FACTORY ORGANISATION

F. J. WHITEHEAD

Factory organisation may be defined very simply as a means of using machinery and factory labour to obtain the best results in the minimum time and at the lowest cost.

The growth of tea is subject to the vicissitudes of weather and season, sometimes it grows quickly and sometimes very slowly. Consequently, a day's work in the same tea factory may be the manufacture of, say, 4,000 lbs. of green leaf or as much as 30,000 lbs.

Under certain conditions wet weather may mean heavy crops and wetter weather no crop at all. In dry hot weather natural withers

will tend to run away, and in cold damp misty weather withers will need assistance by artificial means. Control is necessary in both cases.

Consideration of the above well-known facts will indicate, I think, the need for, and the difficulties of, tea factory organisation.

Tea factories in Ceylon are not equipped to deal comfortably with the biggest day's crop of the year. It would not be economically sound to do this, yet the estate superintendent has to consider how he shall get through a day's work in a day, however big it is. His Company Directors may point out to him his year's estimate is 400,000 lbs. made tea, a tea roller is good for 80,000 lbs. per annum. He has 5 rollers, 2 roll-breakers, ample drying capacity and tat area and therefore there should be no difficulty in doing full justice to his crops. All very true, but the superintendent has to consider how he shall make the best use of his factory equipment in the busy season.

The superintendent will insist on leaf deliveries being up to time at the factory, he will object to leaf being stripped from the tats before it is withered, although the driers may have to wait empty for several hours in between batches, the working day lengthens out, the number of rolls may have to be reduced from 5 or 6 to 4 or even 3, with the result that tea driers may be overloaded and fermentations unduly prolonged. Leaf deliveries continue to arrive, spreading overtakes stripping in the lofts or leaf has to wait, and the 5 p.m. leaf *may* be spread by 9-30 p.m. Few superintendents can spend as much time as they would like each day in the factory attending to details of manufacture and in consequence have to trust to factory records.

These records have of late years grown tremendously in extent. They usually include, besides the leaf and made tea accounts, withering loft records, such as loft temperatures, hygrometer differences, air reversals and working hours of withering fans, rolling room records which include written up rolling programmes, dhool percentages, made tea to withered leaf ratios, fermenting periods, rolling room humidities and outside atmospheric temperatures. There are also firing records showing inlet and exhaust temperatures and fired tea moisture contents.

When such records become too voluminous they are difficult to check and, whilst I do not want to condemn factory records in any

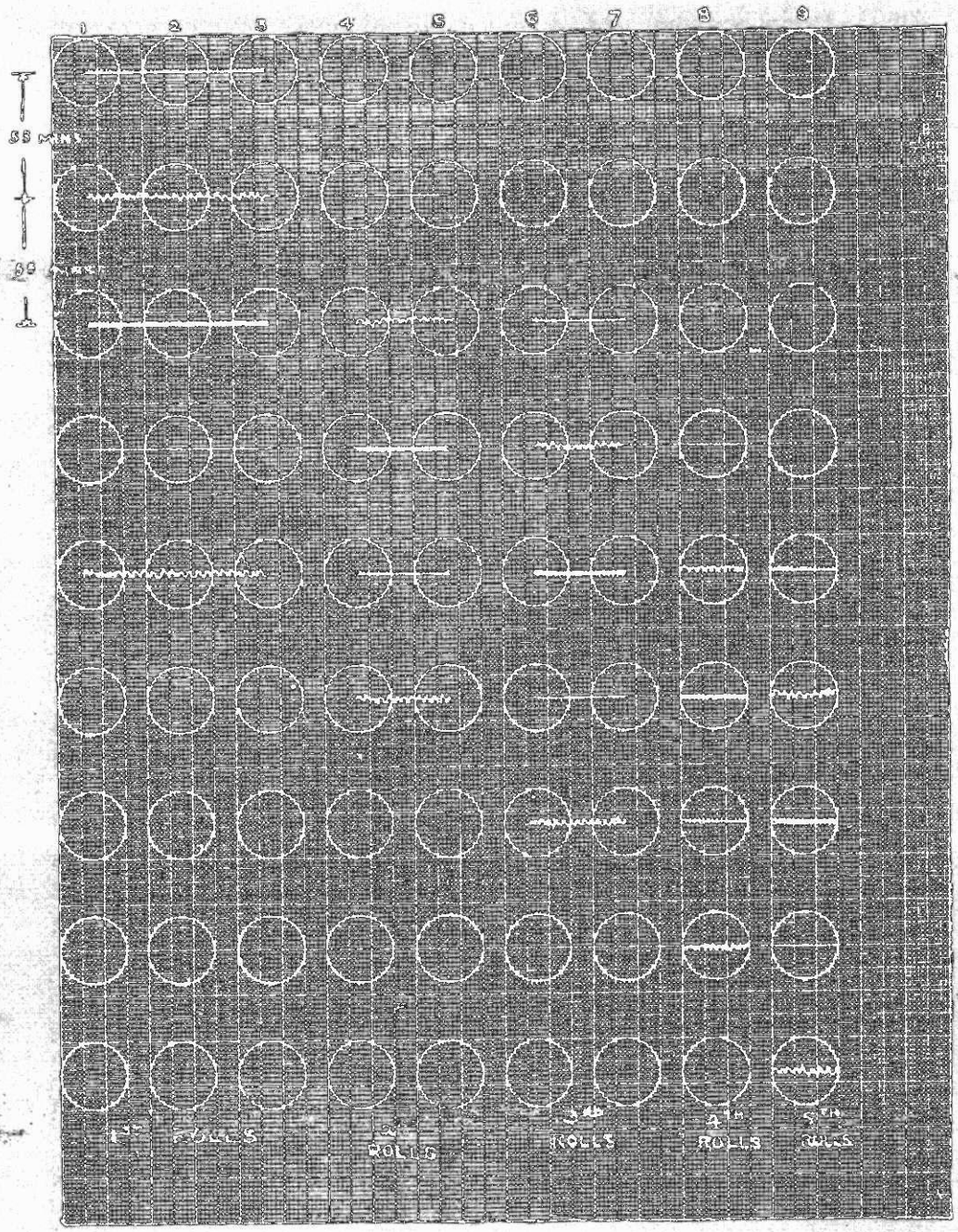


Fig. 1.—Rolling programme for 9 rollers, 5 rolls.

way I would stress the need for simplicity and accuracy. I would suggest the best way to simplify manufacturing records and thereby gain in accuracy is to organise manufacture in such a way as to make it easier for the superintendent to see at a glance if the various processes are according to programme when he pays his daily visit to the factory.

It would take far more time than there is at my disposal to discuss factory organisation in all the processes of tea-making, and so I propose to deal in detail with only a part of manufacture, namely rolling and drying. Now, if we begin by visualising a very small factory with one roller, one roll-breaker, and one drier, we should not have any difficulty in arriving at the best way of working this combination of machinery. We would soon learn that we could charge one roller with at most 350 lbs. of withered leaf and also that a 5th roll would be difficult if our dhool percentages were of the usual order, say, 10 per cent, 15 per cent, 22 per cent, 16 per cent and 15 per cent, giving us a charge of 125 lbs. for our 5th roll.

If our 5 rolls were each of 30 minutes' duration, charging the 1st roll of leaf took, say, 15 minutes, and emptying the roller, roll-breaking, and recharging the roller took 15 minutes, we should want a fresh charge of withered leaf every 3 hours 45 minutes. We should also know that if we wanted to keep our tea drier constantly fed with fermented leaf, the rate of feed to the drier would have to be 350 lbs. in 3 hours 45 minutes or say, 1.5 lbs. per minute.

In short, our rate of work would be 90 lbs. of withered leaf per hour or say, 160 lbs. of green leaf per hour.

If our drier required, say, 3 lbs. of wet leaf per minute to be kept constantly fed, it would need to run empty for half its time, and so we would ask for a second roller. Then we would find we could work these two rollers in two ways. We could do in both rollers exactly what we did in the one, or we could combine the leaf from both rollers at the 4th roll and use only one roller for our 4th and 5th rolls. The out-turn would be the same in either case, *i.e.*, just double what it was with 1 roller, but we should have fewer and bigger dhools to handle in the latter case. If our drier could not take as much leaf as 3.0 lbs. per minute, we should reduce the loading in the first roller charges to accommodate the drier.

By this time I have no doubt someone would like to tell me to get on to something more practical and less elementary.

Let us therefore assume we have nine rollers, and two 4-foot pressure driers. We know very well we should not assume that since one roller gave 1.5 lbs. rolled leaf per minute, and two rollers 3.0 lbs. per minute, that nine rollers would necessarily give 13.5 lbs. per minute.

Let us put down our 9 rollers and find out how we can work them to the best advantage. (See Fig. 1).

For a good many reasons we could not charge all nine rollers at once, but suppose we charge 3 of them with, say, 225 lbs. of withered leaf each. Our diagram tells us that provided we can combine at the second roll and also at the 4th, we can build up a rolling programme which will keep all the rollers busy as long as we have leaf to feed them. Also we see that no roller or rolling cooly has to do anything but the one operation. Rollers 1, 2, and 3 always do the 1st roll, 4 and 5 the second, and 6 and 7 the third, and so on. This should help us in obtaining regular dhool out-turn because our rolling coolies would get very expert at the one particular operation.

By keeping to this arrangement we could experiment to find out what is the best roller speed or type of batten and pressure application for each of our five rolls which would otherwise be very difficult. If we allow 25 minutes for charging the 3 first rolls, 30 minutes for rolling, and 15 minutes for roll-breaking and charging of subsequent rolls, we shall see we need withered leaf to be delivered to the rollers at the rate of 675 lbs. every 55 minutes. We also see that all second, third, fourth and fifth rolls will be spaced at 45-minute intervals.

The rate of feeding first rolls will later on become the rate of feeding fermented leaf to the driers, and as this works out at a little over 12 lbs. per minute, we know that our driers, which together have a capacity of 10 to 16 lbs. per minute, will not be overtaxed. If you will now turn to Diagram 1* you will be able to follow the processes of rolling, roll-breaking, green leaf sifting, fermentation, and firing. There you will see that after rolling has proceeded for 30 minutes, 2 minutes is allowed for emptying the roller and taking the leaf to the roll-breaker. Ten minutes is allowed for actual roll-breaking and it will be obvious that there is always a roll-breaker available for each and every roller charge of leaf throughout the day. Thus for 9 rollers we need 3 first roll-breakers, and extra machines for green leaf sifting or double roll-breaking.

* Diagram 1 is a double page plate facing page 86.

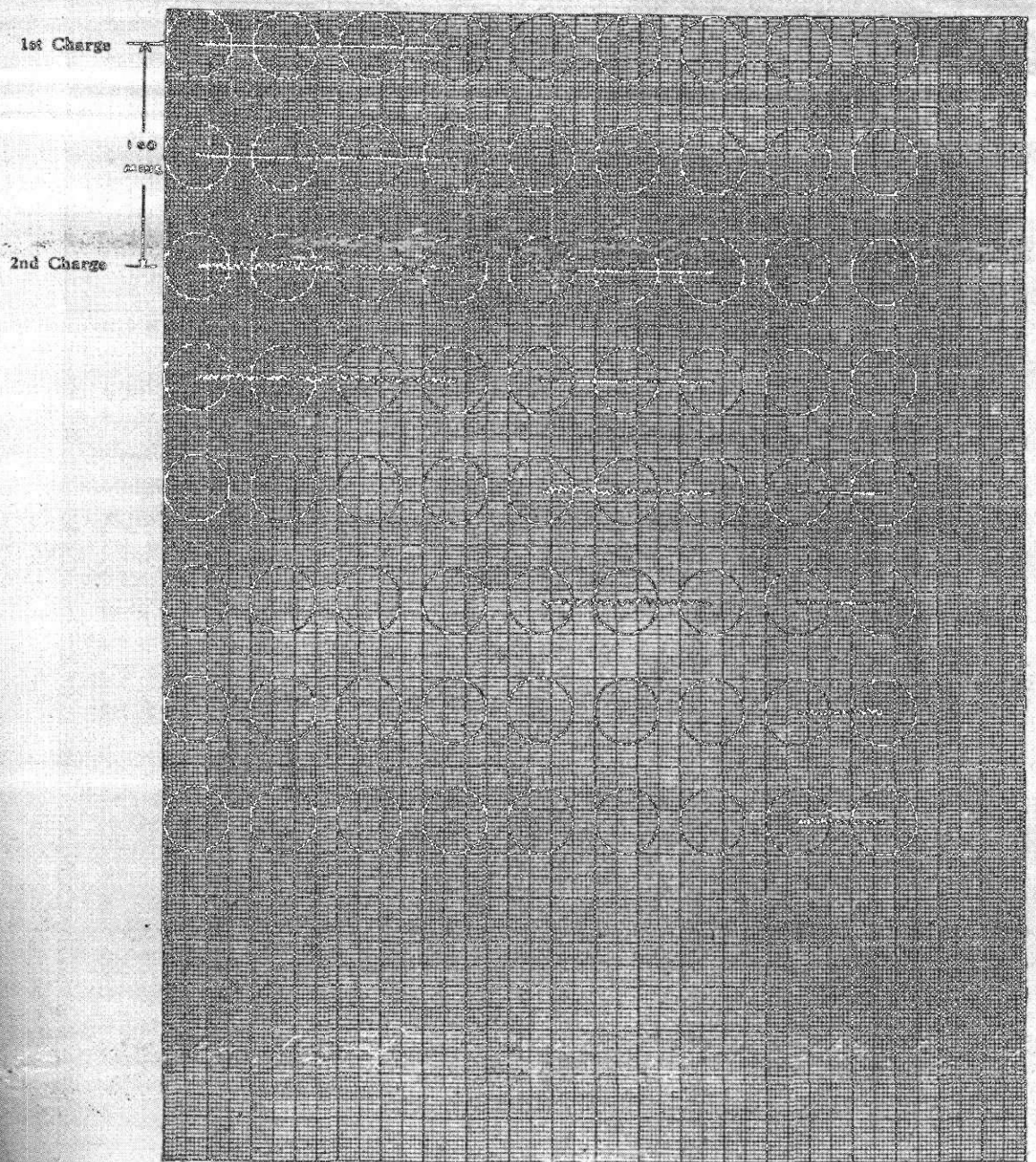


Fig. 2.—Rolling programme for 9 rollers, 6 rolls.

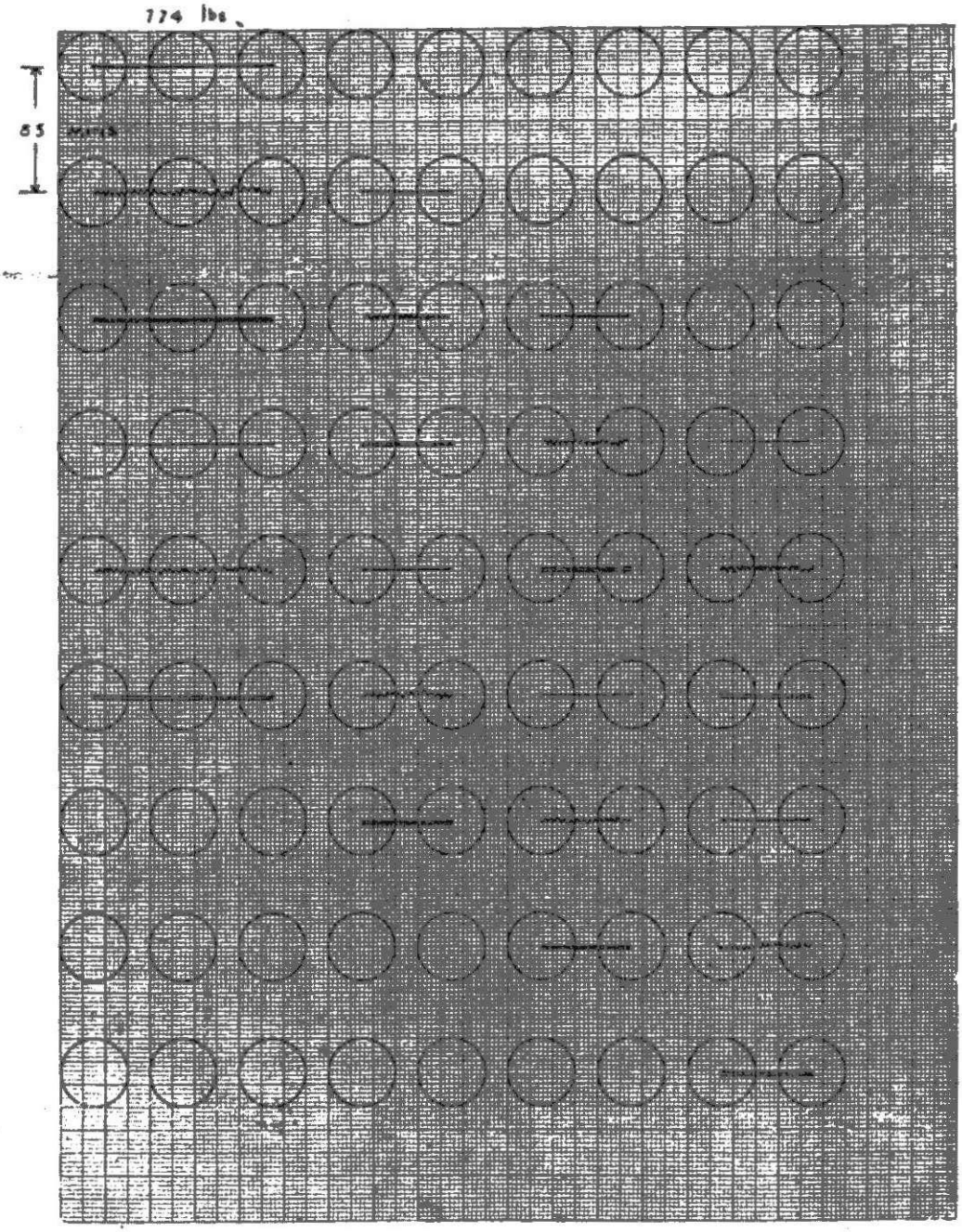


Fig. 3.—Rolling programme for 9 rollers, 4 rolls.

It may be objected that to charge 3 rollers simultaneously is not good practice, also that the state of the wither may not permit of a given weight of withered leaf (in this case 675 lbs.) being stripped regularly every 55 minutes. Regarding the first objection actual trial has proved that it is quite feasible; as to the second it must be admitted there may be some difficulty until there has been proper organisation in the lofts. It can, however, be maintained that once the problem of stripping a given weight of leaf in periods of equal time has been tackled, that is to say, that wither control has been studied and adjusted, the difficulty mentioned will begin to disappear. The rate of stripping tats depends upon the thickness of spreading, in other words a cooly can strip so many square feet of tat area per hour. If we assume the spreading to be 20 sq. feet per lb., we find by actual trial that at this rate of spreading, a cooly can gather 100 lbs. of withered leaf in 55 minutes. As therefore we need nearly 700 lbs. of leaf every 55 minutes, we must arrange for 7 stripping coolies in the lofts, more or less according to the weight of leaf spread on each *bank of tats*.

In the diagram, the vertical line in the centre is marked off to show the time from the commencement of rolling the first charge of 675 lbs. of leaf placed in three rollers.

The large square at the top left-hand corner shows that three rollers worked for 30 minutes. The squares at the bottom right-hand corner of this rolling square show the time taken for emptying the rollers, for roll-breaking, green leaf sifting, and recharging the rollers for the second roll. By counting down, we see the second roll was started 15 minutes after stopping the 1st roll, and that some leaf from the green leaf sifter was put into the rollers 2 minutes after the roll had started. The overlapping of the two squares denoting roll-breaking shows that two minutes after roll-breaking started the dhool was fed to the green leaf sifter, and that both these machines worked together. The big bulk would of course begin to be fed into the roller approximately two minutes after roll-breaking commenced, and thus 13 minutes are allowed for actual charging of all second and subsequent rolls. Any big bulk to be returned to the rollers from the green leaf sifter at the end of this operation would, of course, be very small in amount. Rolls 3, 4, and 5 can be followed in a similar manner, and in this programme it will be seen that all rolls after the first commence at intervals of

45 minutes, of which time 30 minutes are occupied in actual rolling. The weight of leaf, and the number of rolls employed, are marked in the rolling squares. The percentage weight of dhool is shown at the figures to the right of the diagram.

We can now turn to the second batch of leaf to be rolled, that is the second large square from the top at the left-hand side of the diagram. This square, it will be noticed, commences 25 minutes after the rollers in the first square were stopped, that is to say, the second batch is started 55 minutes after starting the first batch. This interval of time is maintained throughout the day.

It is interesting to notice the working of the roll-breakers. Their times of starting and stopping can be followed by reference to the time column. After each 1st roll, 3 roll-breakers would be used because there are 3 roller charges of leaf to be dealt with. After each 2nd roll where 2 rollers are used two roll-breakers would be needed, and so on.

If the roll-breaker times are followed along any horizontal line, it will be seen there is always 2 minutes allowed for cleaning. The same applies to the green leaf sifter, and in factories where these machines are not used, these squares of time can be allowed for double roll-breaking.

Now I think we ought to try to make things a little clearer by asking and answering a few questions:—

Question 1.—Why do we charge 3 rollers with only 675 lbs. of withered leaf ?

Answer.—Because this is about the largest quantity we can deal with if we are not to overload our 2nd and 4th rollers. If we had 10 rollers we could load up with more leaf and use 3 rollers for our 2nd roll, but, what about our fourth roll; we should want another roller still, making 11.

Question 2.—Why do we fix the time interval of 55 minutes for 1st roll charges ?

Answer.—Because we find this to be a convenient time allowing 25 minutes for emptying, cleaning, and charging, and 30 minutes for rolling. Secondly, because, if our charge is 675 lbs. or thereabouts, we shall be working within the capacity of our two driers, and thirdly, because

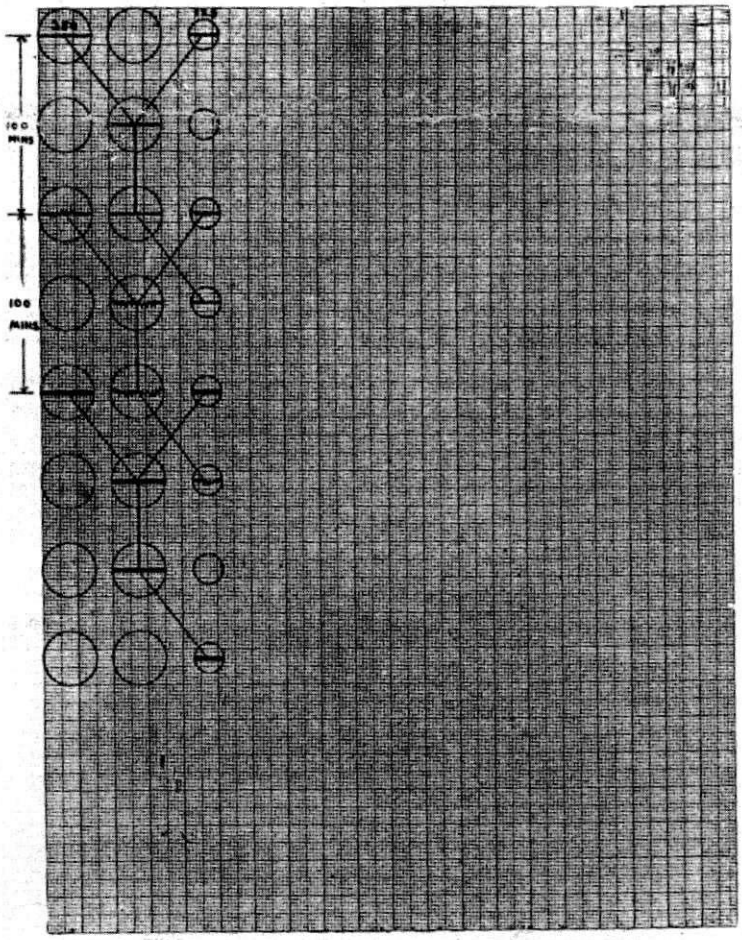


Fig. 4.—Rolling programme for 2 large and 1 small rollers, 4 rolls.

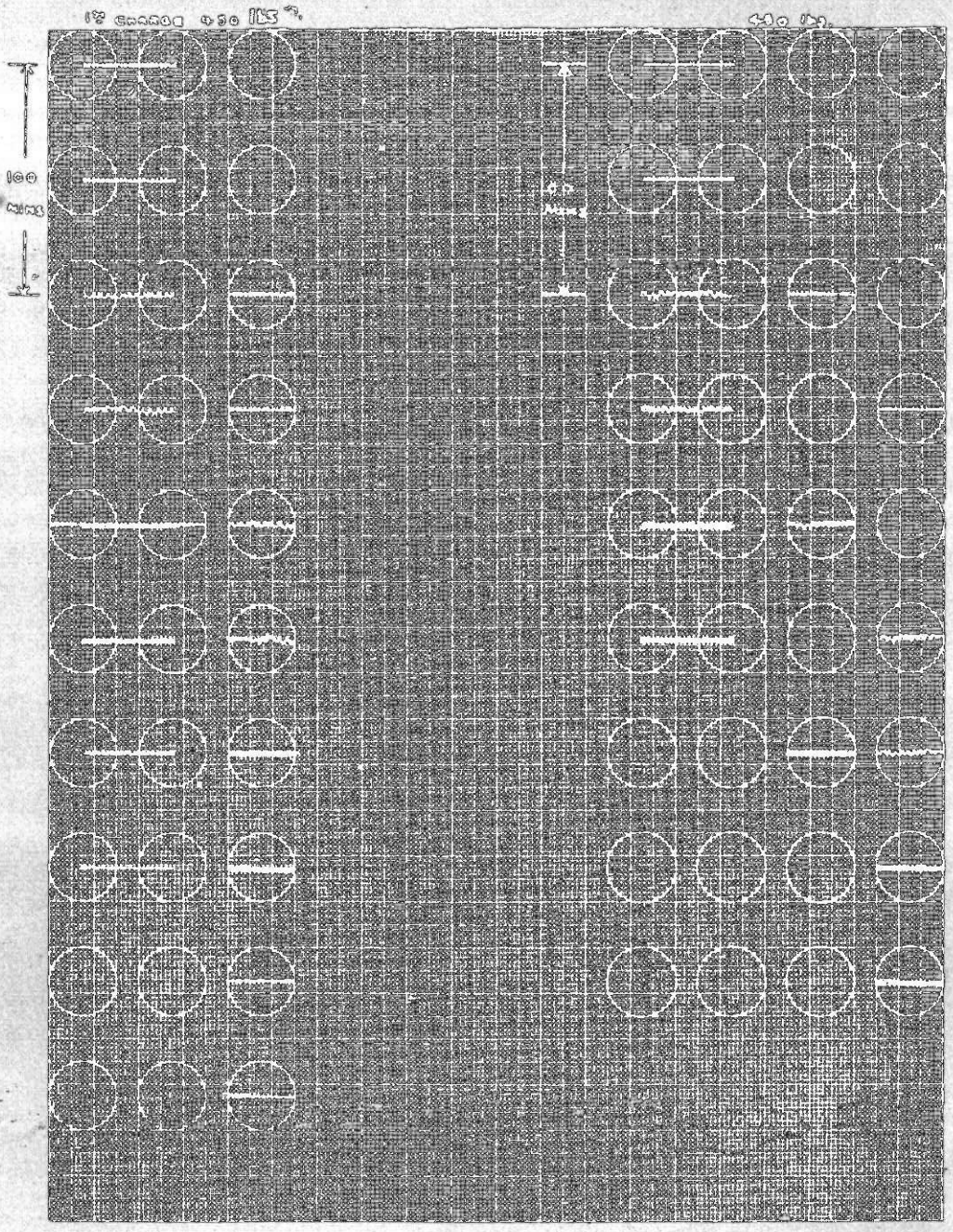


Fig. 5.—Rolling programmes for (left) 3 rollers, 4 rolls and (right) 4 rollers, 4 or 5 rolls.

we find this time interval will prevent any clashing of roll-breaker times, and so enable us to keep going without unexpected delays, although the time interval between any two rolls of the same batch is only 15 minutes. And lastly, because, if for any reason something has gone wrong in the lofts, and we cannot have our charge of withered leaf up to time, 55 minutes should be sufficient to get things right upstairs.

We consider it is far better when this happens to cancel one set, just as we would cancel a train, instead of altering the time and so upsetting the whole system by running a "special" and risking collision at all our roll-breaking stations. In our case the risk would amount to a certainty. Imagine, say, a 10 minutes' delay after the third set had been started off.

If every time a set has to be cancelled an enquiry is held regarding the delay upstairs, steps can be taken to remedy the faults and delays in withering. Similarly it will be found disastrous to shorten the time, and in this case fermentation will be lengthened if we overtake the rate at which the driers can cope with the fermented dhools.

Now to go back to our diagram and study dhools and fermentation.

In any rolling programme the total time taken in rolling a complete batch of leaf will govern the time of fermentation of the last roll. In the present case the big bulk will not be available until it has had 214 minutes' fermentation and the 5th dhool after 222 minutes. The previous dhools of this first batch would of course have been fired earlier, but it would not be possible for us to complete feeding to the drier the big bulk and the 5th dhool before four hours after commencing to roll. Since the whole of the leaf of the first batch can be fed to the driers in 55 minutes, we see that for constant feeding the time of commencing to fire the earlier dhools would be 185 minutes after commencing to roll. All subsequent batches could of course follow on at the same rate. From this we see our range of fermentation is from 3 hours 5 minutes to 4 hours, and whilst few superintendents will have any fault to find with the latter time, a minimum of 185 minutes for earlier dhools may not please everyone. We could, of course, fire the early dhools much sooner, but we are aiming at continuity at the driers. There is, however, a way of overcoming this difficulty, and

still keeping a methodical and regular order of firing. We can commence firing in one of the two driers at 144 minutes after commencing to roll, and if we fire all the first batch in one drier, the time taken will be roughly 110 minutes, which will give us a range from 144 minutes to 254 minutes or 2 hours 24 minutes to 4 hours 14 minutes and this, I think, will be found to suit those who consider the first range too late in starting and too limited in scope.

The order of firing dhools need not, of course, follow the order of dhool production; either number 3 or number 2 could be fired before number one, if found necessary. We can now summarise our rolling, fermenting, and firing records as follows, assuming work was started at, say, 7.00 a.m.:—

First	leaf fed to rollers	675 lb.	at	7.00 a.m.	finished	10.40 a.m.	
Second	,, ,, ,, ,,	675 ,,	,,	7.55 a.m.	,,	11.35 a.m.	
Third	,, ,, ,, ,,	675 ,,	,,	8.50 a.m.	,,	12.30 p.m.	
Fourth	,, ,, ,, ,,	675 ,,	,,	9.45 a.m.	,,	1.25 p.m.	
etc.							

				hrs.	mins.
First batch of leaf fed to drier					
No. 1	9.24 a.m.	Fermenting time	7.00 to 9.24 —	2	24
				4	14
Second batch of leaf fed to drier					
No. 2	10.17 a.m.	,,	,, 7.55 ,, 10.19 —	2	24
				4	14
Third batch of leaf fed to drier					
No. 1	11.12 a.m.	,,	,, 8.50 ,, 11.14 —	2	24
				4	14
Fourth batch of leaf fed to drier					
No. 2	12.07 a.m.	,,	,, 9.45 ,, 12.09 —	2	24
etc.				4	14

Assuming we started with 14,000 lbs. of green leaf, and this was withered down to 7,425 lbs. our working day would be 11 roller charges, each of 675 lbs. and the total rolling time would be 10×55 minutes $+ 3.40 = 12$ hours 50 minutes, or from 7 a.m. until 7-50 p.m.

Drying time would be from 9-24 a.m. until 8-45 p.m. This completes the analysis of Diagram 1.

It may now be asked what would happen if we wanted to adopt a 6-roll programme with the same equipment. In this case it would be impossible to adhere to the principle of keeping the same rollers for the same roll, and instead of charging our first rollers at 55-minute intervals, we should adopt an interval of 100 minutes. Since

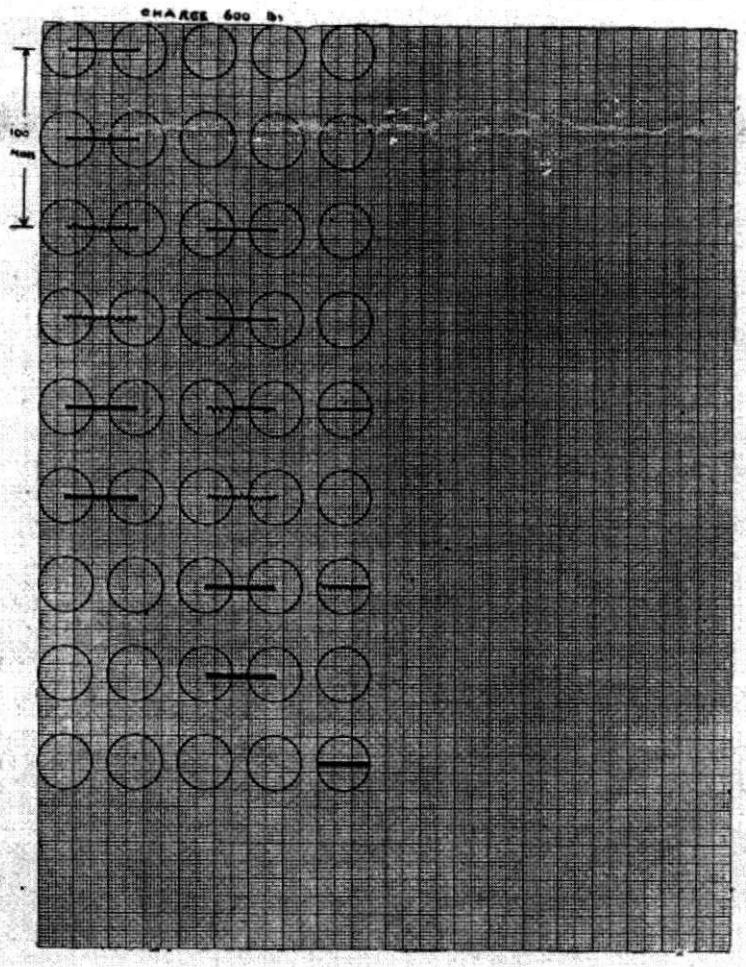


Fig. 6.—Rolling programme for 5 rollers, 6 rolls.

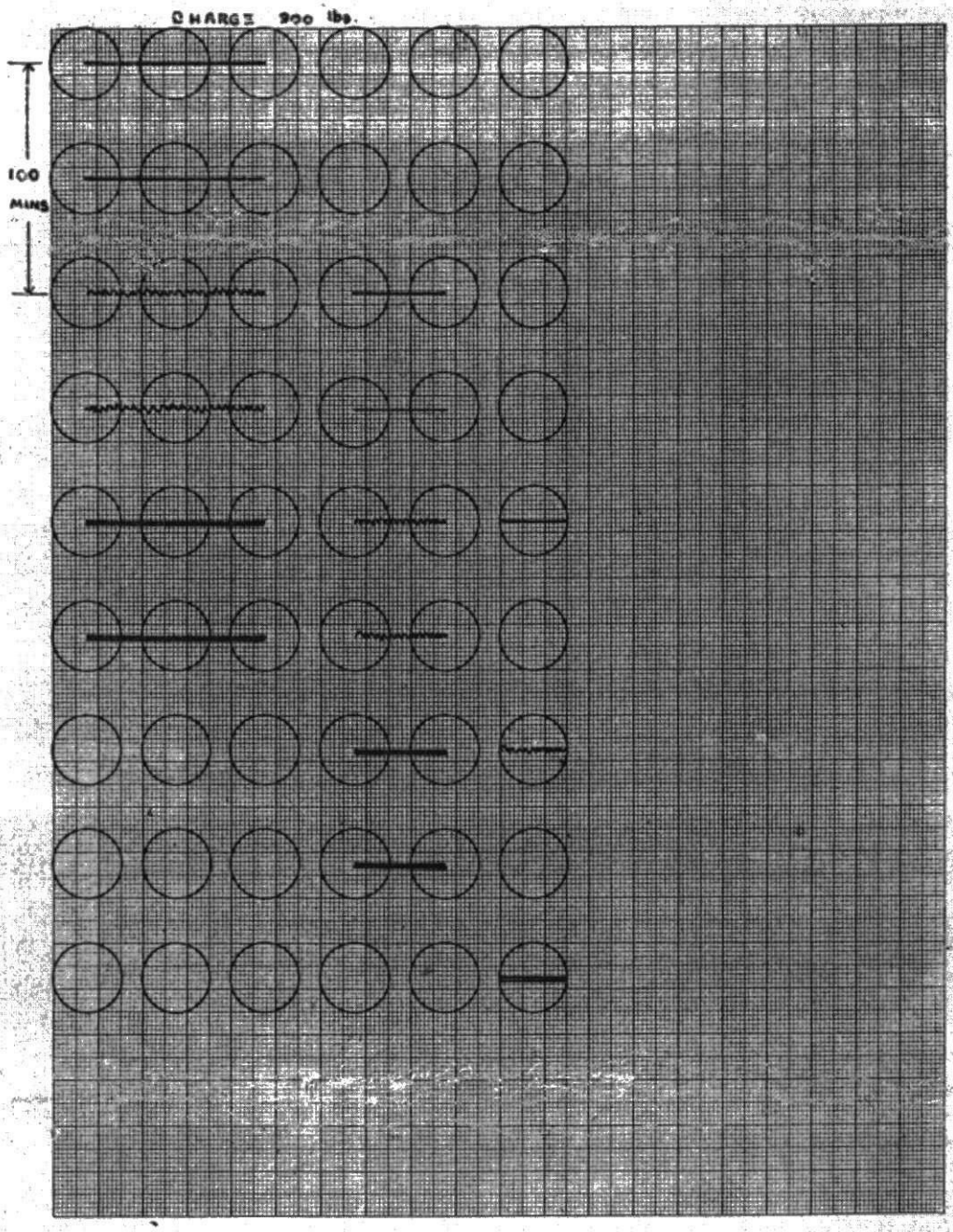


Fig. 7.—Rolling programme for 6 rollers, 5 or 6 rolls.

our interval is now 100 minutes, and our driers require 12 lbs. per minute to be at all economical, we should need to start our rolling with 1,200 lbs. of withered leaf, and this would require 4 rollers. Our rough diagram would be as shewn in Fig. 2.

It would also be an advantage to have four roll-breakers instead of three. The minimum fermenting period for the big bulk would now be 260 instead of 218 minutes, and firing times would be either from 182 minutes to 282 or from 104 to 304, according to whether we started drying in one or two driers, with of course the same range of minimum fermenting periods. The output from this programme would be approximately the same as in the previous one. It was, of course, fitted to the drier capacity.

A four-roll programme with the same equipment is shewn in Fig. 3.

Adopting a charge of, say, 774 lbs. in 3 rollers every 55 minutes, this loading would be as high as it would be safe to go to with the two driers specified. In this programme the fermenting times could be either from 110 to 220 minutes or from 150 to 205 minutes.

However interesting these programmes may be to those people who have large factories, they may convey very little except the principles they contain to the superintendents of small factories.

Take for instance a factory having 3 rollers and a 3-foot pressure drier. Most probably 2 of these rollers will be full-sized rollers, and one a small roller.

In this case the drier will need $3\frac{1}{2}$ to 4 lbs. per minute for constant working, and so one would consider a first charge of, say, 375 lbs. every 100 minutes, and this programme would be as in Fig. 4. For 3, 4, 5 or 6 rollers the rolling programmes could be as shown in Figs. 5, 6 and 7.

SUMMARY

The first consideration in drawing up any rolling programme should be to make the first charges, and their intervals, fit the capacity of the drying machines.

Adopt wherever possible a time interval of 55 minutes between first charges and 45 minutes between subsequent rolls to avoid clashing at the roll-breakers.

Have as many roll-breakers available as first rollers over and above second roll-breakers or green leaf sifters.

Where 55 minutes cannot be adopted because rollers have to be used for more than one particular roll, let the interval be 100 minutes.

When a fixed time programme has been adopted, keep to the times unless withered leaf cannot be gathered. In which case, keep to the times, but drop out one complete round.

When there are sufficient rollers, arrange for each roll to be done in the same rollers and by the same rolling coolies.

To save time adopt rapid clearing arrangements at all roll-breakers and green leaf sifters. This will also comply with hygienic rules.

A lot of extra rolling is got by returning the leaf to the rollers before the rolling periods commence.

And finally, put down your rolling programmes on squared paper. It is not easy to visualise what can or may happen in each of, say, 12 rollers in a rolling room.

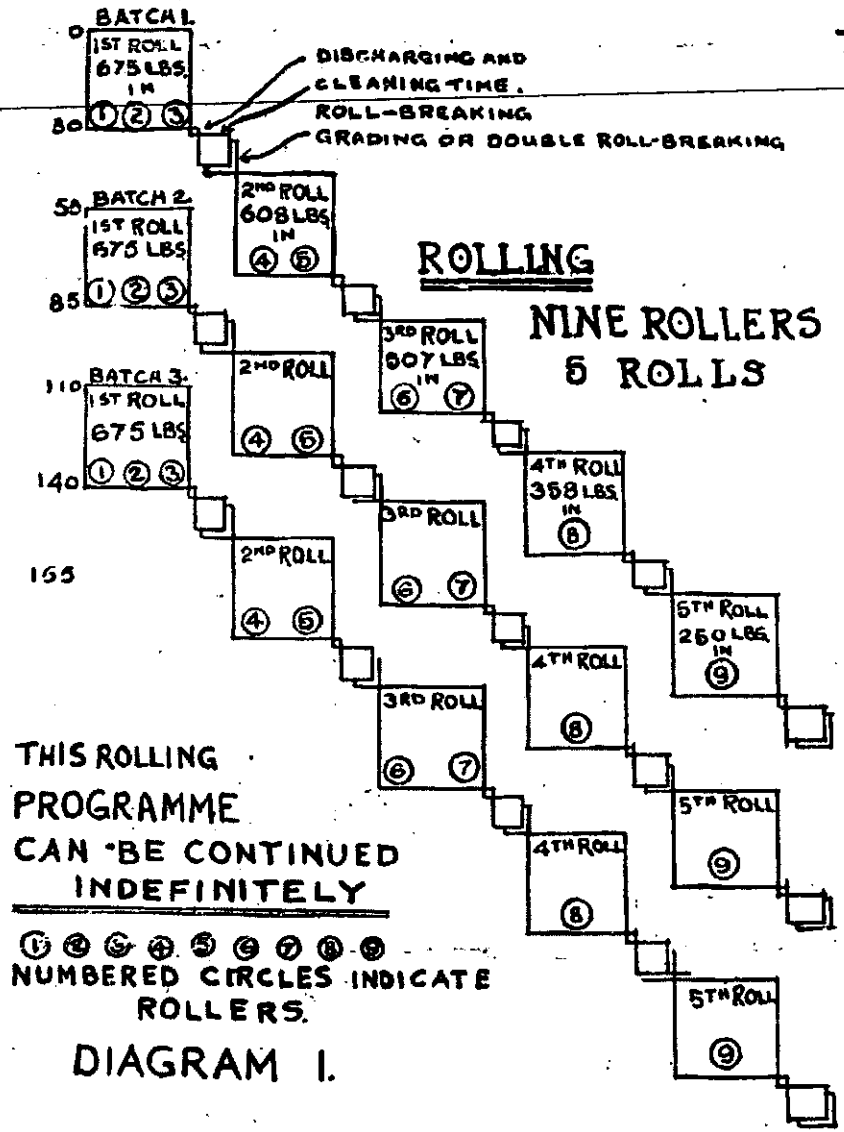
I would like to add, I claim very little originality for this paper. I am indebted to Mr. F. R. Francillon and Mr. C. R. Burnett for their very able assistance, and for making practical tests in their factory. The views I have expressed are also those of my Company, by whose permission I am allowed to speak to you to-day.

DISCUSSION

The Chairman said that he felt sure there would be several questions to be put to Mr. Whitehead in regard to his very interesting paper.

Mr. D. W. Finley said that he could see three principal difficulties in the way of adopting Mr. Whitehead's system of factory organisation. The first arose from the rate of wither which was a matter for an adequate system of fans. The second difficulty concerned the intelligence of factory assistants. It seemed to him that the Planters' Association or other appropriate body should take up that question. He suggested that it might be possible to recruit intelligent, well-educated junior assistants in the near future.

The third difficulty arose in connection with the factory labour. He asked if Mr. Whitehead advised the elimination of one complete batch of leaf in order to provide one hour off duty for each factory cooly that he might take his meals. It seemed to him that towards the end of the day, coolies might be expected to tire, so that the rate of collecting leaf would diminish. In a similar



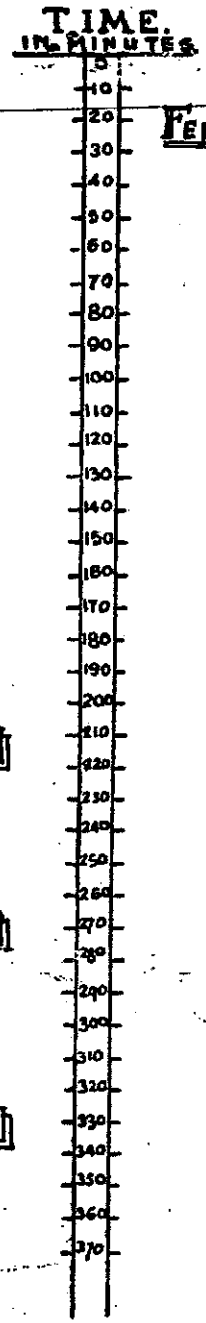
ROLLING

NINE ROLLERS
5 ROLLS

THIS ROLLING PROGRAMME CAN BE CONTINUED INDEFINITELY

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ NUMBERED CIRCLES INDICATE ROLLERS.

DIAGRAM I.

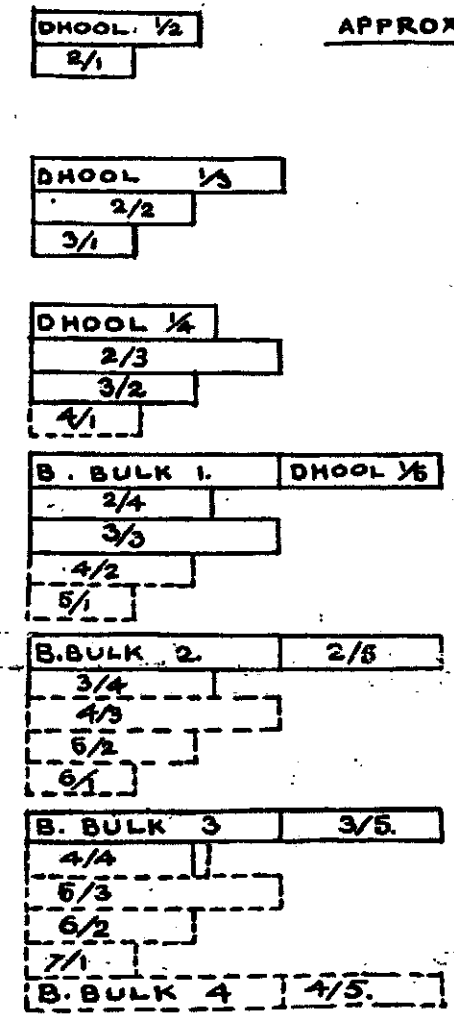


FERMENTATION.

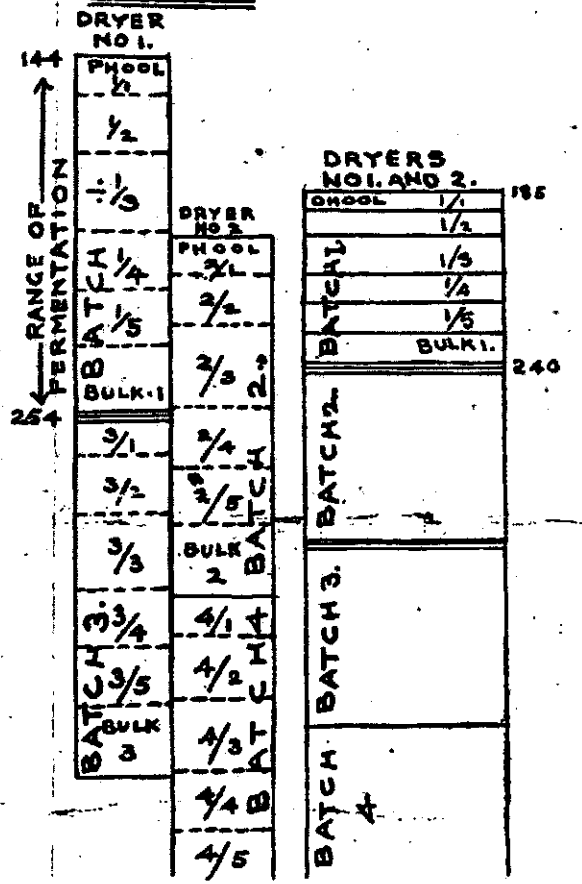
DHOOL X ⅟ INDICATES BATCH NO 1. DHOOL NO 1.
3/2 " " NO 3. " NO 2. Etc.

DHOOL PERCENTAGES

APPROX. 10% 15% 22% 16% 15%



FIRING



way, as in some factories the rate of fermentation varied during the day, did Mr. Whitehead advise diminishing the weights of the batches of leaf to cope with these two factors?

Mr. Whitehead in reply said that he would take Mr. Finley's last question first. If the fermentation in the early morning was, say, 30 per cent. longer than standard, then it would be advisable to reduce first roller charges by that amount. That would enable the drier to be worked methodically and keep pace with the more rapid fermentation occurring later in the day. The first batch would be then, say, 30 per cent. less than the standard — the next batch might be 20 per cent. less, and the next 10 per cent.

Regarding the work in the lofts he preferred to leave that matter to estate superintendents. He agreed that by omitting complete batches of leaf all factory coolies would be freed from duty to get their meal.

Mr. H. L. St. C. Carey said that one point about fermentation he would like to ask was, when a variation of 20 minutes or half-an-hour occurred, how was one to cope with it ?

Mr. Whitehead replied that since fermentation periods were determined by the teamaker's judgment he thought it just as likely that variations would occur in that judgment as in the actual fermentation. In any case, small variations were covered by the fact that the rate of feeding the drier had been fixed say, at 6 lbs. fermented leaf per minute, whereas the drier could take as much as 8 lbs. per minute. That surplus drying capacity gave quite sufficient latitude to deal with small variations of fermentation.

The Chairman in closing the Conference said that he felt sure they would all agree with him when he said that the papers they had listened to had been very instructive. Their appreciation was due to the officers of this Institute, as well as to Mr. Whitehead, for all the interesting information that they had given them. He further added that it had been a great source of pleasure to him to have seen there that day a record number of planters and friends from Colombo, as well as the visitors to the Institute who had come from abroad. Such an attendance he felt must afford encouragement to the research officers. Active co-operation between scientific officers and the planting community was more than ever necessary if the many difficulties ahead were to be dealt with as they must be.

He informed the Meeting that there would be many interesting things to be seen in the factory and laboratories the following morning. He hoped that as many as possible would attend again.