THE OUTPUT OF ESTATE SHEETING BATTERIES.

BY

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Present estate factory practice demands in an increasing measure the utilisation of existing plant for the production of larger quantities of rubber conforming to a higher standard of quality. The following article considers this problem in the light of information obtained from the results of a questionnaire on factory sheeting batteries.

INTRODUCTION.

In order to gather data concerning the average practice adopted throughout the country, a large number of estates were circulated with the following questionnaire:—

1. Crop treated, in lbs. of dry rubber per hour.
2. Number of machines. { Smooth Rolls. / Markers.
3. H.P. of Engine.
4. Approximate R.P.M. of rolls.
5. Width of Rolls. { Smooth Rolls. / Marking Roll.
6. Diameter of Rolls. { Smooth Rolls. / Marking Roll.
7. Number of times sheet passes through each machine.
8. Original width of coagulum from tank and whether hand rolled.
9. Final Width of { Wet Sheet, / Dry Sheet.
10. Thickness of Sheet or weight of Dry Rubber per foot length. (NOTE.—Several feet to be measured to give average).
11. Is coagulum rolled on day of coagulation or next day.
12. Concentration of standard latex. (lbs. per gallon).
13. Distance between division plates in tank.
14. Any remarks on relation between width of sheet and packing cases.

The replies received from 200 estates were tabulated and analysed to ascertain the relationship existing between:—

(a) Width of Dry Sheet and Output per battery hour.

(b) Width of Coagulum and width of Wet Sheet.
This embraces variations due to "same day" and "following day" machining.

(c) Width of Wet Sheet and corresponding width of Dry Sheet.

(d) Thickness of Sheet, as defined by weight per square foot, and Concentration of the Latex before coagulation.

(e) Speed of Machine rolls in feet per minute and Output per battery Hour in lbs. of dry rubber.

When the information was summarised with a view to ascertaining these relationships it became evident that further variables were involved and required consideration; thus with (a) it is valueless to consider width without also taking into account thickness and, for a true representation of the facts, it is necessary to make the comparison in terms of sheet of a standard thickness. It was decided that a suitable standard of thickness would be represented by a sheet weighing $\frac{1}{2}$ lb. per square foot. The actual figures for output appearing in the questionnaire replies were therefore adjusted so that the figures used for comparison represented in each case what the output would be if the battery were producing sheet weighing precisely $\frac{1}{2}$ lb. per square foot.

In the same manner it was found essential to introduce the factor of standard width into the considerations involved; if the standard thickness is combined with standard width, a true comparison of outputs is obtained. It was decided to adopt 12 inches as the standard width.

The figures adjusted on this basis then show the relative efficiencies of batteries of similar type.

For example, Estate No. 14 is reported to be manufacturing 547 lbs. per battery hour. The weight of the sheet is 10.1 ozs. per square foot, the sheet itself being $15\frac{1}{2}$ ins. wide. If the weight per square foot were 8 ozs. the output per battery hour would be 433 lbs. for a sheet $15\frac{1}{2}$ in. wide, and if the sheet were 12 ins. wide instead of $15\frac{1}{2}$ ins. the output would be still further reduced to 335 lbs. per hour.

In comparison, Estate No. 17, having the same type of battery, is reported to be manufacturing 324 lbs. per hour as against 547 lbs. reported by Estate No. 14, but we find that Estate No. 17 is making sheet 10 in. wide, weighing 7.8 ozs. per square foot. By adjusting for these values on the above lines it is found that the output of standard thickness sheet would be 332 lbs. and the output of sheet of standard thickness and standard width would be 399 lbs. per hour. Therefore Estate No. 17 is actually handling rubber more efficiently than Estate No. 14 although the bare questionnaire reply indicates the reverse. Table 1 shows some of the figures obtained from the questionnaire set out in the manner indicated in the above example and the end column of the Table summarises the results in a figure representative of battery efficiency.

TABLE 1.

Estate No.	Actual Output Dry Rubber lbs. per hour.	Number of Machines		H.P. of Engine	Roll Speed Ft. per Min.				Width of Rolls		D.R.C. of latex lbs. per gal.	Width of Coagulum	Width of Sheet		Wt. per foot length	Wt. per sq. ft.	Output of Sheet of Standard Thickness.	Output of Sheet of Standard Thickness and Standard Width
					Machine								Wet / Dry					
		Smooth	Marker		1	2	3	M.	Smooth	Marker		Inches.	Inches.		Lbs.	Ozs.	Lbs.	Lbs.
1	454	3	1	5	55	70	70	45	20	20	1.50	9.0	16	14	0.53	7.2	504	432
2	296	3	1	5	50	50	50	50	18	18	1.00	8.0	14	13	0.50	7.4	320	295
3	325	3	1	4	55	75	75	55	20	20	1.25	7.0	10	9	0.50	9.6	271	343
4	570	3	1	3½	60	60	60	60	20	20	1.50	8.0	14	13	1.00	15.5	294	274
5	400	3	1	5	55	55	55	60	18	18	1.25	10.0	12	11½	0.60	9.4	341	355
6	514	3	1	5	55	55	55	60	18	18	1.25	10.0	12	11	0.44	7.6	541	591
7	311	3	1	5	45	45	45	40	18	18	1.50	10.0	13½	13	0.44	6.5	383	353
8	311	3	1	12	35	35	35	45	18	18	1.50	6.6	14½	14	0.60	8.2	303	260
9	475	3	1	5	40	40	40	40	20	20	1.25	6.5	11½	10	0.40	7.6	495	594
10	707	3	1	4½	70	70	70	70	20	20	1.25	9.0	13	12	0.54	8.6	655	655
11	310	3	1	5	45	45	45	25	18	18	1.50	11.0	14	13	0.75	12.6	207	187
14	547	3	1	3	55	55	55	50	20	20	1.5	10.3	16	15	0.79	10.1	433	335
17	324	3	1	3	40	40	40	40	15	15	1.25	8.0	10½	10	0.40	7.8	332	399
1	201	2	1	5	55	55		55	18	18	1.50	6.75	12	11½	0.55	9.6	168	175
2	314	2	1	6/7	40	40		45	18	18	1.50	10.0	14	12½	0.55	8.8	285	274
3 A	520	2	1	5	55	55		55	18	18	1.25	7.5	11	10	0.53	10.2	408	480
3 B	580	2	1	5	60	60		60	18	18	1.25	7.5	11	10	0.53	10.2	459	551
3 C	600	2	1	5	65	65		65	18	18	1.25	7.5	11	10	0.53	10.2	470	565

From the full list of figures of which Table 1 forms a part, some statistical analyses were made.

The values for coefficients of correlation were determined according to the conventional methods which have been applied and described elsewhere in this Journal and results were obtained for the following relationships:—

CORRELATION BETWEEN:

(a) *Roll speeds and output of standard sheet for batteries of similar type.*

For batteries consisting of three smooth machines and one marker, the coefficient of correlation between output of standard sheet and the speed of the fastest roll was found to be $+ 0.140 \pm 0.075$.

Similarly the coefficient of correlation between output of standard sheet and the speed of the slowest roll was $+ 0.128 \pm 0.075$.

For batteries having two smooth rolls and one marker the coefficient of correlation between output of standard sheet and the speed of the fastest smooth roll was $+ 0.170 \pm 0.097$.

From these figures it is evident that the correlation is in each case insignificant.

If it is assumed that all rolls are correctly adjusted and efficiently fed, then it follows from the above that the figures supplied on the questionnaire sheets were in most cases inaccurate. On the other hand, if it is assumed that the questionnaire replies are accurate, and we see no reason to doubt this, then the inference must be made *that rolls are not in general being correctly adjusted and/or efficiently fed.*

(b) *Width of Dry Sheet and Output of Battery.*

A study of the figures for the above relationship gave no conclusive information even when subjected to a close statistical analysis.

SUMMARY OF STANDARD OUTPUTS FOR BATTERIES OF SIMILAR TYPE.

If the figures recorded in Table 1 above are classified according to the type of battery and the gearing of the machines, useful criteria are obtained for the output values of standard sheet. These values are recorded below in Tables, II, III, IV and V.

Table II records some values for output of batteries having three smooth rolls and a marker running at different speeds.

Table III gives similar values for batteries in which all the rolls are running at the same speed.

Table IV gives values for batteries having two smooth rolls and a marker all of which are running at the same rate.

Table V records output of batteries employing instead of light sheeting rolls a marker combined with heavy smooth rolls from a crepeing battery geared in the usual manner.

In order to conserve space it has been considered sufficient to tabulate only those estates having standard outputs *above average for each particular group*. The average for each battery type is recorded at the head of each table.

TABLE II.

Light Battery Type.—3 Smooth Rolls and 1 Marker, running at different speeds.

Average Standard Output.—345 lbs. per hour.

Est. No.	Standard Output.	Roll Speeds. Feet per minute.		
		Marker.	1st Smooth.	2nd & 3rd Smooth.
25	432	45-50	55-60	70-75
89	405	40-45	40-45	50-55
119	493	45-50	45-50	65-70
122	500	45-50	55-60	55-60
123	392	60-65	65-70	65-70
131	401	50-55	65-70	90-95
171	415	45-50	55-60	55-60
175	412	45-50	35-40	55-60
192	392	40-45	50-55	65-70

TABLE III.

Light Battery Type.—3 Smooth Rolls and 1 Marker, running at the same speed.

Average Standard Output.—345 lbs. per hour.

Est. No.	Standard Output.	Roll Speeds. Feet per minute
12	384	30 - 35
17	399	35 - 40
20	393	55 - 60
32	410	80 - 85
24	345	55 - 60
66	444	45 - 50
83	355	55 - 60
84	591	55 - 60
88A	474	45 - 50
90	427	35 - 40
93	360	40 - 45
96	366	35 - 40
112	375	40 - 45
118	571	35 - 40
120	463	35 - 40
128	487	35 - 40
133	397	50 - 55
134	439	65 - 70
138	420	55 - 60
141	351	45 - 50
163	427	50 - 55

TABLE IV.

Light Battery Type.—2 Smooth Rolls and 1 Marker.

Average Standard Output.—301 lbs. per hour.

Est. No.	Standard Output.	Roll Speeds. Feet per minute.
5	323	35-40
40	345	70-75
29	431	70-75
51	398	35-40
56	545	65-70
78	348	40-45
79	419	40-45
102	489	55-60
135	350	55-60
128	487	35-40
74	320	55-60
165	305	30-35
168	329	50-55
173	418	40-45
193	370	45-50
185	336	40-45
195	506	50-55
200	333	40-45

TABLE V.

Heavy Battery Type.—Heavy Smooth Rolls and 1 Marker, 18 ins. × 12 ins.

Average Standard Output.—353 lbs. per hour.

Output above 354 lbs.		Speed of Marker.	Speed of First Rolls.	Speed of Other Rolls.
Est. No.	Standard Output.			
3	467	50-55	40-45	50-55
23	512	35-40	75-80	75-80
55	565	45-50	90-95	100-105
129	573	30-35	60-65	60-65

From these results, the following conclusions may be drawn:—

(a) Batteries having three smooth rolls and a marker show better standard outputs than those having only two smooth rolls and a marker.

(b) Roll speeds as high as 68—70 feet per minute can be used successfully on first machines, (vide Table V) and it is advantageous to have the machines geared to run at unequal speeds.

In other respects the results were conflicting and it was decided to obtain more data before attempting to draw further conclusions. It was felt that the inferences drawn from the above statistical analyses should be supplemented by experimental work designed to answer the following:—

(a) To what extent is the output of a battery dependent on the efficiency of the individual machines?

(b) To what extent can the output of a battery be improved by the correct harmonisation of the units in the battery?

(c) What is the maximum output which a factory can expect to maintain with the present type of plant?

With the above objects in view work has been carried out on several estates under normal conditions of factory procedure and test runs have been in hand for some time on the plant available at the experimental factory attached to the Chemical Division of the Institute.

It is considered that the results so far obtained are of sufficient interest to warrant publication but it must be emphasised that there still remain many problems unsolved relating to the efficient manufacture of plantation sheet.

As an illustration of the manner in which existing figures require scrutinising it is relevant to quote from observations on some estates which forwarded replies to our questionnaire.

OBSERVATIONS TAKEN ON ESTATE A.

Battery. Two smooth rolls and a marker.

Output **reported,** 700 lbs. per hour.

Output **observed,** 641 lbs. per hour.

Roll Speeds.

		1st Machine.	2nd Machine.	Marker.
Reported,	R.P.M.	26	26	30
Observed,	R.P.M.	29	29	29

Rolls, Diameter 7 inches. Peripheral speed of rolls 53.1 ft. per minute.

In a check run it was found that 348 sheets were machined in 88 minutes.

Time observed for machining separate sheets (mean figures)

Machine.	Time (Secs.)
1	12
2	12.7
3	8.1

Size of Sheet.

Wet Sheet = 17.75 in. × 53.4 in.
Dry Sheet = 14.5 in. × 49 in.

Weight of Dry Sheet.

40 sheets weighed 107.75 lbs. = 2.7 lbs. per sheet.

Weight of Dry Sheet per Square foot.

$$= \frac{2.7 \times 16 \times 144}{14.5 \times 49} = 8.75 \text{ ozs.}$$

Output per battery hour observed.

$$= \frac{348 \times 60 \times 2.7 \text{ lbs.}}{88} = 641 \text{ lbs. per hour.}$$

Output of 12 inch wide sheets would be $\frac{641 \times 12}{14.5} = 531$ lbs. per hour.

Output of 12 inch wide sheet weighing ½ lb. per sq. ft., i.e. Standard Output would be 485 lbs. per hour.

Rate at which rubber passes between the rolls.

348 sheets $= \frac{348 \times 53.4}{12}$ feet of rubber.

Now 1 sheet is handled in 12.6 seconds by the 2nd roll

$\therefore$ 348 sheets take $\frac{348 \times 12.6}{60}$ machining minutes = 73 min.

$\therefore$ Rolls handle rubber at the rate of $\frac{348 \times 53.4 \text{ ft.}}{12 \times 73}$

= 21.2 ft. per minute

Further the time occupied in handling = 15 minutes.

$\therefore$ One sheet occupies 2.6 seconds in handling.

From the observations made on the estate the peripheral speed of the rolls was found to be 53 feet per minute, and yet the sheet of rubber only leaves the smooth rolls at the rate of approximately 21 feet per minute and leaves the marking roll at the rate of 33 ft. per minute.

The fact that the ribbing on the marking rolls does not account for a greater efficiency in the output of the rolls appears to indicate that the differences between 53 (roll speed) and 21 (sheet speed) ft. per minute on the smooth rolls is not altogether accounted for by pure "slip". It may be described as "slip" for want of a better term, but we are of the opinion that it is a characteristic of the deformation of the rubber due to the nip of the rolls and in this connection some

further data which we have collected shows that the figure for slip, high though it may appear from the above, tends to increase still more when the coagulum which is being machined is tough and resilient and possesses elasticity preventing deformation. For this reason it appears desirable to machine very soft coagulum which is plastic and readily deformed and does not spring back like elastic the moment it is released from the nip of the rolls.

In order to investigate this further a piece of apparatus has been designed for measuring the plasticity or deformability of coagulum and it is hoped shortly to be in a position to publish some data connecting the "softness" of coagulum with efficiency of output.

The inference that plasticity of coagulum influences the machining of the crop was borne out by the results obtained in the Institute's Experimental Factory. Here the work has been carried out on 24 inch wide roll sheeting machines handling coagulum from tanks 16 inches deep.

The individual results obtained at the Institute led to the following conclusions:—

(a) A satisfactory sheet could be made from latex coagulated in a deep tank.

(b) Progress towards increased outputs and higher efficiency of sheeting plant is intimately connected with factors influencing the state of the coagulum such as density, plasticity and hardness.

(c) The efficiency with which the drying of the finished sheet can be effected is dependent on the handling and machining of the coagulum and is a consideration which must be given particular attention when any attempts are being made to increase the output of a battery.

(d) The depth and thickness of the coagulum made must be regulated by the accommodation of the smokehouse as well as the width of the machines.

Bearing in mind the above facts it has been possible to produce eminently satisfactory sheet at rates which would have been considered very improbable a year ago and for the purpose of illustrating these the following figures may be quoted:—

OBSERVATIONS TAKEN ON ESTATE B.

Plant Dimensions.

Coagulating tanks	...	18 inches deep, aluminium lined.
Partitions,	...	16 inches deep, aluminium.
Machines	...	3 smooth rolls and 1 marker.
Rolls	...	24 inches wide, 6 inches diameter.

Latex 1½ lbs. per gallon machined on the day after coagulation.

Width of the coagulum	(average of 7 sheets)	10.5 ins.
	(after hand pressing)	11.0 ins.

Length of coagulum from:—		*Time taken to pass through:—*	
1st machine	45.8 ins.	1st machine	13 seconds.
2nd ,,	48.0 ,,	2nd ,,	11.4 ,,
3rd ,,	57.2 ,,	3rd ,,	12.9 ,,
Marker	55.5 ,,	Marker	10.7 ,,

The sheet was even in appearance, but was possibly a trifle thicker than normal and was described by the Manager as being on the thick side for a satisfactory smoking in 7 days.

Dimensions of Dry Sheet.

Average of 24 random sheets = 16.8 ins. at ends and 15.8 ins. at middle.

Latex at 2 lbs. to the gallon coagulated and machined the same day.

Width of the coagulum (average of 7 sheets)	...	13.5 ins.
Length of coagulum	...	39.0 ins.

Time taken for sheet to pass through:—

1st machine	...	15.2 seconds
2nd ,,	...	12.1 ,,
3rd ,,	...	13.2 ,,
Marker	...	15.0 ,,
Width of wet sheet from Marker	=	21 ins.
Length of wet sheet from Marker	=	67 ins.

The sheet was somewhat thick and the average appeared to be over $\frac{1}{8}$ inch.

The handling of the coagulum presented unusual difficulties on account of the softness of the material and the size of the pieces to be put through the first machine. The operators were not used to this and it was only after fixing temporary chutes on which the coagulum could be passed into the first machine that it was found practicable to handle the pieces of coagulum without an abnormal amount of tearing. Observation showed, however, that if suitable chutes could be constructed permanently for the introduction of the rubber into the first and second machines the handling of these big pieces of coagulum would present little or no difficulty.

Dimensions of Dry Sheet.

Average of 24 random sheets 19.7 inches at ends and 18.5 inches in the middle.

The rubber was difficult to dry and in order to obtain a satisfactory cured sheet the ends had to be clipped extensively.

As a result of this it became evident that it would be necessary to employ a greater depth of latex for the purpose of obtaining an 18 inch finished dry sheet from latex diluted to below 2 lbs. to the

gallon and it appeared that the results obtained with that from latex at 2 lbs. to the gallon, coagulated and machined on the same day, were vitiated by difficulties in the smoking of the finished sheet.

Further trials were, therefore, carried out with latex diluted to $1\frac{3}{4}$ lbs. per gallon.

Observations taken on Estate C.

Plant Dimensions.

Coagulating tanks	...	18 inches deep, aluminium lined.
Partitions	...	16 inches deep, aluminium.
Machines	...	3 smooth rolls and 1 marker.
Rolls	...	24 inches wide, 6 inches diameter.

Latex at $1\frac{3}{4}$ lbs. D.R.C. machined on the day after coagulation.

Coagulum was passed directly into the 1st machine and not hand rolled.

Width of coagulum	=	13.0 inches
Length of coagulum	=	39.0 ,,

Time taken to pass through machines:—

1st machine	...	13 seconds.
2nd ,,	...	12 ,,
3rd ,,	...	11.5 ,,
Marker	...	15 ,,

Total time taken to machine 76 pieces of coagulum = 25 min.

Width of wet sheet from marker	=	19.8 inches.
Width of dry sheet	=	17.6 ,,
Weight of dry sheet	=	5.2 lbs.

The sheet took 11 days to smoke and needed some clipping to eliminate thick edges.

From these observations the following deductions were made:—

(a) Latex coagulated at $1\frac{3}{4}$ lbs. per gallon cannot be relied on to produce a dry sheet 18 ins. wide from 16 inches depth of latex.

(b) There is a danger of producing a sheet difficult to dry on account of thick edges.

(c) The 24 inch wide roll machines can roll 1,000 lbs. of dry rubber per hour and this output can be handled by one man per machine.

(d) The battery is capable of a much greater output if roll speeds of the units are better harmonised.

As a result of the above, further trials were made on the same plant with latex at 1¾ lbs. D.R.C. coagulated and machined the same day.

Capacity of tank 226 gallons. Coagulant added to latex at 1.30 p.m. Depth of latex between partitions 16 inches. Coagulum lifted at 3.30 p.m. Depth of coagulum between partitions varied between 12 and 14.5 inches.

The pieces of coagulum were very soft and represented the extreme degree of softness at which it would be possible to lift coagulum from the tanks into the first machine. It was found, however, that if the material could be supported as it was passed into the first machine it could be machined successfully and without tearing.

The rate at which the sheets passed through the machines was found to be approximately the same as that recorded above, and the output worked out at approximately 1,000 lbs. dry rubber per hour. The width of the wet sheet varied considerably—those sheets from the first 20 pieces of coagulum had widths between 19.5 ins. and 22 ins. and those from the last 20 pieces of coagulum varied in width between 22 ins. and 24 ins. These differences did not correspond to variations in the depth of the original pieces of coagulum.

The wet sheets gave a satisfactory marking and machined to a uniform thickness. The edges were soft and even.

It was found that the sheets smoked in 13 days over all, there was no delay in drying the ends and the colour and appearance of the finished rubber was satisfactory.

Weight of dry sheet 5.2 lbs. Width of dry sheet varied between 16.5 ins. and 19 ins.

From these figures and the observations made at the time of the trials it was evident that an attempt should be made to arrange for some method of improved handling of the coagulum from the tank to the first machine. If this could be done it would be possible to handle coagulum 2—3 hours after adding the coagulant and then 16 ins. depth of latex would produce a finished sheet of 18 inches width.

The necessary steps were taken to arrange for further trials in this direction and, pending these, some alterations were made to the gear ratio of the machines.

The results of these to date can be judged from the following figures taken during actual working conditions on Estate C.

Coagulum from latex containing 1¾ lbs. dry rubber per gallon to which the coagulant had been added the previous day.

Dimensions of coagulum	{	40 ins. long.
,, ,,	{	14 ins. to 11½ ins. wide.

Individual speeds and Outputs of separate machines.

	R.P.M.	Peripheral speed. Feet per min.	Time of Sheet through machine.	Dimensions of Sheet leaving machine Length.	Width.
1st Machine	27	40	13 secs.	$45\frac{1}{2}$ ins.	18 -16 ins.
2nd ,,	40	60	12.6 ,,	$53\frac{1}{2}$,,	$20\frac{1}{2}$-$18\frac{1}{2}$,,
3rd ,,	40	60	13.0 ,,	59 ,,	$22\frac{1}{4}$-20 ,,
Marker	40	60	12.5 ,,	66 ,,	23 -21 ,,

Average width of dry sheet 17.4 ins.

Average weight of dry sheet 5.28 lbs.

Total time taken to machine 76 sheets = 18 minutes.

Therefore output of battery = 1337 lbs. dry rubber per hour.

It is of interest to note that if the output of Estate C is reduced to terms of standard output for comparison with the figures recorded previously (Table I.) the following values are obtained.

Average standard output of batteries having 3 smooth machines and one marker = 345 lbs. per hour.

Standard output of Estate C having 3 smooth machines and one marker = 645 lbs. per hour.

Conclusions.

The above results lead to the following conclusions:—

(1) The sheeting batteries on the majority of estates are not working efficiently. The harmonisation of the units can be improved and the handling of the coagulum is far froin ideal.

(2) 18 ins. deep tanks and 24 ins. wide machines can be used to produce 18 inches wide standard quality sheet at rates up to 1400 lbs. of dry sheet per hour.

Acknowledgements.

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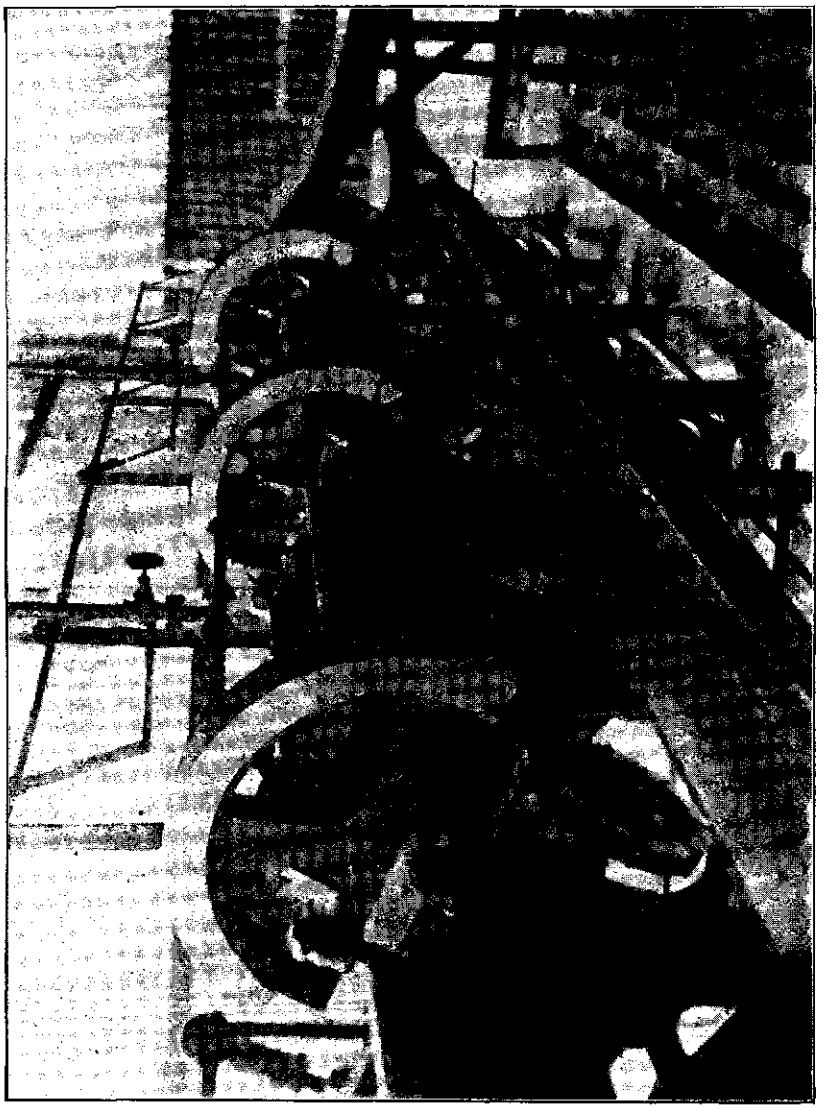
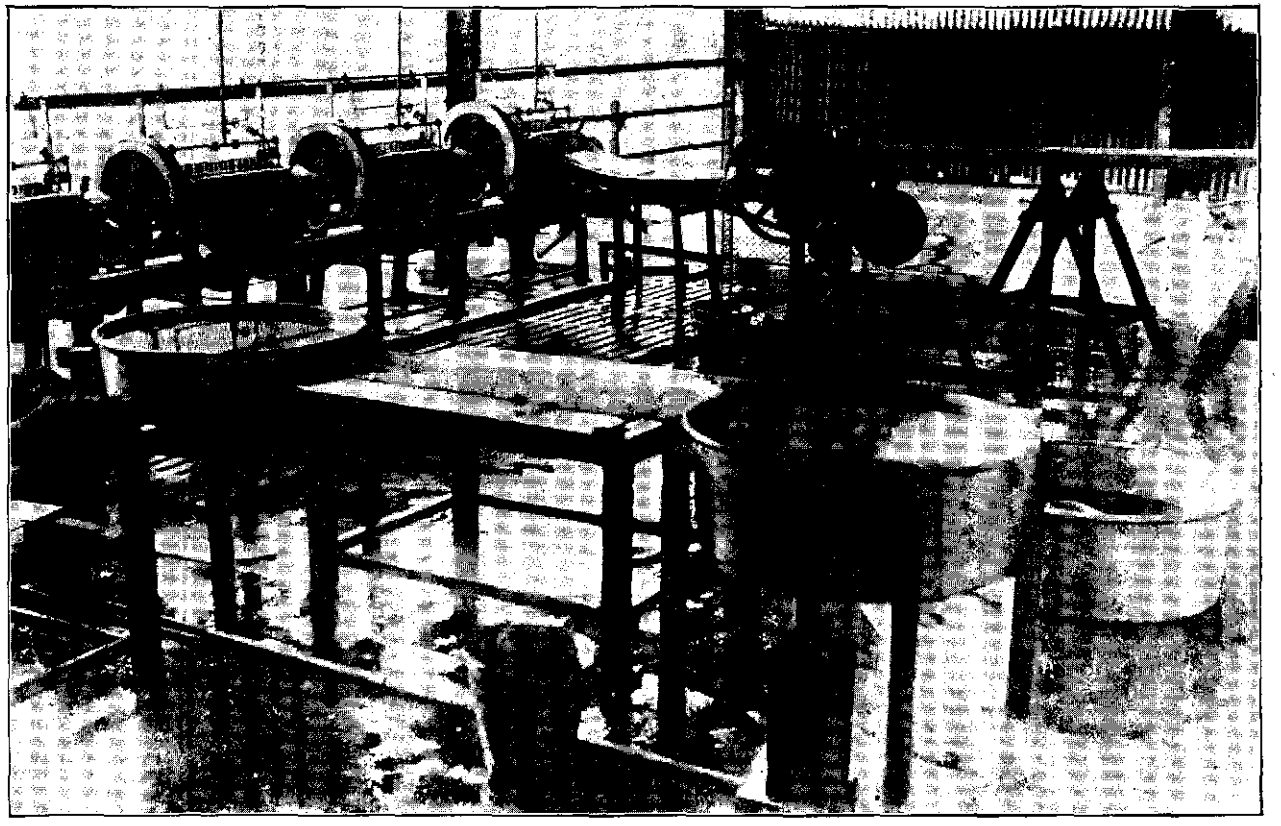
Special thanks are due to Lt. Commander A.P. Mackillingin for permission to publish the illustrations showing the sheeting machines and aluminium chutes installed in his factory.

We also wish to thank Mr. Gunnery of this Institute for taking the photographs used to illustrate this article.

PLATE I.



Sheeling Battery showing conveying trough in front of Machine.



Sheeting Battery showing chute for conveying coagulum to First Machine.

General view of Coagulating Tanks, Chute connecting Tanks to First Machine, and Sheeting Battery.
At the time when this photograph was taken the plant was handling 1,200 lbs. of dry rubber per hour.
Note the entire absence of accumulations of partially treated coagulum and unfinished sheet.