TECHNOLOGY OF COTTON MACHINERY

Part 1.—CALCULATIONS ON PICKERS

By A. A. Mercier

ABSTRACT

A study was made of the calculations on cotton pickers which may be applied to similar machines in the industry or to like machines used in experimental or research work. Methods are given for finding (a) the revolutions per minute of pulleys, rolls, and various moving parts; (b) the ratio between surface speeds of rolls; (c) the production resulting from the revolutions of the calender or delivery rolls and weight of lap; and (d) the amount of beating given the cotton. The speed of the beater is used as a basis or starting point when calculating the speed of rolls and fans.

The machines from which the diagrams were taken are of the ordinary commercial type and represent machines put out by two manufacturers of well-known cotton mill machinery. The calculations are put into the form of tables and charts, permitting the formation of "organizations" with ease and rapidity. The speeds are used in connection with production, the draft with regard to the weight of the lap, and the blows per inch are determined with regard to the amount of cleaning the cotton will receive. The settings of feed rolls and grids to the beater have not been considered in these calculations. The production of the pickers is tabulated for beater speeds from 500 to 1,500 revolutions per minute, when using feed pulleys from 5 to 15 inches in diameter and for laps weighing from 5 to 20 ounces per yard. Various drafts, draft constants, and blows per inch are also included in the calculations.

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I. INTRODUCTION

1. PURPOSE

In no phase of the textile industry do calculations play such an important part as in research or experimental work. This work requires that speeds, ratios of speeds, settings, performance of machines, quality of product, and the condition of the waste removed be noted more in detail than is done ordinarily in the industry, and the success of any experimental work depends largely on the exactness and ease of interpretation of the data.

These calculations are used to determine immediate changes in settings, speeds, and production of machines when changing from a short to a long staple cotton, or vice versa, and from one organization to another.

In planning experimental or research work to be conducted in the experimental cotton mill at the Bureau of Standards, it was found that for each machine the computation of the necessary data required considerable time. These data do not appear to be available in any convenient form either in textbooks or in machine catalogues from

which the adjustments of speeds or settings could be readily taken and applied. Consequently, such rules and methods applying to the parts of machines affected by changes in speeds or ratios of speeds have been prepared and put into form of tables and charts.

It is the purpose of this paper to present detailed methods for making the calculations generally used in making adjustments on cotton pickers, as well as other more unusual calculations. More details than are usually found are given. To cover the whole industry would require a large volume, so the calculations have been divided into parts, the first being on cotton pickers. The information given is not intended to be complete or to cover all makes of machines, but it can be used by those who make frequent changes in weight of product, amount of beating, or production, and can be applied in principle to any machine.

2. APPLICATION TO MACHINES

The parts of machines to be considered when using calculations are those moving parts, the speeds of which are subject to change to meet mill conditions or the requirements of the various experiments. These include the beaters, feed rolls, and fans on pickers, and the cylinders, spindles, and draft rolls on spinning frames. It is necessary to know (*a*) speed of moving parts used in calculations, (*b*) ratios of surface speed of rolls or cylinders (draft), (*c*) the weight of product obtained from the draft, (*d*) the length of time to operate a machine to deliver a certain amount of material, (*e*) number of machines to operate, (*f*) number of doffs, (*g*) yards in each doff of lap or bobbins, and (*h*) the number of laps or bobbins needed for each process.

3. LIMITS OF MACHINES

While the widest possible speed limits of a machine may be known or ascertained, ordinarily only those are used which will maintain high production with a good quality of work and keep the wear and tear of the machines at a minimum. Low speed does not permit a profitable production; excessive speed tends to wear unduly the gears, cylinders, etc., and may burst pulleys, break belts, and injure operatives. Likewise, with very wide settings, the fibers would not be brought under the action of certain parts, and a close setting would be apt to injure the fibers. These factors determine the desirable limits of the machines which have been ascertained by the manufacturers of machinery and which have been adopted in a general way by the industry. Speeds, settings, etc., are such that these limits are not exceeded.

4. ORGANIZATIONS

An organization consists of a record of settings, speeds, weight of product, and production from the raw cotton to the finished product. The performance of the machines, the condition of the product, or the waste that is removed would depend on the particular organization which was used in conducting the experiment.

In conducting various tests or experiments in the manufacture of yarns, the records of different settings, speeds, and performance of the machines furnish data from which organizations are formed.

With different types of cotton, the organizations of speeds and settings must be changed to meet any change in material. Long staple cotton requires different settings on pickers, cards, and frames, a different speed and less twist than short staple cotton. These changes are numerous even on one machine, and any one change in the speed, settings, etc., on a machine may affect the finished product as may be shown by the final tests.

Although it does not require much raw cotton to make yarn or fabric enough for final tests, it would require a larger amount to conduct any experiment on the first processes, such as on the pickers and cards; that is, only 5 to 30 pounds of cotton are necessary for one experiment on yarn; the amount required for an experiment on the picker would probably be 100 pounds or more. Thus, in experimenting on pickers, several yarn tests should be combined and the cotton should be run through the pickers and cards. Branching out into the several yarn organizations can be accomplished in later processes. To do this, the number of pounds and counts of yarn and the organization for each experiment must be known. These organizations can be combined at some machine, such as the drawing frame or card, making the sliver for all yarns the same in weight per yard.

5. METHODS OF FORMING ORGANIZATIONS

Charts or tables may be used to advantage in forming organizations and in combining and branching out for the various experiments. These may be used to obtain the necessary information, such as a range of speeds, drafts, twists, weights, and the production resulting from the combinations. The formulas used are taken from diagrams of the machines, using certain constants. Constants are used to shorten calculations and are obtained by computation of a train of gears and pulleys where change gears are used, omitting the change gear. Different constants may be calculated for the same machine, as will be shown in subsequent calculations.

As the main calculations on cotton machinery usually consist of speeds, draft, or ratios of surface speeds, production resulting from speed, and weight of product, these topics will be considered in this paper, which considers calculations on cotton pickers.

II. CALCULATIONS

1. GENERAL

(a) MACHINES TREATED

The calculations apply for two makes of pickers, one marked type A and the other type B. Each type consists of a breaker and a finisher picker. The machines are represented in Figures 1 to 4.

(b) BASIC EQUATIONS

1. **CONSTANT TRAIN GEARS.**—In all of the calculations on the pickers there are certain pulleys and gears which are not changed when the changes for various results are made. These pulleys and gears are grouped together into a constant train and this train used with the various change factors to obtain the desired results. The constant train differs on each machine due to the different number of teeth in the gears for each train, and the trains will be designated in the following equations by letter "*C*" with the subfigures "*C₁*," "*C₂*," etc.

2. **CHANGE FACTORS.**—The constant train of gears is used in connection with certain change factors, such as (a) pulleys of different diameters, (b) gears possessing a greater or smaller number of teeth, and (c) the position of the belt on the cones. The pulley size affects the speed of all moving parts, while the number of teeth in the gears used and the diameters on the cones affect the ratio of surface speeds. These factors are explained in the following paragraphs. The first of the change factors to be considered will be the pulley.

3. **PULLEYS.**—The diameter of the driving pulley multiplied by its revolutions per minute is equal to the diameter of the driven pulley multiplied by its revolutions per minute; that is,

$$D \times R = d \times r$$

When

D = diameter of driving pulley, *R* = r. p. m. of driving pulley.

d = diameter of driven pulley, *r* = r. p. m. of driven pulley.

The revolutions of the beaters and fans are found by using the above formula. To find the beater speed, the beater shaft is used as the driven shaft and the motor or the countershaft as the driving shaft. The fans are driven from the beater shaft, so the fan shaft is used as the driven shaft and the beater shaft as the driving shaft.

To simplify calculations when finding sizes of pulleys, a pulley chart is shown whereby combinations of pulleys can be determined easily when the two speeds required are known.

FIG 1.—Breaker picker, type A

FIG. 3.—Breaker picker, type B

FIG. 4.—Finisher picker, type B

The motor speed is 1,800 r. p. m., and a speed of 900 r. p. m. is desired for the beater. To find pulley sizes, place straightedge on 1,800 and 900. The point of intersection is then used as an axis and the straightedge turned to the pulley sizes. The revolutions per minute and pulley on each side of diagonal line are used together. Thus, $1,800 \times 6 = 900 \times 12$.

FIG. 5.—Pulley chart

For computing combinations of pulleys to give any required speed:

To find the combination of pulley sizes which will give a specified speed when the speed of one pulley is fixed. Place a straightedge on the horizontal scale points representing the two speeds. The point of intersection of the straightedge with the diagonal may be used as a center and the straightedge rotated on this center indicates on the vertical scales the required combination of pulley diameters.

4. ROLLS.—To find the speed or revolutions per minute of the rolls on pickers, it is necessary to take into consideration a train of gears and pulleys. It is found by multiplying the revolutions per minute of the beater by the product of the diameters of the driving pulleys by the product of the numbers of teeth in each driving gear and dividing this product by the product of the diameters of the driven pulleys by the product of the numbers of teeth in the driven gears. In the following equations, let

A = diameter of calender roll in inches

B = diameter of feed roll in inches

C = constant, obtained by computing the constant train of gears

D = diameter on cone in inches (fig. 2)

F = diameter of feed pulley in inches

G = draft change gear, number of teeth

N = r. p. m. beater

R = ratio on cones (fig. 4)

Y = yards for one revolution of calender roll (0.7854)

(a) *Calender rolls*.—The constant train of gears from the beater to the calender or delivery rolls in Figures 1 and 2 is the same, while the trains of gears for Figures 3 and 4 differ, in that the gears do not have the same number of teeth. The method for calculating the revolutions per minute of the calender rolls is the same for each machine, and is as follows:

$$N \times F \times C = \text{r. p. m. of calender rolls}$$

C_1 = constant pulley and gears from beater to calender rolls (figs. 1 and 2)

C_2 = constant pulley and gears from beater to calender rolls (fig. 3)

C_3 = constant pulley and gears from beater to calender rolls (fig. 4)

$$C_1 = \frac{14 \times 14 \times 18}{24'' \times 76 \times 73 \times 37} = 0.000716$$

$$C_2 = \frac{15 \times 17 \times 12}{18'' \times 35 \times 96 \times 53} = 0.0009546$$

$$C_3 = \frac{27 \times 18 \times 17 \times 12}{12'' \times 27 \times 60 \times 96 \times 53} = 0.001002$$

Example: Where

$$N = 1,000$$

$$F = 7 \text{ inches}$$

then

$$N \times F \times C_1 = 5.01 = \text{r. p. m. of calender rolls}$$

Figure 6 may be used to compute the revolutions per minute and yards per hour of the calender rolls for breaker and finisher pickers, types A and B.

Example (refer to fig. 6): If a beater speed of 1,000 revolutions per minute is being used and a feed pulley of 7 inches in diameter, to find the revolutions per minute of the calender rolls place straightedge on 1,000 (axis "A") and on 7 (axis "D"). The point of intersection

on axis "B" is then noted and the straightedge placed on this point and on point on axis "E," representing the machine used. The revolutions per minute of calender rolls for type A will be 5, for breaker picker type B will be 6.7, and for finisher picker type B will be 7.

(b) *Feed rolls.*—To find the revolutions per minute of the feed rolls, the method used is like that for finding the revolutions per minute of the calender rolls, or

FIG. 6.—Calender roll speed and production chart

For computing the revolutions per minute and yards per hour of the calender rolls for breaker and finisher pickers, types "A" and "B."

To find the revolutions per minute or yards per hour of the calender rolls, place a straightedge on the beater speed, axis "A," and on the diameter of the feed pulley, axis "D." The point where the straightedge intersects axis "B" is noted and the straightedge laid on this point and on the point, axis "E," representing the type of machine used. The revolutions per minute and yards per hour are read on axis "C" at the point where the straightedge intersects this axis.

$$N \times F \times C = \text{revolutions per minute feed rolls}$$

$$C_4 = \text{constant train from beater to feed rolls. (Refer to fig. 1.)}$$

$$C_5 = \text{constant train from beater to feed rolls. (Refer to fig. 3.)}$$

$$C_4 = \frac{14 \times 13 \times 26 \times 15 \times 19}{24'' \times 76 \times 36 \times 15 \times 26 \times 38} = 0.001386$$

$$C_5 = \frac{15 \times 17 \times 14 \times 24 \times 28 \times 37}{18'' \times 35 \times 96 \times 30 \times 24 \times 28 \times 33} = 0.002206$$

Referring to Figures 2 and 4 (finisher pickers), in addition to the change of beater speed and diameter of feed pulley two other change factors are included in the calculations, namely, the draft change gear and the position of the belt on the cones, and to obtain the revolutions per minute of the feed rolls on these machines the formula is

For Figure 2, $N \times F \times C_6 \times \frac{G}{D}$ = revolutions per minute of feed rolls

$$C_6 \times \frac{G}{D} = \frac{G \times 40 \times 10'' \times 1 \times 20 \times 16}{24'' \times 30 \times 54 \times D \times 85 \times 28 \times 15} = 0.0000922 \frac{G}{D}$$

For Figure 4, $N \times F \times C_7 \times \frac{G}{G'} \times R$ = r. p. m. of feed rolls

$$C_7 \times \frac{G}{G'} R = \frac{G \times R \times 9 \times 2 \times 12}{12'' \times G' \times 9 \times 78 \times 24} = 0.001068 \frac{G}{G'} R$$

The D , G' , and R are put in both sides of the equation to show where they occur in the train.

Example (refer to fig. 2): Where

$$N = 1,000$$

$$F = 7 \text{ inches}$$

$$G = 28 \text{ teeth}$$

$$D = 3.5 \text{ inches}$$

then

$$N \times F \times C_6 \times \frac{G}{D} = 5.16 = \text{r. p. m. of feed rolls}$$

Example (refer to fig. 4): Where

$$G = 50 \text{ teeth}$$

$$G' = 40 \text{ teeth}$$

$$R = 1 : 1.6$$

then

$$N \times F \times C_7 \times \frac{G}{G'} \times R = 5.84 = \text{r. p. m. of feed rolls}$$

The change factors for draft gear and diameter on cones are used with regard to the weight per yard of product or lap and affect the ratio between the feed rolls and the calender or delivery rolls, while a change in the size of the feed pulley affects the speed of the moving parts of the pickers with the exception of the beater and fans. The above changes will affect the ratio between these parts and the blows struck by the beater blades and, therefore, the amount of beating the cotton receives.

2. DRAFT

(a) DEFINITION OF TERMS

In every mill organization it is most important that the weight of the product per unit of length from each machine be kept uniform in order to obtain the best results. Keeping the weight uniform is usually accomplished by doubling at the back of a machine and by drawing or attenuating. The doubling of several ends or laps at the back of the machines tends to overcome the defects of any one of the strands or of the laps, because the laps or strands containing the thick and thin places are combined with other laps or other strands of normal size or weight, so that when they are drawn out an even product results.

The drawing out process, or attenuating, necessary to reduce the product to the desired size or degree of fineness is called drafting. This attenuation may be done by means of air currents where the fibers are carried along by currents of air and deposited on rotating screens, such as are found on the picker. These carry away the cotton at a higher speed than they receive it. It may be done by rotating cylinders and rolls, as on cards, or it may be done by rolls which have a different surface speed between the feed and delivery.

Draft may be expressed (a) as the ratio between the surface speed of the front or delivery roll and the surface speed of the back or feed roll, (b) the ratio between the weight per yard of material fed and delivered in a given time, or (c) the ratio between the length delivered and the length fed in a given time. Draft may thus be expressed in different ways, but each gives the same result.

On the breaker picker there is but a slight draft or ratio between the feed and delivery, while on the intermediate and finisher pickers there is usually a doubling of four laps and a draft of four, more or less, depending on the weight of lap desired at the calender rolls.

(b) RULES FOR FINDING DRAFT

A few rules for finding draft are given.

1. Divide the weight of 1 yard of cotton fed by the weight of 1 yard delivered. Example: If four doublings of cotton lap on the apron weigh 16 ounces per yard each and 1 yard delivered weighs 14 ounces, the draft is

$$\frac{4 \times 16}{14} = 4.57 \text{ draft}$$

2. Divide the number of yards delivered in a certain time by the number fed during the same time. Example: If 4 yards of cotton are fed into a machine and 18 yards delivered in the same time, the draft would be

$$18 \div 4 = 4.5 \text{ draft}$$

To find the draft between two pairs of rolls which are connected by a train of gears, multiply the number of teeth in all the driven gears by the diameter of the front roll and divide this product by the product of the number of teeth in the driving gears and the diameter of the back roll. Always consider the gear on the front or delivery roll to be a driver and express the diameter of the delivery and feed rolls in the same terms, such as "inches," "eighths," etc.

(c) FORMULAS AND EXAMPLES OF DRAFT CALCULATIONS

The draft on the breaker picker remains constant, and when a heavier or lighter lap is desired adjustments are made so that more or less cotton is fed to the machine. The draft is usually less than 2. The constant train is as follows:

C_8 = constant train of gears between the calender or delivery rolls and the feed rolls (fig. 1)

C_9 = constant train of gears between the calender or delivery rolls and the feed rolls (fig. 3)

$$C_8 = \frac{A}{B} = \frac{9'' \times 18 \times 14 \times 36 \times 15 \times 26 \times 38}{2.5'' \times 37 \times 73 \times 13 \times 26 \times 15 \times 19} = 1.86 = \text{draft}$$

$$C_9 = \frac{A}{B} = \frac{9'' \times 12 \times 30 \times 24 \times 28 \times 33}{2'' \times 53 \times 14 \times 24 \times 28 \times 37} = 1.95 = \text{draft}$$

On the finisher picker there are two change factors mentioned in the feed-roll calculations—the draft change gear and the position of the belt on the cones. Either will affect the ratio between the surface speeds of the feed and delivery rolls. The changes made are usually with the draft change gear with the belt at the center of the cones.

Finisher picker (fig. 2). C_{10} = constant for gears and pulleys between the calender and feed rolls.

Finisher picker (fig. 4). C_{11} = constant for gears and pulleys between the calender and feed rolls.

$$C_{10} \times \frac{D}{G} = \frac{A}{B} = \frac{9'' \times 18 \times 14 \times 14 \times 30 \times 54 \times D \times 85 \times 28 \times 15}{2.5'' \times 37 \times 73 \times 76 \times G \times 40 \times 10'' \times 1 \times 20 \times 16} = 27.955 \frac{D}{G}$$

The D and G are put in both sides of the equation to show where they occur in the train.

$$C_{10} \times \frac{D}{G} = \text{draft}$$

where

$$D = 3.5 \text{ inches}$$

$$G = 28 \text{ teeth}$$

then

$$C_{10} \times \frac{D}{G} = 3.51 = \text{draft}$$

$$C_{11} \times \frac{G'}{G} \times R = \text{draft}$$

$$C_{11} \times \frac{G'}{G} R = \frac{A}{B} = \frac{9'' \times 12 \times 17 \times 18 \times 27 \times G' \times R \times 9 \times 78 \times 24}{3'' \times 53 \times 96 \times 60 \times 27 \times G \times 9 \times 2 \times 12} = 2.8146 \frac{G'}{G} R$$

The G' , G , and R are placed on both sides of the equation to show where they occur in the train.

Where

$$G' = 40 \text{ teeth}$$

$$G = 50 \text{ teeth}$$

$$R = 1.6:1$$

then

$$C_{11} \times \frac{G'}{G} \times R = 3.602 = \text{draft}$$

Draft constants are used to shorten the method of finding the draft or the draft change gear. The draft is obtained by dividing the draft constant by the number of teeth in the draft change gear, and the draft change gear is found by dividing the draft constant by the draft. Referring to the preceding formula for the finisher picker (fig. 2), the draft constants will be found by multiplying the constant train (C_{10}) by the diameter on the cone ($C_{10} \times D$).

$$C_{10} = 27.955$$

$$D = 2.5 \text{ to } 5$$

Referring to Figure 4, there will be found the same variables as in Figure 2—the draft change gears and the position of the belt on the cones. There are two cones used, each having a curved taper, so that calculations for draft constant include the two cones instead of one. With the belt at the center of the cones, the draft constant is

$$C_{11} \times R \text{ or } 2.8146 \times \frac{1}{1} = 2.8146$$

With the ratio of 1.6 : 1, the draft constant is

$$C_{11} \times \frac{1.6}{1} = 4.503 = \text{draft constant}$$

(d) "EVERER" MOTION

When variations occur in the thickness of cotton fed to the "everer" and feed rolls, the revolutions of the rolls are increased or decreased to meet this change by the action of the "everer" motion,

FIG. 7.—Draft chart

For computing the draft, draft gear, and weight of lap resulting from draft when using various draft constants or positions on the cone.

To find the draft, place a straightedge on the point representing the draft constant, axis "C" and on the point representing the draft gear, axis "A." The draft is found at the point where the straightedge intersects axis "B." The draft may also be found by placing the straightedge on the point representing the weight of lap on the apron, axis "D," and on the point representing the weight of lap desired at the calender rolls, axis "E." The draft will be read on axis "B."

The weight of lap at the calender rolls is found by placing the straightedge the draft, axis "B" and on the weight of laps on the apron, axis "E." The point of intersection on axis "D" will give the weight of one yard of lap at the calender rolls.

which retards the feed when thick places occur and accelerates the feed when thin places occur. The cotton passes under sectional plates to the feed rolls, and a thick place causes these plates to rise and by levers the belt is shifted on the cones to retard the feed. A new position on the cones gives a new draft constant. The new draft constant with the same draft gear gives a different draft, which offsets the difference in the weight of cotton fed.

(e) USE OF DRAFT CHARTS AND TABLES

The draft chart (fig. 7) has been calculated using gears in Figure 2, as shown in the calculation of C_{10} . The draft, draft gear, and draft constant may be found when combining four laps of a given weight per yard on the apron and producing another weight lap at the calender rolls. Several draft constants are used, although those constants obtained when the belt is at the center of the cones are most desirable.

Example (refer to fig. 7): If it is intended to use a constant of 112, or 4-inch diameter, on the cone, and a 25-tooth draft gear, the draft is found by placing a straightedge on these two points or a draft of slightly less than 4.5. If four 14-ounce laps are used on the apron, the weight delivered at the calender rolls would be found by placing the straightedge on 56 (axis "E") and on 4.5 (axis "B"), and the weight of finished lap would be 12.5 ounces.

Ordinarily, one tooth is added to allow for waste or droppings. A finer adjustment is made by shifting the cone belt slightly by means of the adjusting screw or wheel.

Similar charts may be used for pickers of designs differing from those used in these calculations where the train of gears may differ somewhat but performs the same operation.

TABLE 1.—Draft table for finisher picker type B. (See fig. 4)

CONSTANT 2.814 (BELT AT CENTER OF CONE)

Bottom cone change gear	Cross shaft change gear	Draft	Bottom cone change gear	Cross shaft change gear	Draft
55	35	4.42	44	46	2.69
54	36	4.22	43	47	2.58
53	37	4.03	42	48	2.46
52	38	3.85	41	49	2.36
51	39	3.68	40	50	2.25
50	40	3.52	39	51	2.15
49	41	3.36	38	52	2.06
48	42	3.22	37	53	1.97
47	43	3.08	36	54	1.88
46	44	2.94	35	55	1.79
45	45	2.81			

CONSTANT 4.503; RATIO ON CONE $\frac{1.6}{1}$

55	35	7.08	44	46	4.31
54	36	6.75	43	47	4.12
53	37	6.45	42	48	3.94
52	38	6.16	41	49	3.77
51	39	5.89	40	50	3.60
50	40	5.63	39	51	3.44
49	41	5.38	38	52	3.29
48	42	5.15	37	53	3.14
47	43	4.92	36	54	3.00
46	44	4.71	35	55	2.86
45	45	4.50			

In Table 1 there are two draft gears used together instead of one. The two gears have a total number of teeth equal to 90. Two positions on the cones are used in this table, one at the center of the cones and the other where the ratio of diameters is 1.6 to 1. The table shows the drafts obtained when using combinations of 55 teeth and 35 teeth to 35 teeth and 55 teeth.

3. PRODUCTION

(a) DEFINITIONS

The calculations concerning production are probably the most used of any in the industry. They include the speed calculations, draft calculations, and the weight of the product. By regulating production the mill organization is kept balanced. An increase in production of any machine is apt to cause an accumulation of a certain product, while, on the other hand, a decrease in production of some machines would cause idle machines in later processes.

The production of the picker is determined by the speed of the calender rolls and the weight of laps being made. The speed of the calender rolls is controlled by the speed of the beater and the size of the feed pulley, and the weight per unit of length of the product is controlled by the draft.

The production may be increased or decreased by changing the speed of the beater, which affects all the various moving parts, or by changing the feed pulley (the speed of the beater remaining the same), or by changing the weight of the lap.

The speed of the beater is usually changed by changing the driven pulley on the beater shaft. The fans are driven from the beater, and any change in the speed of the beater changes the speed of the fans unless the fan-driving pulleys on the beater shaft are changed also. Supposing that the weight of the lap is to remain the same, the increase or decrease in production would then be caused by a change in the beater speed or by changing the feed pulley.

(b) FORMULAS AND EXAMPLES

To find the yards per minute delivered by the calender rolls, the following example is given:

$$C \times N \times F \times Y = \text{r. p. m. calender roll} \times Y$$

Where ¹

$$\begin{aligned} C_1 &= 0.000716 \\ C_2 &= 0.0009546 \\ C_3 &= 0.001002 \\ N &= 1,000 \\ F &= 7 \\ Y &= 0.7854 \end{aligned}$$

then

$$C_1 \times N \times F \times Y = 3.936 \text{ yards (figs. 1 and 2)}$$

¹ See page 193.

The yards per hour are found by multiplying the yards per minute by 60. The calculations for yards per minute are useful when a small amount of cotton is to be put through the pickers or when the performance of these machines is not to be considered in the experiments. The above constant for the train of gears was obtained in the paragraph under speed calculations.

(c) USE OF PRODUCTION CHART

The production in yards per hour is found in Figure 6 and in the same manner as that for finding the revolutions per minute of calender rolls. The yards per hour found on the right-hand side of axis "C." The calculations in this chart makes no allowance for time lost when cleaning, oiling, or removing laps. The per cent loss allowed may differ somewhat according to the material used, skill of operators, and mill practice. This allowance may be deducted from the total production using whatever per cent may be found to be most nearly accurate.

Example (refer to fig. 6): Using a beater speed of 1,000 r. p. m. and a 7-inch feed pulley, to find the production in yards per hour place straightedge on 1,000 (axis "A") and on 7 (axis "D"). On axis "B" the intersection is noted, and from this point the straightedge is laid to the type of machine used and the yards per hour read on axis "C," which for type A is about 236 yards.

Figure 8 shows the weight in pounds of from 5 to 20 ounce laps of lengths from 1 to 10,000 yards. This chart may be used in connection with the production chart showing the yards per hour. After the number of yards has been determined the weight of the total may be found by use of this chart.

Example: If 3,000 pounds of cotton are to be used in making a 12-ounce lap, the number of yards would be found, as follows. Trace up from the bottom along vertical line 3, 30, 300, or 3,000 to the intersection of diagonal line 12 ounces and read at the left of the chart in yards along the horizontal line, which would be 4, 40, 400, or 4,000. As the 3,000 was in the fourth group, the reading would be 4,000 yards.

If 3,500 pounds of cotton were to be used, the number of yards for 3,000 first would be found and then for the 500 yards. By following the diagonal line to the point of intersection for the line 5, 50, or 500 the reading at the left would be about 670 yards, then there would be 4,670 yards in 3,500 pounds of cotton making a 12-ounce lap. No allowance has been made for the waste removed. This may be deducted from the total to obtain the net amount.

(d) LAP-MEASURING MOTION

In order to get as nearly as possible the same weight of full laps and the same number of yards per lap, a measuring motion or knock-off device is attached, so that when a lap has a certain number of yards all parts of the picker except the beater and fans, or all but the beater, fans, and fluted lap rolls, stop automatically. The knock-off gear makes one revolution for each lap wound, each

FIG. 8.—Chart showing length against weight of laps

For computing the weight of cotton laps weighing from 5 to 20 ounces per linear yard and containing from 1 to 10,000 yards.

To find the weight of a certain number of yards of cotton lap, trace the diagonal line representing the weight of 1 yard of lap to the intersection of the horizontal line which represents the number of yards. From this point of intersection, trace the vertical line to the bottom of the chart.

knock-off change gear representing a definite number of yards. A change in the number of teeth in the knock-off change gear gives a different number of yards in the lap.

Referring to Figures 1 and 2, the knock-off gear determines the number of yards as measured on the 9-inch lap, or calender roll. At each revolution of this gear all the parts of the picker stop except the beater, fans, and fluted lap rolls. As the fluted calender rolls keep revolving the lap breaks off at the smooth calender rolls, and thus causes the termination of a full lap containing a definite number of yards.

The formula for calculating the knock-off gear for full lap is determined as follows:

$$\frac{\text{Change gear}}{18} \times \frac{35}{1} \times \frac{80}{13} \times \frac{14}{73} \times \frac{18}{37} \times \frac{9 \times 3.1416}{36} = 0.8768$$

Constant for yards per lap = 0.8768

Constant $\times$ number of teeth in change gear = yards per lap

Yards per lap $\div$ constant = number of teeth in change gear

One tooth in change gear = 0.8768 yards.

The formula may also be expressed in similar terms as

$$\frac{36}{9 \times 3.1416} = 1.27 \text{ revolutions of 9-inch roll to 1 yard of lap}$$

$$\frac{\text{Change gear}}{18} \times \frac{35}{1} \times \frac{80}{13} \times \frac{14}{73} \times \frac{18}{37} \times \frac{1}{1.27} = 0.8768 = \text{constant}$$

TABLE 2.—*Knock-off gear table for type A (figs. 1 and 2)*

Number of teeth in gear	Yards per lap	Number of teeth in gear	Yards per lap	Number of teeth in gear	Yards per lap
20.....	17.5	34.....	29.8	48.....	42.1
21.....	18.4	35.....	30.7	49.....	42.9
22.....	19.3	36.....	31.6	50.....	43.8
23.....	20.2	37.....	32.4	51.....	44.7
24.....	21	38.....	33.3	52.....	45.6
25.....	21.9	39.....	34.2	53.....	46.5
26.....	22.8	40.....	35.1	54.....	47.3
27.....	23.7	41.....	35.9	55.....	48.2
28.....	24.5	42.....	36.8	56.....	49.1
29.....	25.4	43.....	37.7	57.....	50
30.....	26.3	44.....	38.6	58.....	50.8
31.....	27.2	45.....	39.4	59.....	51.7
32.....	28.1	46.....	40.3	60.....	52.6
33.....	28.9	47.....	41.2		

Referring to Figures 3 and 4, the full lap is determined by the number of revolutions of the 7-inch calender roll to one revolution of the knock-off gear. The constant is obtained as follows:

$$\frac{31}{19} \times \frac{\text{change}}{1} \times \frac{7 \times 3.1416}{36} = 0.9967 = \text{constant for yards of lap to 1 revolution of gear.}$$

Constant $\times$ number of teeth in change gear = yards in full lap.

Yards per lap $\div$ constant = number of teeth in change gear.

One tooth in change gear = approximately 1 yard.

A 50-tooth change gear will give about 50 yards ($50 \times 0.9967 = 49.8$ yards).

In certain mill organizations it may be desirable to divide the amount of cotton used into an even number of laps at the picker, so that different knock-off change gears can be used to advantage.

If, for instance, 400 yards of cotton are to be used, with four doubling of laps at the finished picker, it would be best to have the laps of 50 yards each, or a 57-tooth gear for pickers, type A (figs. 1 and 2), or a 50-tooth gear for pickers, type B (figs. 3 and 4). This will make eight 50-yard laps or two sets.

4. COTTON BEATING

(a) DEFINITION

No doubt the most important feature of the picker is the amount of beating given to the fringe of cotton as presented by the feed rolls. The ratio of blows struck by the beater to the number of inches of material fed must be regulated so that the cotton will not be injured by too many blows or a too severe beating and yet receive enough blows to clean it properly. The action of the beater in connection with the grid bars and air current gives the cotton a certain amount of cleaning which removes the heavier impurities, such as dirt, pieces of seed, leaf, etc. It also tends to separate the tufts of cotton and prepares the cotton for the next process or for the carding.

As this amount of beating is regulated by the ratio of the revolutions of the feed rolls to the revolutions of the beater, the changes which affect these parts will be considered and will include the sizes of feed pulleys, draft, and draft constants, also the number of blades on the beater. With the beater speed remaining the same, a change in the size of the feed pulley causes an increase or decrease in the revolutions per minute of the calender and feed rolls or the ratio of these rolls to the speed of the beater. By increasing the revolutions of the feed rolls there are more inches of cotton presented to the beater, and therefore the cotton receives a lesser number of blows per inch fed, while by slowing down the feed rolls there is less cotton presented and a more severe beating results.

On the finisher picker, in addition to the change in the ratio between feed rolls and beater caused by change in size of feed pulley, the ratio is also changed by the draft gear and draft constant, which increases or decreases the revolutions per minute of the feed rolls. The draft constant changes with the position of the belt on the cones. The belt shifts on the cone to meet the change in the thickness of laps fed, so that when the revolutions of the feed rolls are decreased by the action of the evener motion the amount of cotton is practically the same in weight per unit of length, although the inches of material fed are less.

Example: If the belt is at the 4-inch diameter on the cone when feeding 32.9 inches of cotton per minute and the beater is striking 61 blows per inch and a thin place occurs in the laps, the belt shifts to the 3-inch diameter to feed 43.9 inches and the beater will strike 46 blows per inch. Or, if the feed rolls are delivering 50 ounces of cotton

per yard when feeding 32.9 inches and striking 61 blows per minute, the rolls will deliver 37.5 ounces per yard when feeding 43.9 inches, and in each case the amount of cotton per minute will be 45.7 ounces and the total number of blows in each case 2,000 per minute. A two-blade beater at 1,000 revolutions per minute will strike 2,000 blows per minute, so in each case the beater will strike 2,000 blows, or 44 blows per ounce.

$$\frac{32.9}{36} \times 50 = 45.7 \text{ ounces per minute.}$$

$$\frac{43.9}{36} \times 37.5 = 45.7 \text{ ounces per minute.}$$

$$2,000 \div 45.7 = 44 \text{ blows per ounce.}$$

The blows per inch on the breaker picker are not increased or decreased to meet the difference in weight as in the above example, so when thick and thin places occur in the feed the cotton receives a more or less severe beating, and any change in blows per inch is regulated by the size of the feed pulley and the number of blades.

The amount of beating the cotton receives on the finisher picker is regulated by the feed pulley, number of blades, and the draft. The draft constant and draft are first calculated so that the weight of the product or lap may be determined, and then the amount of beating or blows per inch, when using this draft, is calculated and is regulated by the size of feed pulley.

To keep the production uniform or to give equal production when using a two-blade beater or a three-blade beater, the speed of the entire machine must be increased or decreased according to the change being made in beaters, as will be shown in the organizations.

The blows per inch have been determined for type A (figs. 1 and 2). The table for blows for Figure 1 (Table 3) allows for the blows per inch when using two and three blade beaters and for feed pulleys from $4\frac{1}{2}$ to 12 inches in diameter.

The calculations from Figure 2 (fig. 9) were determined with different size feed pulleys, draft gears, and different draft constants.

TABLE 3.—Blows per inch breaker picker struck by two-blade and three-blade beaters for various diameters of feed pulleys

STRUCK BY TWO-BLADE BEATER

Diameter feed pulley in inches	Number of blows per inch	Diameter feed pulley in inches	Number of blows per inch
4½	41	8½	22
5	37	9	20
5½	33	9½	19
6	31	10	18
6½	28	10½	17
7	26	11	17
7½	24	11½	16
8	23	12	15

STRUCK BY THREE-BLADE BEATER

4½	61	8½	32
5	55	9	31
5½	50	9½	29
6	46	10	28
6½	42	10½	26
7	39	11	25
7½	37	11½	24
8	34	12	23

(b) RULES FOR FINDING BLOWS PER INCH

Example: Breaker picker (fig. 1).

To find the blows per inch, it is necessary to find the number of inches fed per minute and to find the ratio between the number of blows per minute and the inches fed in the same time.

The formula for inches fed is

$$N \times F \times C_1 \times (2.5'' \times 3.1416) = 76.2 \text{ inches}^2$$

$$1,000 \times 2 = 2,000 \text{ blows per minute}$$

$$2,000 \div 76.2 = 26 \text{ blows per inch.}$$

Another formula for the above figures is

$$\frac{\text{Number blades}}{F} \times 91.9 = \frac{2}{7''} \times 91.9 = 26 \text{ blows}$$

Example (finisher picker, fig. 2): In finding the blows per inch for the finisher picker the draft (draft gear and draft constant) must be considered as well as the feed pulley and number of beater blades. A change in the position of the belt on the cones changes the draft constant and, therefore, the draft, and this in turn alters the revolutions per minute of the feed rolls.

The formula for finding the blows per inch is as follows:²

$$\frac{\text{r. p. m. beater} \times \text{number blades}}{N \times F \times C_e \times (2.5'' \times 3.1416) \times \frac{G}{D}} = \text{blows per inch}$$

$$\frac{1,000 \times 2}{1,000 \times 7 \times 0.0000922 \times 7.854 \times \frac{28}{3.5''}} = \frac{2,000}{40.55} = 49$$

Another formula is

$$\frac{\text{Number of blades}}{F} \times \frac{D}{G} \times \frac{1,381}{1} = \text{blows per inch}$$

$$\frac{2}{7''} \times \frac{3.5''}{28} \times 1,381 = 49$$

FIG. 9.—Cotton beating chart

For computing the number of blows struck by two and three blade beaters when using feed pulleys from 5 to 15 inches in diameter.

To find the number of blows, place a straightedge on the point representing the diameter on the cone, axis "D" and on the point representing the draft gear, axis "A," these points having been used for the draft. The intersection of the straightedge with the dummy axis "B," is noted. The straightedge is then placed on this point and on the diameter of the feed pulley, axis "E."

The blows per inch are read at the point of intersection of the straightedge with axis "C."

(c) USE OF COTTON BEATING CHART

The chart for the finisher picker was calculated for two and three blade beaters using feed pulleys from 5 to 15 inches in diameter, draft gears from 18 to 50 teeth, and for several diameters on the cone.

² See page 195.

Example (refer to fig. 9): To find the blows per inch struck by a two or three blade beater when the cone belt is at the 3.5-inch diameter on the cone using a 7-inch feed pulley and a 28-tooth draft gear, place straightedge on axis "A" at 28 and on axis "D" at 3.5. On axis "B" note the point of intersection and place straightedge on this point and on point 7 on axis "E." The number of blows struck by a two-blade beater is then found on the left side of axis "C," and the number of blows for a three-blade beater is found on the right side of axis "C," which are in this case 49 and 74.

III. EXAMPLES OF USE OF THESE CALCULATIONS IN CHANGING ORGANIZATIONS

By the use of the charts and tables shown in this paper organizations may be quickly formed, and one organization changed to another in a comparatively short time.

This may be illustrated by considering the following calculations necessary to change from one organization to another to accomplish some desired result. Organization No. 1 (Table 5) is in use, and it is desired to change the organization to make a lighter-weight lap—say, 14 ounces at breaker picker and 12.5 at calender rolls of finisher picker, using a two-blade beater. The conditions imposed are that the cotton shall receive practically the same amount of beating and the production shall remain approximately the same in pounds per hour.

TABLE 4.—Outline of changes necessary in picker processes from loose cotton to cotton lap

Material (input)	Machinery	Material (output)	Reference
Loose cotton from bale or bale breaker (1).	Automatic feeder.....	Loose cotton (2).....	
Loose cotton (2).....	Opener.....	do. (3).....	
Do. (3).....	Breaker picker.....	Cotton lap (4).....	
	Feed, to regulate.....	Weight.....	II-2(a)
	Beater, affecting.....	Cleanliness.....	II-4(a)
	Feed pulley, size of.....	Ratio between inches fed and blows per minute.....	II-4(a)(b)
	Beater, speed of.....	Yards in output.....	II-3(b)(d)
Cotton lap (4) (four laps).	Intermediate or finisher picker..	Cotton lap (5).....	
	Doubling, to produce.....	Evenness.....	II-2(b)
	Draft, to regulate.....	Weight.....	II-2(c)
	Beater, affecting.....	Cleanliness.....	II-4(a)
	Feed, pulley, size of.....	Ratio between inches fed and blows per minute.....	II-4(a)(b)
	Beater, speed of.....	Yards in output.....	II-3(b)(d)

TABLE 5.—Change in organization

BREAKER PICKER

Item	Initial organization, No. 1	Changes required	How to compute			Final organization, No. 2
			Reference	Table	Chart	
Beater...number of blades...	3	Change beater.....	II-3 (a).....	-----	-----	2
Weight of lap.....ounces...	16	Decrease 2 ounces.....	II-4 (a).....	-----	-----	14
Blows per ounce.....	31	No change.....	II-4 (a).....	-----	-----	28
Blows per inch.....	31	Decrease to equal blows per ounce.....	II-4 (a).....	3	-----	28
Diameter of feed pulley, inches.....	9	Change to give required blows per inch.....	II-4 (a) (b).....	3	-----	6.5
Pounds per hour.....	213	No change.....	II-3 (b) (c).....	-----	6, 8	213
Yards per hour.....	213	Increase to give 213 pounds per hour.....	II-3 (b) (d).....	2	6	243
Beater speed.....r. p. m....	700	Increase to give necessary yards per hour.....	II-3 (b).....	-----	6	1,100

FINISHER PICKER

Beater...number of blades...	3	Change beater.....	II-2 (a).....	-----	-----	2
Weight of lap on apron, ounces.....	16	Decrease 2 ounces.....	II-2 (a).....	-----	-----	14
Number of laps on apron.....	4	No change.....	-----	-----	-----	4
Weight of lap at calendar rolls, per yard.....ounces...	14	Decrease 1½ ounces.....	-----	-----	-----	12.5
Draft.....	4.57	Change to produce required weight.....	II-2 (b).....	-----	7	4.48
Draft constant.....	98	No change.....	II-2 (c).....	-----	7	98
Draft gear number of teeth...	22	Change to produce required weight.....	II-2 (c).....	1	7	23
Blows per ounce.....	73	No change.....	II-4 (a).....	-----	-----	-----
Blows per inch.....	73	Decreased to equal blows per ounce.....	II-4 (a) (b).....	-----	9	65
Diameter of feed pulley, inches.....	9	Change to give required blows per inch.....	II-4 (a) (b).....	-----	9	6.5
Pounds per hour.....	213	No change.....	II-3 (b) (c).....	-----	6, 8	213
Yards per hour.....	243	Increase to give same pounds per hour.....	II-3 (b) (d).....	2	6	272
Beater speed.....	800	Increase to give yards per hour.....	II-3 (b).....	-----	5, 6	1,250

1. BREAKER PICKER CALCULATIONS FOR ORGANIZATION NO. 2

(a) BLOWS PER INCH (REFER II-4-b)

Since the draft on the breaker picker is constant, the lighter-weight lap is obtained by decreasing the amount of cotton fed. To give this cotton the same amount of beating as in organization No. 1, the number of blows per inch is decreased in proportion (in organization No. 1, the number of blows per inch is 31), then

$$16 : 14 = 31 : \text{the blows per inch, organization No. 2}$$

$$27 + = \text{the blows per inch, organization No. 2}$$

(b) DIAMETER OF FEED PULLEY (REFER II-4-b)

To obtain 27+ blows per inch on the breaker picker, it is found in Table 3 that the condition will be more nearly met by using a 6.5-inch feed pulley obtaining 28 blows per inch.

(c) PRODUCTION IN YARDS PER HOUR (REFER II-3-b)

To approximate the production in organization No. 1 (213 yards per hour of 16-ounce lap), it is found that $213 \times 16 = 14 \times$ the yards per hour for organization No. 2.

243 = the yards per hour for organization No. 2

(d) BEATER SPEED

Since the number of yards delivered at the calender rolls is increased, it will be necessary to increase the beater speed. Referring to chart No. 6, and breaker picker type A, to obtain 243 yards per hour, using a 6.5-inch pulley, the beater speed is found by placing straightedge on axis "E," point type A, and on axis "C," 243 yards. On axis "B" the intersection formed with straightedge is noted, and the straightedge laid on this point and on point 6.5 (axis "D"), so that the straightedge will cross axis "A" at about 1,100 revolutions per minute.

Those results are listed in Table 4 under organization No. 2.

2. FINISHER PICKER CALCULATIONS FOR ORGANIZATION NO. 2

Since it is desired to change the weight of lap from 14 ounces per yard (organization No. 1) to 12.5 ounces per yard, it will be necessary to consider the draft or ratio between the feed and calender rolls.

(a) DRAFT (REFER II-2-b)

With a doubling of four 14-ounce laps and a 12.5-ounce lap being made, for organization No. 2

$$\frac{4 \times 14}{12.5} = 4.48 = \text{draft}$$

(b) NUMBER OF TEETH

The number of teeth on the draft gear when using the draft constant 98 is $\frac{98}{4.48} = 22$. Adding one tooth for estimated waste removal, fixes the number of teeth on the draft gear at 23.

(c) BLOWS PER INCH (REFER II-4-b)

As stated under breaker picker calculations for organization No. 2, to get the same amount of beating the blows per inch are increased or decreased in proportion to the amount of cotton fed, and since the weight of 1 yard of lap fed in organization No. 1 was 16 ounces with 73 blows per inch struck, the blows per inch for the 14-ounce lap fed are

16:14 = 73: blows per inch for organization No. 2, finisher picker
64 = blows per inch for organization No. 2, finisher picker

(d) DIAMETER OF FEED PULLEY (REFER II-4-b)

Referring to Figure 9, to find the size of feed pulley to strike 64 blows per inch when using a 23-tooth draft gear and a draft constant of 98, or 3.5-inch diameter on the cone, place straightedge on 23 (axis "A") and on 3.5 (axis "D"). The intersection on axis "B" is noted and the straightedge then placed on this point and on 64 (axis "C"). This will show a 6.5-inch feed pulley on axis "E."

(e) PRODUCTION IN YARDS PER HOUR (REFER II-3-b)

In a similar manner to that used to obtain these results in the breaker picker organization No. 2, it is found

$$243 \times 14 = 12.5 \times \text{yards per hour organization No. 2}$$

$$272 = \text{yards per hour organization No. 2}$$

(f) BEATER SPEED (REFER II-4-a)

To obtain 272 yards per hour when using a 6.5-inch feed pulley, the beater speed is found (fig. 6) by placing straightedge on point indicating finisher picker, type A (axis "E") and on point 272 (axis "C") and the intersection on axis "B" noted. The edge is then placed on this point and on 6.5 (axis "D"), so that the straightedge will intersect axis "A" and this point of intersection, showing the beater speed required which is 1,250 r. p. m.

IV. SUMMARY

The contents of this paper may be summarized as giving the methods and formulas for determining:

- (a) Sizes and revolutions per minute of pulleys,
- (b) Revolutions of calender rolls,
- (c) Revolutions of feed rolls,
- (d) Draft, draft gears,
- (e) Productions in yards delivered by the calender rolls for laps of different weight per yard,
- (f) Amount of beating given cotton,
- (g) Assembling of data into organizations.

The charts and tables set forth the data in detail and give a wide range of speeds, diameters of pulleys, teeth in gears, and weight of product.

WASHINGTON, December 27, 1924.