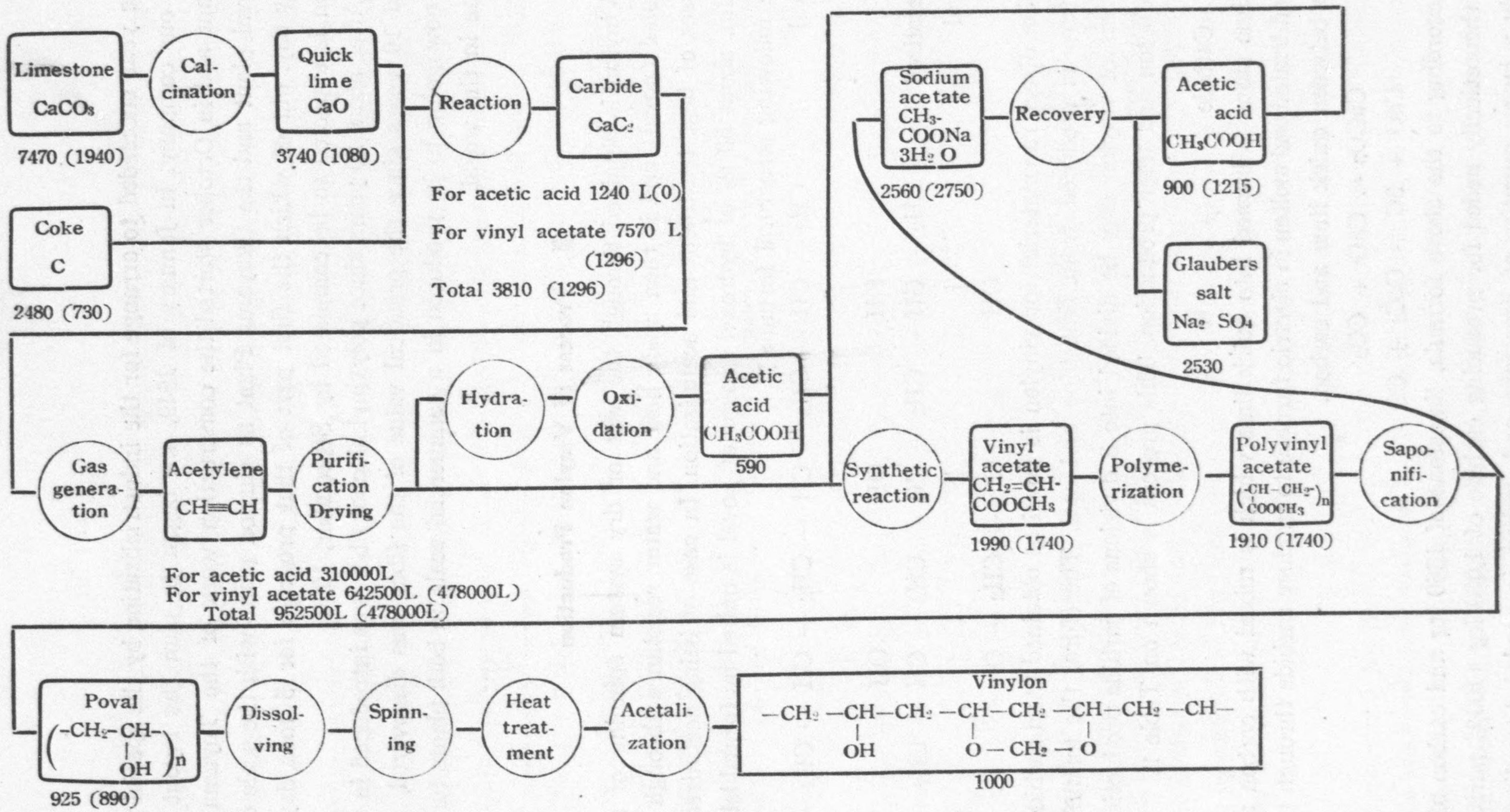
Lime stone is burned into quick lime which is mixed with carbon and then is red-heated and molten in electric furnace to produce carbide through the reaction between quick lime and carbon.

$$CaCO_3 = CaO + CO_2$$

$$CaO + 3C = CaC_2 + CO$$

According to the above formula, limestone of 1560 kg and carbon of 563 kg are theoretically neded for producing carbide of 1,000 kg (100% purity). Actually a larger quantity of limestone and carbon is needed according to the

Table 2. Flowsheet of Vinylon Manufacture



Notes; 1. The figures show base materials as against 1000 Vinylon staple fiber (with 5% moisture regain) in case of 10 ton/day production.
2. The available limestone is of 97% purity and coke of 80% carbon.
3. The figures in blackets represent theoretically calculated values.

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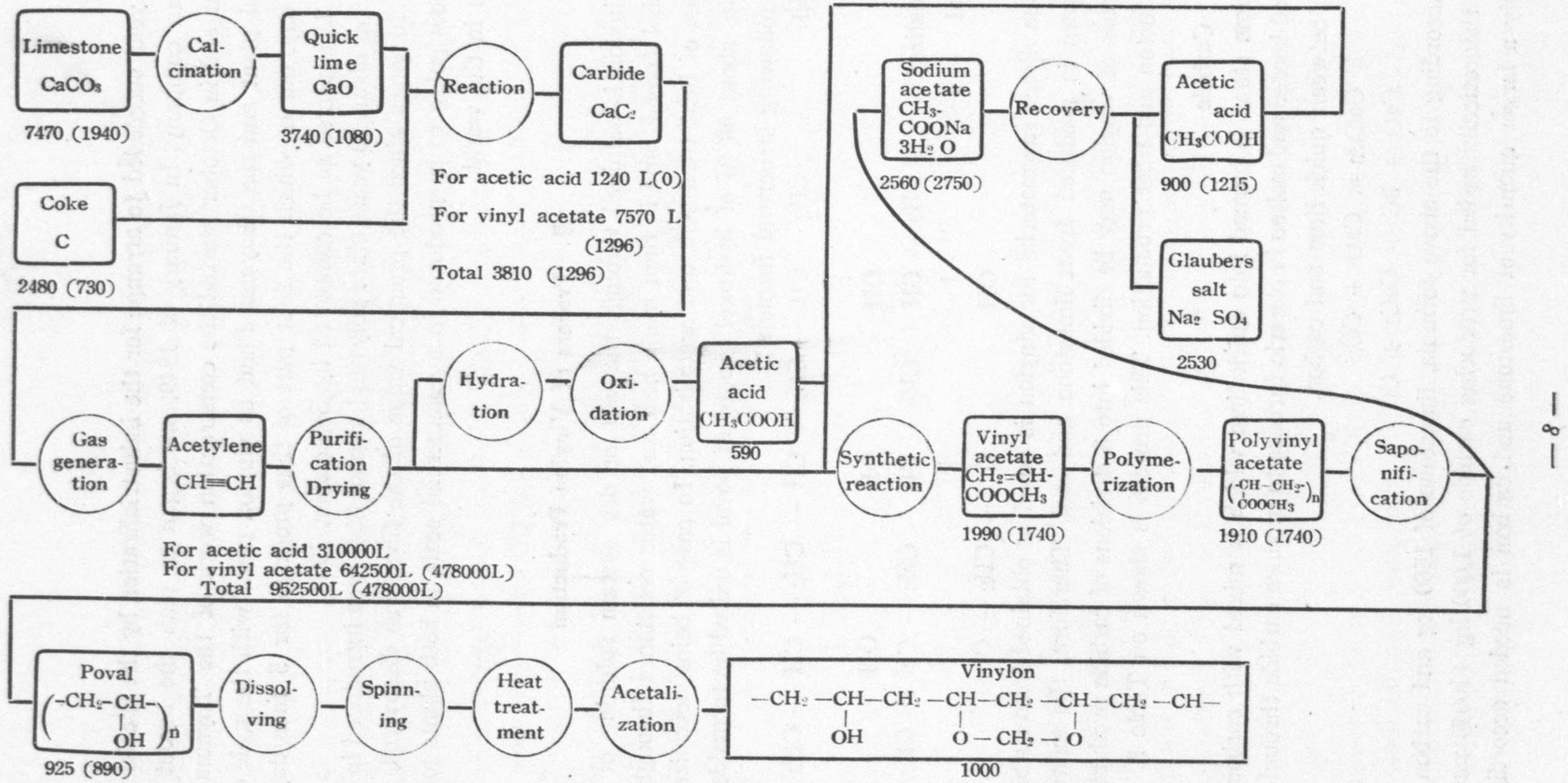
Table 2. Flowsheet of Vinylon Manufacture



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2. The available limestone is of 97% purity and coke of 80% carbon.

3. The figures in blackets represent theoretically calculated values.

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degree of purity which effects also on the quality of carbide.

Limestone of more than 97% in its purity are generally used but that of crystalline structure is no good as it makes the calcination difficult bacause it is easily pulverized when it being calcinated. A lot of carbon is needed because of its low purity which effects much on the quality of carbide. As the carbon, charcoal, anthracite or coke containing much carbon and few volatile material and also few sulphur and phosphorous are desirable to be used.

There are several varieties in the quality of carbide, for example, from 50% to 80% in its purity. 1 kg of pure carbide generates 369 L acetylene at 15°C and 760 mm mercury, but carbide for industrial use are classified into four kinds as the first grade (more than 280 L), 2nd grade (more than 250 L), 3rd grade (more than 220 L) and 4th grade (more than 190 L). In case of using limestone of 97% purity and coke of 80%, carbon the carbide generating the gas of about 250 L can be obtained. In order to produce 1,000 kg of the carbide of this grade, 1960 kg of limestone and 650 kg of coke are needed. Production technique of carbide has been established in Japan on the world level. Still there are many points to be improved and to be solved by the research in the future.

(2) Poval

Poval has the chemical structure of a polymer of acetylene being added by the water.

$$nCH \equiv CH + nH_2O = \left(-CH_2 - \underset{\displaystyle OH}{\overset{\displaystyle |}{CH}} - \right)_n$$

Vinyl alcohol monomer, however, which is constructed by acetylene being added by the water is unstable and not existed. Therefore, acetylene is at first subjected to reaction with acetic acid to produce vinyl acetate which is polymerized into polyvinyl acetate and then saponified by acid or alkali into poval. In this process acetic acid behaves as a mediator and is discharged as sodium acetate or acetic ester from which acetic acid is recovered to be used again in the first reaction of vinyl acetate synthesis.

(a) Production of acetic acid.

Carbide is subjected to reaction with water to generate acetylene. The gas thus produced is purified and dried, and is absorbed into the dilute solution of sulphuric acid where mercury catalyst is contained to subject acetylene to react with water into aldehyde.This aldehyde is distilled and refined into pure acetaldehyde (purity: more than 99.8%) and then is oxidized by oxigen with

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manganese acetate as catalyst. The resulting crude acetic acid is distilled into acetic acid. (purity: more than 98%)

$$CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2$$
$$C_2H_2 + H_2O = CH_3CHO$$
$$2CH_3CHO + O_2 = 2CH_3COOH$$

According to these chemical relations 1,390 kg of carbide (250 L) is needed to produce 1,000 kg of acetic acid, but practically much more carbide is needed. For example, if we assume the reaction yield from acetylene as 85% and distillation yield as 96% (ratio of acetylene used is 81.6%) in the production of aldehyde and if we assume the reaction yield from aldehyde as 96% and distillation yield of acetic acid as 96% (ratio of aldehyde used is 92.2%), about 2,100 kg of carbide is needed to produce 1,000 kg of acetic acid.

(b) Synthesis of vinyl acetate.

Then, acetic acid is gasified and mixed with acetylene, and with zinc acetate bearing active carbon as catalyst the acetic acid is subjected to react with acetylene to produce vinyl acetate.

$$C_2H_2 + CH_3COOH = CH_2 : CH \cdot COOCH_3$$

The crude vinyl acetate as produced by the condensation of reacted gas contains the unreacted acetic acid, aldehyde and other biproducts and so purified vinyl acetate is extracted by the distillation and the separated acetic acid is re-used. For poval production, highly purified vinyl acetate is needed and it contains acetic acid less than 0.2% and aldehyde less than 0.1%.

According to the chemical relation, 1,100 kg of carbide (25OL) and 697 kg of acetic acid are needed to produce 1,000 kg of vinyl acetate. If we assume the reaction yield from acetic acid as 98% and distillation yield of yinyl acetate as 95% (ratio of acetic acid used is 98% and ratio of acetylene used as 85%), 1,292 kg of carbide and 750 kg of acetic acid are needed to produce 1,000 kg of vinyl acetate.

(c) Polymerization and saponification of vinyl acetate.

The vinyl acetate is dissolved in methanol, and is polymerized into polyvinyl acetate under certain temperature by peroxide as catalyst.

$$nCH_2 : CH \cdot COOCH_3 = \left(\begin{array}{l} -CH-CH_2- \\ \quad | \\ \quad COOCH_3 \end{array} \right)_n$$

In this process, the quantity of catalyst, reaction temperature and quantity of solvent, etc. are the important factors to determine the polymerization degree of polyvinyl acetate. By adding caustic soda to the methanol solution, the polyvinyl acetate is saponified into polyvinyl alcohol, which is precipitated and the

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precipitate is pressed to remove solution and is well dried into finished product.

$$\left(\begin{array}{l}-CH-CH_2-\\ \quad\;|\\ \quad COOCH_3\end{array}\right)_n + nNaOH = \left(\begin{array}{l}-CH-CH_2-\\ \quad\;|\\ \quad OH\end{array}\right)_n + nCH_3COONa$$

$$\left(\begin{array}{l}-CH-CH_2-\\ \quad\;|\\ \quad COOCH_3\end{array}\right)_n + nCH_3OH = \left(\begin{array}{l}-CH-CH_2-\\ \quad\;|\\ \quad OH\end{array}\right)_n + nCH_3COOCH_3$$

Methyl acetate produced by the 2nd formula is decomposed into sodium acetate and methanol by adding caustic soda.

$$nCH_3COOCH_3 + nNaOH = nCH_3COONa + nCH_3OH$$

Sodium acetate produced by the lst and 2nd equations is separated from the waste solution and the residual solution is distillated to recover the methanol. As the rawmaterial of vinylon, poval is to be of the quality as 1,400—1,600 polymerizaton degree, with the content of sodium acetate less than 0.3%, residual acetyl radical less than 0.5% and as possibly free from impurities which cause the colouring of vinylon and being easily solved in the water without insoluble matter. In polymerization and saponification of polyvinyl acetate, if we assume the yield of polymerization as 96%, and saponification as 95%, 2,150kg of polyvinyl acetate is needed to prodnce 1,000 kg of poval and at the same time 2,770 kg of sodium acetate ($CH_3COONa \cdot 3H_2O$) is produced as bi-product.

(d) Recovery of sodium acetate.

The productive cost of poval is largely influeuced by the proper utilization of sodium acetate. Excepting the case of selling it to the others, there are several methods for its recovery, for example, to produce aceton by heat-de composition or to recover the acetic acid by hydrolysis or electrolysis. Coside-ring the re-use of chemicals in the process from carbide to poval, it may be rational to recover the aceic acid to be used again for the synthesis of vinyl acetate in order to run up the process with few bi-product. If the sodium acetate is decomposed by hydrochloric acid into acetic acid and sodium chlo-ride, the latter is in turn decomposed into caustic soda, chlorine and hydro-gen by electrolysis.

Caustic soda thus obtained is used for saponification of vinyl acetate and chlo-rine and hydrogen is synthesized into hydro chloric acid to be used for decom-position of sodium acetate.

$$CH_3COONa + HCl = CH_3COOH + NaCl$$

$$NaCl + H_2O = NaOH + HCl$$

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In another way, the sodium acetate is mixed with sulphuric acid to be decomposed into acetic acid and sodium sulphate, the latter is used in spinning bath for vinylon and acetalization bath.

$$2CH_3COONa + H_2SO_4 = 2CH_3COOH + Na_2SO_4$$

If the recovery yield of acetie acid reached at 80% by this method, 353kg of acetic acid is recovered from 1,000 kg of sodium acetate. Accordingly, in the production of 1,000 kg poval, 975kg of acetie acid is recovered from bi-product, sodium acetate amounting to 2,770 kg. Recovery yield of acetic acid is expected to increase as much more than 85%.

It is worth to be mentioned that sodium acetate will be efficiently decomposed into caustic soda and acetic acid by electrolysis.

(e) Summary.

General description of poval production is mentioned above. As the quality and cost of poval give a large influence to the quality and sort of vinylon, it is necessary to improve the technique in each process so as to get poval suitable for vinylon propuction, and at the same time to bring down the productive cost through increasing up the yield of each process and lowering down its material consumption ratio, for which purpose we need to establish the complete technique through the whole process.

The production technique of acetic acid in Japan has reached the world level and its productive cost is also capable to reach the world level. But the synthesis, polymeization and saponification of vinyl acetate are not being carried on in Japan in a big scale of plant operation. Although it depends on the future development, we have continued researches on it to increase the yield and we are sure to reach the standard of Europe and the United States. But the poval for vinylon is not being produced in the foreign countries. Therefore, our research has been originally carreid out to produce the suitable one for vinylon production by the improvement of purity and quality. If we summarise the production unit, 2,150 kg of vinyl acetate is needed to produce 1,000 kg of poval and 2.780 kg of carbide and 1,615 kg acetic acid to produce 2,150 kg of vinyl acetate. As 975 kg of acetic acid is recovered from sodium acetate, the bi-product, 640 kg of acetic acid is quite enough to supplement. 1,340 kg of carbide is needed to produde 640 kg of acetic acid. Therefore, we can conclude that 4,120 kg of carbide is needed to produce 1,000 kg of poval. Thus, so far as the basical industrial technique is concerned we can say that we have reached the step to cultivate the future development by the plant operation of the practical economical unit.

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(3) Vinylon.

The production process in vinylon fiber division is similar to that of viscose rayon which is divided into three departments, spinning solution dept, spinning dept and finishing department.

In spinning solution department, poval is dissolved in hot water to prepare about 15% conc solution which is then made into spinning solution by filtering and removing bubbles. Spinning solution does not need aging as in viscose process but it should be treated so that the solution may be stable not to be gelatinized.

In spinning department, the spinning solution is pressed out into coagulation bath through a small hole of the spinnerett, and then dehydrated, coagulated and spun into fiber. As the coagulation bath, glaubers salt aqueous solution is used, in which the dipping length is fixed as long according to the coagulatability of spinning solution and appropriate tense drawing is applied. As shown by its morecular structure, poval is highly capable of fiber formation, and if it is spun with appropriate tense drawing, its molecules will be satisfactorily arranged, producing a very strong fiber. Since this fiber is weak against water, its water resistance is imparted by after-treatemnt, that is, as mentioned before, heat treatment is combined with acetalization and then is washed, oiled and dried into vinylon.

The finished product may be in the form of either mono-filament yarn, multi-filament yarn, multi-filament tow or staple fiber. Different spinning and finishing methods have been devised for each kind to make use of characteristics to improve its workability and practical quality. In staple fiber production, products of several deniers and staple length were made, and the eveness was increased. The spinninability was much elevated by crimping of the staple. Special staple fiber is produced for blending with cotton, wool or rayon staple. Vinylon tow is spun by draftbreak system into spun yarn of high strength. The production of vinylon filament yarn and monofilament were also studied. Respecting the preparation of poval solution, spinning of several forms of vinylon, after-treatment, acetalization and finishing, we established original processes and equipments. The quality of vinylon should be improved in accordance with its use which might be further progressed by the industrial development. The consumption of rawmaterials for its production is based on the rationalization in the relation of poval together with rationalization in each process of fiber division. This matter will mostly be solved by industrial development.

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If we fix the moisture regain of vinylon as 5%, the weight increases by acetalization (50%) as about 7% and the waste of poval in the production of staple fiber or filament, as 3% or 5% respectively, then 925 kg of poval is needed for 1,000 kg of vinylon staple fiber and 944 kg of poval is for 1,000 kg of vinylon filament.

(4) Summary.

We described above the vinylon production in respective division of carbide, poval and vinylon fiber. We think we could set up the important technique for the production of vinvlon concerning the quality and productive cost on the commercial base and arranged ourselves for its industrialization.

The prospective consumption ratio of principal rawmaterials as based on the foregoing process of vinylon production is considered to be that 1,000 kg of vinylon staple fiber requires 925 kg of poval, which is produced from 3,810 kg of carbide, for which 7.470 kg of limestone and 2,480 kg of coke are needed. This relationship is supplementarily given on Table 2. The reduction way will be realized by a considerable amount in the future development.

II. Resources of Vinylon

The principal rawmaterials of vinylon are carbide, methanol, formalin, sulphuric acid and caustic soda. Carbide is produced from limestone and coal, methanol and formalin from coal, sulphuric acid from pyrites and caustic soda from salt. In short, resources of vinylon are limestone, coal, pyrites and salt. While the natural fiber and regenerated cellulose fiber depend on the living resources which are cultivated on the arable land or in the forest, vinylon is produced from the inanimate resources wherein lies the prospect of its future development. Resources of vinylon are to be found abundantly in the world and also inexhaustively in Japan. Actually the production may be controled by electricity which is rather looked upon as the most important element. Here will be given a short account of the resources of vinylon in our country.

(1) Limestone.

Limestone in Japan is the resource which is most abundantly available. It it found everywhere in the country and the good quality one for carbide production is obtained in several places. Therefore, as far as limestone concerned it is to be said inexhaustively available. The problem is only how to use it economically.

(2) Coal

Domestic anthracite, coke and charcoal are used for producing carbide and

methanol. Even if those containing so much fixed carbon, at least more than 75%, with little phospherous and sulphur are self-supplied in our country, the import of appropriate coal is desired due to the quality involved. Besides that, much fuel coal is needed. We should do our best to utilize the coal effectively.

(3) Pyrites

Pyrites or brimstone as the rawmaterial of sulphuric acid are abundantly available in Japan.

(4) Salt

Salt as the rawmaterial of caustic soda has to be imported from abroad. As is well known, Japan has no rock salt and is not favoured in producing the sea salt. Therefore, up to now sea-salt has been produced under the protection of the government by the special and complicated method. Despite this unfavourable condition, soda industry of Japan has been developed to produce caustic soda, soda ashes, chlorine and other chemicals with the salt imported from abroad yearly in a large quantity. However, Japan is surrounded by the sea where the salt and other resources are inexhaustibly hidden waiting to be utilized by anybody.

The United States, Germany and other civilized nations are blessed with rock salt or well brine so much that they need not think of a salt making technique to utilize sea water but Japan standing on a quite different situation should discover the special technique to utilize the sea resources. Consequently, utilization of sea water has been deeply concerned by the intellectuals here and in case of much salt being obtained, rawmaterials for vinylon are possible to pe completely self-supplied.

(5) Electricity.

As to electric power, its supply is rather abundant and water power source can be traced everywhere in the country with the possible supply capacity of 25 million kw or more. Therfore there is fabourable prospect for the supply increase of electricity at cheap price in view of the possible development of water power generation. Electricity for carbide is quite different from that of motoring electricity, that is, the electrical energy itself is solidified in the form of carbide. Accordingly, a large surplus electric power being generated in time of abundant water may be utilized for carbide production and kept in stock indirectly. From geographical standpoint, it is advisable in the country like Japan to undertake carbide production so that the electric power may be fully utilized.

(6) Summary

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As is mentioned in the followiug paragraph, natutal resources of vinylon are abundant in our country and carbide, methanol, formalin and sulphuric acid industry together with the soda industry have been already developed based on these domestic resources and imported salt from abroad.

Table 3 Output of carbide, methanol, formalin, sulphuric acid and caustic soda

(Industrial statistics by Trade and Industry Ministry) Unit : ton

Year	Carbide	Methanol	Formalin	Sulphuric acid (50° Be)	Caustic soda
1935	279, 700	3, 598		2, 208, 181	
1936	329, 056	3, 746		2, 891, 020	
1937	357, 239	6, 529		3, 866, 749	
1938	350, 722	7, 142		3, 422, 317	435, 200
1939	357, 122	8, 282		3, 071, 022	427, 900
1940	356, 956	7, 388		3, 145, 483	406, 489
1941	360, 280	12, 889	6, 059	3, 303, 770	404, 667
1942	306, 388	13, 133	7, 282	2, 713, 294	230, 342
1943	301, 143	—	8, 070	2, 393, 719	211, 229
1944	271, 580	—	7, 951	1, 596, 377	143, 047
1945	143, 272	3, 718	4, 150	476, 643	77, 310
1946	213, 648	4, 882	2, 702	917, 000	30, 166
1947	260, 915	5, 196	3, 723	1, 598, 097	52, 043
1948	364, 155	7, 944	4, 768	2, 088, 000	129, 116

As shown on Table 3, Japan produced more than 360,000 tons of carbide per year before the war. After a decrease of production due to the war, it was now recovered again to overproduce in 1948 the quantity before the war. Production capacity of carbide is estimated as 520,000 tons in February, 1949 and can be increased by 90,000 tons afer the completion of repair of the equipments. In 1948, carbide was used for fertilizing lime nitrogen by 58%, for the heavy industry as acetylene welding and for fishing as illuminating purposes by 28% altogether, and for the production of acetic acid and other organic chemicals by 10% and for others by 4%. In future, this percentage will be varied and a large quantity of carbide will be provided gradually for the production of organic chemicals.

Production quantity of methanol and formalin reached 13,000 tons and 8,000

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tons respectively during the war time and after the war, it has been recovered to 8,000 tons and 5,000 tons in 1948 with the surplus capacity.

The sulphuric acid reached 3,870,000 tons before the war, and after the war it has been recovered to 2,090,000 tons in 1948 with surplus capacity. The quantity of caustic soda reached 440,000 tons before the war and it has been recovered to 130,000 tons in 1948 with a fairly surplus capacity.

As is mentioned above, the production of rawmaterials of vinylon such as carbide, methanol, formalin, sulphuric acid and caustic soda have surplus capacity and are capable to supply some amount of vinylon even at the present situation.

For producing 1 ton of vinylon, about 4 tons of carbide, 0.7 ton of methanol, 0.7 ton of formalin, 1.9 ton of sulphuric acid and 1.0 ton of caustic soda are required. Therefore, for producing 100 tons per day, that is, 36,000 tons per year of vinylon, the following materials and quantity are required:

Carbide:	144,000 tons	Limestone:	282,000 tons
		Coke:	94,000 tons
		Electricity:	547,200,000 KWH
Methanol:	25,200 tons	Sulphuric acid:	68,400 tons
Formalin:	25,200 tons	Caustic soda:	36,000 tons

(The consumption of methanol, formalin, sulphuric acid and caustic soda will be much reduced by the future development)

If it would be possible to insure the supply of these amounts, nearly one ld of vinylon per capita will be given to 80 million peoples in Japan. Reduction of rawmaterial consumption should be tried by the technical development in the future. For example, caustic soda will be reduced if the production method of poval would be improved by saponification method using the sulphuric acid or other chemical instead of caustic soda. If hydrochloric acid is used instead of sulphuric acid for acid decomposition of sodinm acetate, the quantity of salt and to produce sulphuric acid consumed will be remarkably reduced. In short, it is possible to produce a fairly large amount of vinylon by making use of domestic resources, and it is due to this that much is expected of the vinylon industry for its future development.

V. Manufacture of Vinylon

Manufacture of vinylon is to be taken up from the exploitation of natural resources such as electricity, limestone and coal and carried on at the plants of carbide, poval and vinylon, relatively connected with the manufacture of

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supplemetary materials such as methanol, formalin, sulphuric acid, caustic soda and others. Its technical range is very wide and complicated and highly qualified technique is required and so vinylon manufacture should be developed by establishing the overall technique in close connection of each division.

Apart from an exploitation of natural resources and manufacture of supplementary materials, we bescride here the manufacture of carbide, poval and vinylon.

(1) Production equipment

(a) Plant.

Production of carbide, poval and vinylon is decisively influenced by its plant scale. The economical minimum unit in case of each plant being operated independently may be variable due to several conditions. Carbide plant for 40 tons per day, poval plant for 10 tons per day and vinylon plant for 10 tons per day are supposed to be existed. Since 10 tons of poval and 40 tons of carbide are required for producing 10 tons of vinylon, these three plants are possible to be operated either in the separate independent plant or in an ovea-all single plant. But the larger the scale of plant is, the operation is much more economized, so that plants for 80 tons/day of carbide, 20 tons/day of poval and 20 tons/day of vinylon may be considered to be most appropriate.

In view of several conditions for plant erection, overall plant for 20 tons per day is possible to be undertaken. By the operation of an overall single plant, overall technique will be established, transportation will be reduced and productive efficiency will be promoted. Looking at the track transportation, the quantity of carbide, poval and glaubers salt transferred between the independent plant occupies 20% of the whole so that the reduction of this quantity by the erection of overall sigle plant is of serious importance.

For the erection of an overall plant for 20 tons per day of vinylon, important factors are not cite of land, employees and water supply but electricity and transportation. 479,400 KWH of electricity and 579 tons of transporting are daily required and the land is to be selected so as these conveniences may be acquired at the same time. In view of transporting, the plant should be erected at the seashore as viscose rayon plants do, being equipped with port, landing, and transporting facilities or in case of plant being erected on the inter-land, branch railway road should be constructed for transporting. Furtheremore, the land convenient for transporting coal, limestone and coke should be selected. On the other hand, in view of electricity, the land which is near to the water power supply source should be selected where carbide has to be

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produced consuming 60% of whole electricity.

It may be anticipated at the time of plant's location that the conditions for electricity and transporting are sometimes contrary to each others and if this question is hard to be solved, two separate plants are to be erected. There are two cases of erecting two plants; that is, one is for carbide and for poval, vinylon or another is for carbide, poval and vinylon. In some cases, the former is better and in other cases, the latter is advantageous. Therefore, the location is to be decided in consideration of each actual condition. Besides these two, construction of three plants is considered to be carried out, separating the carbide, poval and vinylon production closely related to each other.

(d) Equipments.

Equipments in the carbide, poval and vinylon plants are classified as two kinds: the supplementary equipments as residential, welfare, electric, water supply, steam supply, refrigerating, transporting and other facilities and production equipments, the detailed explanation of which is omitted here. Productive efficiency should be promoted with the completion of each equipment as well as the rationalization of relative operation.

Poval and vinylon plants are now being erected for the first time. Among the production cost of vinylon, expense for poval occupies 60% and so it must be considered seriously to bring down the production cost of poval for which the equipments must be complete for the whole processes from carbide to poval and especially for recovery of acetic acid from sodium acetate and to utilize glaubers salt produced as bi-product. At the same time, consumption of manual power, electricity and steam should be reduced as possible. Especially, as the steam consumption is great, heat control should be strictly carried out by the rational use of coal with a small piping loss. We set up the special method to sum up the processes from acetylene generation—synthesis of acetic acid—synthesis of vinyl acetate-polymerization and saponification of vinyl acetate and recovery of acetic acid. This method is applied practically to the equipments and will be still more improved in the future. In the vinylon plant, we set up the original method in regard to the preparation of poval solution, spinning, heat treatment, acetalization and finishing which are practically applied to the equipments and will be also still more improved.

For the erection of carbide, poval and vinylon plants, its construction materials are available in the country and need not to be imported from abroad, and this is also one factor to promote the vinylon industry in Japan. However, special materials and apparatus of highly progressed are desired to be

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imported from foreign countries to operate the equipments more efficiently.

(c) Construction expense of plant.

An estimated rough account of construction expense for vinylon plant of 20 tons per day is shown on Table 4. An estimate of construction expense for rayon plant is referred for comparison:

Table 4. Construction expense of production equipments for vinylon of 20 tons per day

Unit: one million yen

Vinylon staple			Rayon staple		
Carbide:	80ton/day	600			
Poval:	20ton/day	2, 200	Pulp:	20 ton/day	1, 500
Vinylon:	20ton/day	2, 400	Rayon:	20 ton/day	3, 000
Total		5, 200			4, 500

Notes: 1. All plants are supposed to be erected newly.

2. Construction expense of pulp plant is estimated as one thirds of the plant for 60 tons per day.

In general, the construction expense of poval plant is larger than that of pulp plant, and the construction expense of staple plant is less than that of rayon staple, while there is no considerable difference between the construction expence of poval and vinylon plants and that of pulp and rayon plants. Therefore, for vinylon production, only construction expense of carbide plants has to be added.

If it is possible in Japan to convert the former viscose rayon plants to effectively make use of its residential, welfare, electric, water supply, steam supply, refrigerating, transporting and many other facilities for the construction of a poval and vinylon plant, the construction expense will be considerably cut down.

(2) Production cost.

The consumption ratio of rawmaterials and production cost of vinylon industry are variable according to the kind of product to be produced and its quality and also are decisively influenced by the production scale. In accord with the enlargement of the plant scale, consumption ratio of rawmaterials and production cost are rapidly brought down and when it reaches the economical unit, they are varied in gradual step, as in the case of viscose rayon production. Since only a small scale trial production is now under operation it is

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difficult to anticipate the plant operation of economical unit. But here a trial assumption is made with several references.

An estimated consumption ratio of carbide, poval and vinylon is shown on Table 5.

As mentioned before, production technique of carbide is established and the consumption ratio cited here is the figures in a fairly good condition and will be reduced only by the improvement of fundamental technique. Consumpton ratio of materials for poval production is cited here as that to be obtained and to be reduced by the future development. Furtheremore, if the rationalization through the whole process would be set up, that is, if the overall technique would be established by excluding an individual operation, the further reduction of consumption ratio of materials is possible, and then consumption ratio of manual power, electricity and coal is fairly brought down. Divisions of carbide and poval should be closely connected so that the overall technique may be established. The consumption ratio of materials for vinylon is an estimate in case of fairly good condition and this also is possible to be brought down by the rationalization of whole process and the strict control of operation.

Table 5 Consumption ratio of principal rawmaterials for 1,000 kg of vinylon staple

(Production scale. Carbide: 40 ton day Poval: 10 ton/day)
Vinylon: 10 ton/day

	Unit	Carbide 3,810kg	Poval 925kg	Vinylon 1,000kg	Total
Manual power (actual working hr: 8 hrs)	Person	15.2	44.5	60	119.7
Electricity	KWH	14,400	5,170	4,400	23,970
Coal (5,000 cal)	kg	1,260	7,060	3,000	11,320
Limestone (97%)	kg	7,470	0	0	7,470
Coke (fixed carbon: 80%)	kg	2,480	0	0	2,480
Sulphuric acid(50°Be)	kg	0	1,550	350	1,900
Caustic soda (97.5%)	kg	0	925	0	925
Methanol	kg	0	695	0	695
Formalin	kg	0	0	730	730
Glaubers salt	kg	0	(—) 2,530	1,000	(—) 1,530

Note: (—) means to be earried out.

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The production cost is estimated as in the following Table 6 on the basis of above cited consumption ratio of rawmaterials.

Table 6 Estimated production cost of carbide, poval and vinylon

	Production cost in Japan	Market price in U. S. A.	Ditto. Exchanged into yen ($=¥360)
Carbide (2nd grade 250 L)	16.00 ¥/kg	0.06 $/kg	21.60 ¥/kg
Glacial acetic acid	65.00 〃	0.20 〃	72.00 〃
Vinyl acetate	105.00 〃	0.33 〃	118.80 〃
Poval	450.00 〃	1.40 〃	504.00 〃
Vinylon staple	300.00 ¥/lb	—	—
Vinylon filament 100d	380.00 〃	—	—

As mentioned before, carbide production in Japan has so many favourable conditions that the production cost of carbide, acetic acid, vinyl acetate and poval is expected to be reduced along with the technical progress. Nothing is available as to the production cost of the American products, but the figures in Table 6 shows that the production cost of acetic acid, vinyl acetate and poval in Japan are cheaper than the market price in the United States. By this comparison, one may not judge that production costs in Japan are cheaper than that of the U. S., but at least they seem to be at the same level. Therefore, production cost of vinylon is possible to be the same with that if vinylon is suppsed to be produced in the United States.

It is expected that the producton cost of vinylon staple is estimated as ¥300 per lb which is 2.7 times of viscose rayon. But technical progress and expansion of the factory scale will bring down the production cost, and this, together with possibility of rationalization of rawmaterial division, makes us suppose that it will be possible to render the production cost of vinylon close to that of viscose rayon.

(3) Quality.

Vinylon is spun into several forms and made into various textile goods through the processes of spinning, weaving, dyeing and finishing. Here we describe the general properties of the goods, the comparison of which with other fibers is shown on Table 7.

(a) Physical property.

(1) In specific gravity, vinylon is a little lighter than natural silk and wool, and much lighter than cotton and viscose rayon but a little heavier than nylon and Orlon.

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Table 7, Comparison of Properties of Various Fibers

Properties \ Kind	Natural fiber			Regenerated cellulose fiber			Polyamid synthetic fiber		Polyvinyl synthetic fiber			
	Silk	Wool	Cotton	Viscose rayon	Cupra rayon	Acetate rayon	Nylon	Amilan	PeCe	Vinyon	Orlon	**Vinylon**
Specific gravity	1.36	1.32	1.55	1.5	1.5	1.3	1.15	1.14	1.43	1.22–1.28	1.18	1.30
Dry tenacity, g/d	3.0–6.0	1.7	2.5–4.0	1.6–4.0	2.0–2.5	1.1–1.5	4.5–7.5	4.5–7.5	1.8	3.7–4.5	4.0–4.8	2.0–6.0
Dry elongation, %	16–25	54	7–10	8–30	15–30	20–27	14–25	14–25	20	8–28	16–21	15–30
Young's modulus, kg/mm²	950	260	800	800–1.000	800–1.000	800	120–400	260	350	300	—	238–1.150
Elasticity	good	very good	not good	not good	not good	good	very good	very good	very good	very good	very good	good
Bending strength.	rather strong	very strong	strong	weak	weak	rather strong	very strong	very strong	—	—	—	strong
Abrasion strength.	rather strong	weak	weak	weak	weak	weak	strong	strong	—	—	—	very strong
Heat resistance, relative strength at 100 °C, %	75	76	55	93	—	88	87	—	10	10	73	70
Softening point in air, °C	—	—	—	—	—	180	235	210	100	80	250	200
Strength at law temp., relative strength at -50°C, %	115	100	110	135	—	150	134	—	—	126	140	140
Moisture regain (20 °C 65%) %	11	16	8	12	12	7	3-4	3–4	0.1	0.1	0.9	4.5-5.5
Water absorption in water (20°C) %	43	33	40	86	86	40	8	—	0.2	0.2	2.5	30
Wet/dry tenacity, %	80	63	102	45–70	50–70	80	85–93	85–93	100	100	100	65–85
Shrinkage in water 100 °C				3–5		2–3					1.5	2.5
Dyeing property	good	good	good	good	good	good	rather good	rather good	not good	not good	not good	good
Acid resistance	rather strong	rather strong	weak	weak	weak	rather strong	rather strong	rather strong	very strong	very strong	very strong	strong
Alkali resistance	weak	weak	rather strong	rather weak	rather weak	rather strong	strong	strong	very strong	very strong	very strong	very strong

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(Ⅱ) In tenacity, it is as strong as natural silk and nylon. The same is the case with elongaton.

(Ⅲ) In Young's modulus, vinylon is variable, some being as low as wool and others are as high as natural silk and cotton.

(Ⅳ) The tensile elasticity of vinyon is better than cotton and viscose rayon and worse than wool, nylon and Orlon. For the improvement of this property, the research is in progress.

(Ⅴ) Bending strength is higher than natural silk and viscose rayon, equal to cotton and lower than wool and nylon.

(Ⅵ) Abrasion resistance is astonishingly strong showing the highest value among the fibers,

(Ⅶ) Against temperature, polyvinyl synthetic fibers are generally weak Vinyl chloride fiber softens at the temperature below 100°C but vinylon does not soften at the temperature of 200°C. Vinylon softens at higher temperature but is hard to flame, and does not evolve poisonous elements through burning.

(Ⅷ) Against water, synthetic fibers generally have a little hygroscopicity. At the standard temperature of 20°C, 65%, moisture regain of vinyl chloride fiber is 0.1 %, Orlon is 0.9 % and nylon is 3-4 % and vinylon is 4.5-5.5 %: that is, among the synthetic fibers vinylon has a biggest moisture regain but compared with natural fiber it is far little. The water absorption of vinylon in the wet state is 30%, also the biggest among the synthetic fibers but is less than natural fibers and far less than viscose rayon. Tensile strength at the wet state is 65-85 % at the dry state, and this is not so strong as other synthetic fibers and cotton but is the same with natural silk and wool.

(Ⅸ) Against water at high temperatnre, vinylon is weak. This is one of the defects of vinylon. But this property is improved by the original after-treatment, and therefore vinylon can stand even in boiling water of 100°C without much change and is enough to be used for practical use. Further improvement is expected.

(Ⅹ) Thermal conductivity of vinylon is small, larger than silk and wool and smaller than cotton and viscose rayon.

(b) Chemical property.

(Ⅰ) It has a strong resistance against acid and is durable in the sulphuric acid of 20 % conc, at room temperature and of 5 % conc at 70°C.

(Ⅱ) It is exceedingly strong against alkalis and at 100°C it resists against caustic soda of various conc.

(Ⅲ) It is strong against salt of several kinds.

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(Ⅳ) It has strong resistance against organic or inorganic solvents. It is strong against carbon tetrachlorine, carbon bisulphide, alcohol, glycerine, aceton, ether, acetic acid, butyric acid, ethyl acetate, pyridine, formaldehyde, and mineral oil etc. but it is swoolen or dissolved at a higher temperature over 60°C in formic acid, hydrogenperoxides, formalin, phenol and cresol.

(Ⅴ) It is very strong against oils.

(c) Biological property.

(Ⅰ) It is resistant against fungus and mildew. For example, after being buried in the soil or being steeped in the sea water for six months, there is no variation.

(Ⅱ) It is free from damage by insects.

(d) dyeing property.

The dyeing property of synthetic fibers is generally inferior to other fibers but it means that it is not dyed just like natural silk, wool, cotton and viscose rayon by the same dyes and dyeing method. It is of course due to the nature of synthetic fiber itself. Even the fiber which has been existed can not be dyed by every kind of dyes and be durable. Dyeing of synthetic fiber has been and is now being heavily studied and this problem may be solved in the near future. As the dyeing of vinylon concerned, many kinds of dyestuff and their dyeing methods have been already found and it is now going to study the durable dyeing corresponding to the durabilty of the fiber by utilizing the special features of excellent acid resistance, alkali resistance and moderate hygroscopicity of vinylon.

(e) Characteristics of vinylon goods

The foregoing properties are due to the morecular structure of which vinylon is composed. As mentioned before, poval has the construction of the chain of carbon atoms having hydroxyl group at every two carbon atoms, and this moreculer chain is easily extended straightly to make the hydroxyl groups pulling each other. The hydroxyl group has the nature to combine strongly with each other and water molecule. Some parts of hydroxyl groups of the chain are closed by acetal formation. Such a particular molecular structure together with its orientation in the fiber is responsible for the characteristic properties of vinylon, which are generalized as follows:

(Ⅰ) Due to the different orientation of morecules, vinylon of different Young's modulus can be obtained.

The vinylon staple fiber with low Young's modulus and coarse crimps resembles wool and is used for light, soft and warm textiles like woolen cloth, and

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the vinylon staple fiber with high Young's modulus and fine crimps proves similar to cotton and is made into strong and tight textiles like cotton and hemp textiles.

The fine and strong vinylon filament with high Young's modulus proves similar to natural silk and nylon and is used for thin and beautiful textiles like natural silk goods. There is no fiber like vinylon from which so many kinds of textile goods can be produced.

(Ⅱ) Due to the good orientation of poval's chain molecules the vinylon of strong tenacity of 3-6 g/dr is now obtained and the vinylon of much stronger tenacity is possible to be made.

(Ⅲ) The strong pulling of hydroxyl group with each other at many places may be the reason why vinylon is strong against abrasion. This means that vinylon goods are exceedingly durable.

(Ⅳ) The specific gravity of vinylon is comparatively light and therefore vinylon goods are substantially light.

(Ⅴ) As the heat conductivity of vinylon is low, vinylon goods are substantially warm. But the lightness and warmth of the goods depend on the quantity of air contained in the fabrics and therefore the form of the fiber and the structure of the textiles are of importance.

(Ⅵ) Vinylon is strong against heat. Vinylon goods are hard to flame. It is softened at a high temperature over 210°C, and solidified and then is flamed at very higher temperature.

(Ⅶ) Vinylon is strong against microbe and free from damage by insects. Therefore vinylon goods can be easily kept in stock.

(Ⅷ) Vinylon has strong resistance against acid, alkali and oil and therefore is used for industrial materials.

(Ⅸ) Vinylon is also atrong against salts and sea water and therefore is used for fishing materials.

(Ⅹ) Vinylon has an affinity to water. As the hydroxyl of poval has affinity to water, the fiber of poval itself is weak in the water. But the fact that the cotton which has many hydroxyl groups is strong in the water suggests that the water resistance of vinylon may be raised by closing the germ of hydroxyl, that is, the water resistance is raised by the combination of hydroxyl, the process of heat treatment and acetalization of hydroxyl. Therefore, in proportion to the closing of the hydroxyl germ, water resistant goods of several degrees can be produced. If closed completely, the water is not absorbed and is used for some purpose if not for clothing.

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Hygroscopicity of the clothing fiber is very important factor for warmth and health in relation with the skin breathing of the human body, and among the synthstic fibers now introduced, it is only vinylon which has the moisture regain of moderate degree, the moisture regain of the present vinylon is 4.5 ~5.5% which is able to be changed upon the demand. In case of little hygroscopicity, it is not suitable for clothing and if much, it is weak in the boiling water, for which we have made the best efforts and succeeded to produce vinylon which has the moderate moisture regain like the above and durable even in the hot water at 110°C—120°C and possible to be ironed.

As mentioned above, the characteristic properties anticipated from the morecular structure of vinylon are displayed practically in the products, showing the way for further improvements.

In view of the foregoing different properties, vinylon will find very extensive uses compared with natural fiber, regenerated fiber and other synthetic fibers. The excellent acid resistance, alkali resistance and salts, organic solvent and oil resistance of vinylon along its resistance against corrosion are expected to lead to the development of special uses for industrial, fishing and clothing materials. And the property of moderate hygroscopicity and strong durability will find new uses as clothing materials. The excellent blending and mixing property of vinylon will increase the value of vinylon together with the value of natural silk, wool, cotton, hemp and viscose rayon.

Ⅶ Market for Vinylon

1. Its use.

In the present age when various fibers are being produced, the property of each fiber ought to be rationally utilized. Natural fibers have their own properties which have been rationally utilized into various kinds of textiles, but some were inevitably used because of the lack of suitable fiber. Accordingly, the new fiber which has the more suitable property will naturally take place of it, and if the chemical fiber with the better property than natural fiber is discovered, it will have a very wide range of use and new textile products will come out much more abundantly.

In view of the foregoing properties, vinylon will find new extensive uses. Some of these uses may be as follows:

(a) For clothing.

Suits, linings, overcoat, underwears, stockings, socks, gloves, hats, blankets,

knitting yarn, sewing thread, ribbon, etc.

(b) For special clothing.

Bathing dress, raincoat, working clothes for chemical or mining industries, diving dress, etc.

(c) For daily necessaries.

Parasol, umbrella, table cloth, curtain, sheets, carpet, mats, guts and brush, etc.

(d) For industrial uses.

Filter cloth, packing, paper making felt, eletctrolytic diaphragms, etc.

(e) For fishing.

Fishing net, angling string, ropes, etc.

(f) For other uses.

Tents, ropes, cable, surgical sewing thread, etc.

Among above prospective uses, vinylon is expected to take the place of natural fibers and other chemical fibers which have been temporarily used due to the lack of suitable fibers. For example, vinylon will be welcomed as a new fiber for industrial and fishing purposes. The exceeding durability of vinylon will find its way in daily necessaries, furniture and special clothing. It will be used for stockings, socks, underwears, working dress and linings which are specified as the durable goods, and then will be used for the elegant suits changing after the fashion. The excellent blending and mixing property of vinylon increases the value of other fibers and with the development of it, there will be an increase in the production of the blended and mixed products.

The output of vinylon production is very little at present and still in an experimental age, but the practical value has been gradually recognized.

The results of test uses are as follows:

(a) Acid resistant filter cloth of vinylon.

Vinylon cloth was used as the filter cloth for sulphuric acid solution (conc: 6-10%) and the result proved the durability is 5 or 6 times of cotton cloth. In this case, the damage of vinylon cloth was not caused chemically but mechanically, and therefore if the filter cloth is thick and strong enough for machinery operation it is expected to have the practical value 10 times more than cotton cloth.

(b) Fishing net of vinylon.

After testing of vinylon fishing net, its superior property was proved. It is durable 10 times of cotton. The test carried out in summer time when the fishing net is most liable to be corrodad showed that the cotton and silk lost

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their strength after 20 days and vinylon was not varied after 120 days. In addition, vinylon needs no antiseptic treatment which is being applied to cotton and silk fishing net. Vinyon fishing net is light, quickly dried and is easy to handle it with a few spair stock. In view of the above results, it is expected that the practical value of vinylon is 10 to 20 times of cotton fishing net.

(c) Vinylon furniture.

The excellent durability, its strength against rubbing and the property not easily to be stained indicate its practical value as chairclothing, table cloth and other upholstery.

(d) Vinylon working clothes.

Wearing test of vinylon working clothes in the spinning room of viscose rayon plant showed no variation after one and half year. It is durable 10 times more than cotton cloth. Acid resistance, alkali resistance, oil resistance, along with its hygroscopicity will show its excellent value in the chemical plants, mines and others.

(e) Vinylon socks.

Abrasion test for vinylon socks and those of natural silk, wool and cotton showed that vinylon is durable 8 times as much of natural silk, 5 times of wool and 3 times of cotton. The ratio are now being proved by practical wear. Due to a small heat couductivity and suitable hygroscopicity, vinylon socks are comfortable to wear and warm.

(f) Vinylon underwears.

Vinylon underwears are highly praised as much as vinylon socks. Wearing test is not yet finished, but it is warmer than expected, comfortable to wear and hard to be stained because of its little bygroscopicity.

(g) Vinylon suit clothes.

We mention before that the property of vinylon textiles is possible to be changed into the textile similar to silk, cotton, hemp or wool textiles. The first feature of vinylon clothes is its strong durability. The abrasion test of vinylon serge and pure woolen serge showed that the former was durable about 5 times as much than the latter, and it will be proved by the practical wear. Vinylon cloth is free from damage by insects, mildew and fungus, and is easy to be preserved for a long time.

Generally, the synthetic fiber textiles may give the feeling as of plastic resin, but vinylon is comfortable to wear because of its moderate hygroscopicity. In order to give the soft feeling as if woolen textile, a coarse and durable crimping has to be given for which the research is in progress.

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The research on dyeability is also in progress. At first, the colour faded by washing, but to-day vinylon is being well dyed with different colours.

Being of a little hygroscopicity compared with natural fiber and rayon, it is easy to wash and quick to dry.

Lack of heat and water resistance has been one drawback of this fiber. To-day it does not soften in boiling water but it needs careful ironing. It must be careful not leaving it in the hot water over 110°C and not be ironed directly on the wet cloth at a high temperature. It is desired to be ironed below 140°C. If the cloth is dried, no damage by ironing at 180°C.

If one may look for the beautiful and soft suits, the mixture of vinylon and other fibers will come out. The excellent blending and mixing property of vinylon raises the value of wool, cotton, silk and rayon and produce the better goods than a single use. Therefore, it is natural that vinylon has been introduced in the clothing field in combination with other fibers in the early period of its development.

As mentioned above, there is prospect of extensive uses of vinylon by its practical value but its development is determined closely relating with the price of it.

(2) Price.

Vinylon is widely used. How vinylon is valued for each use?

While the production cost is high with a small quantity of production, special features are recognized for special use and there it is highly valued. With an increase of production amount the price is gradually brought down in match with the reduction of production cost and so the field of uses is extended. Since only a small scale trial production is under working, the production cost of vinylon is at present exceedingly high and there may be only a development over a limited range. When the daily production is increased as much as 10 tons, the production cost will be brought down to ¥300 per lb. to be widely used, and thus vinylon industry promises its rapid progress in proportion as the price becomes lower.

It is needless to say that the price of fiber is various according to its kind. The yarn can be classified by its denier, that is, there are thin thread such as natural silk of 13/15 denier and also coarse thread like rayon yarn of 3,000 denier, among which the most simple one is the continuous filament yarn such as silk and rayon yarn which is constructed of some scores or hundreds of straight and smooth single filaments stabilized by a low twist. It is characterized by its high uniformity, its being very long with few knots, and further

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its being produced very cheaply.

If we look for the price of the cheapest yarn in relation with the denier, in the U. S. market the natural silk is the cheapest in the range of around 14–20 denier. Within the cireles of 45–100 denier, acetate rayon is the cheapest and in the circles over 150 denier, viscose rayon is the cheapest. We can draw a line along the lowest prices against the denier axis, the line may be considered as a price base.

Every technical improvement may bring down this price base and among several kinds of yarn, those which can reach to this base will develop within the range of denier and those which are not reached will decline unless the quality is not highly valued.

Of course, good quality is highly valued. Among the filament yarn of the same denier, fine denier yarn, high tenacity yarn, delustered yarn, colored yarn, the yarn which is highly twisted and long yarn, with few knots are valued higher than the price base. Compared with the filament yarn, spun yarn is also highly valued because of its appearance and feeling.

In order to develop vinylon, the production method and process should be studied at first to produce the most suitable kind in view of the relative production cost with the kinds, and to improve the quality lowering the cost. The production cost of vinylon should be brought down to the level of rayon. There are many steps before that aim is reached and vinylon should exploit its uses corresponding to the demand of the domestic and foreign market in proportion to its quality and cost at each step.

Ⅶ Signification of Vinylon manufacture.

A new synthetic fiber, vinylon, is now going to be introduced to participate in the development of the textile field of the world. On its starting point, it may be very worthy to look upon the signification of vinylon manufacture.

(1) Economical signification.

How vinylon will give an influence to the textile economy in Japan? The hemp has grown on the soil of this land and silk and cotton were introduced from abroad and have been cultivated on our soil for a long age and processed to supply their textiles to satisfy the demand of the nations. During the ancient age, the textiles soaked into the heart of the nations to bring up the nationality familiar to the textiles and served to develop the civilization originated in this country.

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Since the middle of Meiji era, being influenced by the mechanical civilization of the world, the textile industry of Japan has been rapidly mechanized to make a remarkable progress. But with the poor textile resources, the silk was increasingly produced and mostly exported abroad and cotton, wool and pulp were imported from abroad for export of the processed goods, thus establishing the industrial organization based on the processing and trade system to participate in the textile field of the world. This was achieved by the nationality familiar to the textile industry and also by the fact that Japan was blessed with climate, abundant water source and transportation and that many foreign markets were located nearly.

Textile industry thus established by the nationality and national situation is most suitable to our country and it should be developed further so as to keep the prosperity of the past. This industry, however, was heavily damaged by the war and is on the start to fulfil its duty of recovering Japan.

How this responsibility will be carried out by the textile industry of Japan? After the war, the textile circle in the world was quite changed and seems to have entered into a new age. Every country in the world is trying to make a technical progress in the textile production to self-support its textiles by the manufacture of natural or synthetic fibers utilizing the resources found in each country and to avail the textile goods for domestic consumption as well as for export purposes. This general trend is rapidly in progress in the whole world and textile industry of Japan is forced to make a big turn. It is surely impossible to recover and develop the textile industy of Japan on the basis of the processing and trade system which contributed much to the industry for past 50 years. It is necessary to establsh a new system of production, processing and trade in accord with the trend of the world, that is characterized to produce textile fibers from domestic natural resources and to process various textile goods with domestic and imported fibers and to supply the domestic demand and to participate in the world trade.

How vinylon will contribute to establish such a situation? The land of Japan is very narrow with big mountains running through the islands and has a small lot of cultivated land and wild field. From the point of climate, she is not suitable for cotton growth and sheep raising. Its production of raw silk and hemp is rather negligble due to a small area. From the point of quality, they can not satisfy the nation's demand. In short, because of the poor natural resources, the production of natural fiber is very poor and the production of man-made fibers is earnestly required.

In 1938, the forests of our country became one of the textile resources and

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the production of rayon pulp reached to 196,400 tons in 1941 (if converted to rayon, 345 million lbs). In spite of its attemp to self-supply the textiles, the exhausting forests need a big effort to increase the source of rayon. Therefore, it is important for us to scientifically manage the land and to cultivate the rayon resources by the plantation in the forests and unutilized land. Still there is also a limit and moreover rayon is not possible to satisfy the demand of nation in view of its quality.

Here the synthetic fiber produced by coal, limestone and electricity called the attention of the public. As mentioned before, vinylon is abundantly produced along with the exploitation of an electric power. The forests of Japan might not be suitable for rayon pulp but the abundant water source may be utilized to the extreme for an abundant production of vinylon. Being qualified with the special property to substitute for silk, wool, cotton and hemp together with the property lacked in natural fibers and viscose rayon, vinylon will satisfy the different demand of nations.

Thus, a large quantity of chemical fibers such as vinylon, rayon and others which are produced from natural textile resources in addition to silk and hemp may be possible to self-supply the textile goods in our country. In any way vinylon will play a big role with a great success.

Japan also has to process the various fibers by the rational utilization into textile goods just as other foreign countries will do. Even if the domestic vinylon, rayon, silk, hemp and other fibers might be utilized to satisfy the demand of the nations, we ought to process the textile goods meeting to the demands of nations by mixing of cotton, wool and hemp imported from abroad because of the quality and price of the goods. Since synthetic fibers with special properties are now promoting the rational application of fibers into the new textiles and if synthetic fibers are not produced here, Japan must import them in addition to cotton, wool, and hemp. From this standpoint, vinylon will play a big role in the textile industry.

The market of the world will demand the new textile products processed by rational application of various fibers and each country will buy those which are lacking in her own country. Therefore, for the promotion of textile goods' trade, new textiles must be produced and processed and then exported to the market abroad. Vinylon fiber and its textile goods processed as either alone or blended with other fibers are specialized to our country and may be possible to meet the demand abroad and therefore the export of vinylon will be widely opened. We may say that if not vinylon or other synthetic fibers on