To find the number of coils this length of roving delivered will occupy on the empty bobbin, we have:

$$\frac{585.13}{1\frac{9}{16}\times 3.1416} = 119.17$$ coils or excess revolutions of bobbin at beginning of set.

While that number of coils are not put on the empty bobbin, yet the speed must be added to the speed of the spindles in order to obtain the speed of the bobbins while winding on the first layer, because it is the proportional part of this speed per minute.

The speed of the spindle is found as follows:

$$\frac{350\times p\times r}{q\times s},$$ and substituting gearing in connection with our diagram thus: $p = 42$, $q = 35$, $r = 44$ and $s = 23$, we have:

$$\frac{350\times 42\times 44}{35\times 23} = 803.5$$ revolutions per minute.

Then the speed of the empty bobbin equals

$$803.5 + 119.17 = 922.67 \text{ r.p.m.}$$

The next step is to find the r.p.m. "**a**" of the sun wheel (*D*) with the speed "**m**" of the fixed gear corresponding to *B* known, and the speed "**n**" of the loose gear corresponding to *G* found as follows, by considering the bobbin as the starting point.

$$\frac{922.67\times M\times J}{L\times H}$$ and substituting gearing in connection with our diagram thus: $M = 23$, $L = 44$, $J = 35$ and $H = 42$, we have:

$$\frac{922.67\times 23\times 35}{44\times 42} = 401.92$$ r.p.m. of the collar, and consequently of the gear corresponding to G.

From the formula derived we have: $\mathbf{a} = \dfrac{\mathbf{n} - \mathbf{e\,m}}{1 - \mathbf{e}}$

We have that "**m**" = 350, "**e**" = — 1, and "**n**" = — 401.92, since it revolves in the opposite direction. Substituting in the formula, we have:

$$\mathbf{a} = \frac{-401.92 - (-1 \times 350)}{1 - (-1)}$$

$$= \frac{-401.92 + 350}{2} = \frac{-51.92}{2} = -25.96 \text{ r.p.m. of sun wheel, the}$$

minus sign indicating the opposite direction from the fixed gear on main shaft.

By finding the speed of the cone gear shaft and knowing the speed of the sun wheel, it will then be easy to calculate the proper gear to give the required speed to the sun wheel.

We find speed of cone gear shaft by starting with main shaft, as follows:

$$\frac{350 \times N \times \text{large dia. of top cone}}{P \times \text{small dia. of bottom cone}} = \text{revolutions of cone gear}$$

shaft, and substituting gearing in connection with our diagram thus: N = 32, P = 39, large dia. of top cone = 6, small dia. of bottom cone = 3, we have:

$$\frac{350 \times 32 \times 6}{39 \times 3} = 574.35 \text{ revolutions of cone gear shaft.}$$

$$\text{Now } \frac{574.35 \times * \times T' \times W}{T \times V \times D} = \text{revolutions of sun wheel, and}$$

substituting gearing in connection with our diagram thus: T = 70, T′ = 56, V = 64, W = 14, D = 110, we have:

$$\frac{574.35 \times * \times 56 \times 14}{70 \times 64 \times 110} = 25.96 \text{ and}$$

$$\frac{25.96 \times 70 \times 64 \times 110}{574.35 \times 56 \times 14} = 28.41 = 28 \text{ cone gear.}$$

The method of ascertaining the proper cone gear and figuring the differential motion by analysis is also made use of, and besides giving another method of calculating, it will also prove the answer obtained by the formula. We will make use again of the Figs. 200 and 203 in giving the explanation and a little repetition of what has been said will also be necessary in order to make the explanation clear.

Suppose the sun wheel E in Fig. 203 were held still, and the gear B on the main shaft revolved in the forward or positive direction, then, as we have seen, the gear H will revolve loosely on the shaft in the opposite direction from that of the gear B, which we will call negative, and at the same speed, since both gears have the same number of teeth.

Again, suppose B to remain stationary and the sun wheel to be revolved in the negative direction, then the intermediate bevel C as pivoted in the sun wheel E (the gear D not having to be considered) will be revolved bodily with its teeth in mesh with the gear B. The teeth of said gear C, which are in mesh with those of gear H, will therefore have twice the speed of the centre of the gear C. This is a case of instantaneous centre, that is, the teeth of gear B act as a pivot for an instant for the gear C, and as the teeth on the opposite from this momentary pivot are twice as far as the centre of the gear, they will consequently have twice the speed of the centre. These momentary centres are constantly made, so that the opposite teeth continue to have twice the speed of the centre. Therefore, if the sun wheel makes one revolution, it will carry the centre of C around for one revolution, and the edge of C in contact with H will be taken a distance equal to two revolutions of B, and thus we see that when E makes one revolution, H which is in gear with C will make two revolutions.

Now if B makes 350 revolutions in the positive direction while the sun wheel goes backward one revolution, the gear H will consequently make 350 revolutions in the negative direction from the gear B and two negative revolutions on account of the sun wheel, or a total of 352 revolutions.

The example given will serve to derive a general rule for finding the speed of the gear H when the speed of the gear B and sun wheel are known: The speed of gear H, or bobbin driving gear, is equal to the speed of the gear B on the main shaft plus twice the speed of the sun wheel.

When the speeds of the gears B and H are known, the rule would be: The speed of sun wheel is equal to half the difference between speed of the gear H and the gear B.

The application of the rules in practical work can be shown by calculating the cone gear, as before, with the same data and on the same machine.

We found that, with the data given for the machine as shown in Fig. 200, the front rolls deliver 585.13 inches of roving per minute, and this length would produce 119.17 coils on an empty bobbin.

The speed of the spindles was found to be 803.5 r.p.m., which made the speed of the bobbins $803.5 + 119.17 = 922.67$ r.p.m.

The speed of the gear corresponding to G was found from this to be 401.92 r.p.m., and the speed of the gear corresponding to C was 350 r.p.m., since it is fast on the main shaft.

Now to find the required speed of the sun wheel, we refer to the rule given that the speed of the sun wheel is equal to half the difference between speeds of the gear G and the gear C, or $401.92 - 350 = 51.92 \div 2 = 25.96$ revolutions of sun wheel.

The speed on the cone shaft is found to be 574.35 r.p.m. and in the same manner as explained, the cone gear is found to be 28 teeth.

Daly's Differential.—This is one of the latest types of differential motion, being used in connection with the fly frames as built by the Woonsocket Machine & Press Company. As applied to the fly frame, all the gears and collars of this differential revolve in the same direction, thus reducing the amount of friction between the collars and the main shaft to a minimum, and consequently requiring less power from the cones and decreasing the strain on that part of the mechanism. Two views of the motion, separated from the frame, are given, Fig. 204 being a perspective view of the motion with the internal gears in position in the casing, while Fig. 205 is a view, showing the sleeve pulled

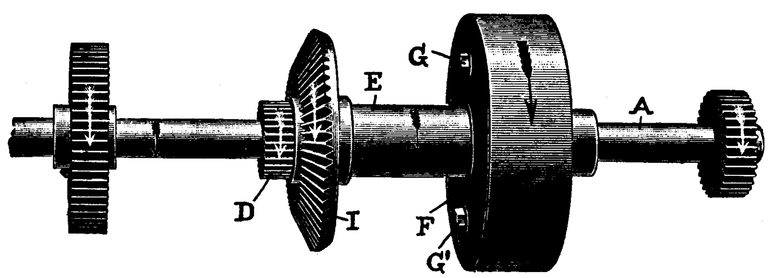


FIG. 204.

out on the shaft, in order to see the arrangement of the internal gears. Referring to the illustrations, A indicates the main shaft of the machine, to which is secured the internal gear B, said gear being made on the inside of a casing as used to enclose the mechanism when in working position (see Fig. 204). The gear C is fixed on a collar which is loose on the shaft A, the other end of said collar carrying a gear D which is driven through gearing from the bottom cone of the machine. A second collar E fits over the first collar (not to be seen) and carries a disk F, in which two studs G and G' are fastened on opposite sides from each other, each stud carrying a gear, H and H' respectively, which mesh with the internal gear B and also with the gear C. The other end of the collar carries a bevel gear I, which, through proper gearing, as will be shown later, drives the bobbins. The main driving power comes through the internal gear B, on the main shaft, and the excess speed is gotten through the gear C on the same collar with the gear D, as is driven from the bottom cone.

In order to make use of the same formula as used for Holdsworth's Differential for calculating the speeds of gears, we will use the same letters to indicate speeds of corresponding gears in this motion, that is, the speed of the internal gear B = "**n**" revolutions, the speed of the disk F carrying the gears H and H' = "**a**" revolutions, and the speed of gear C = "**m**" revolutions. The gear C to contain 28 teeth, the gears H and H' 25 teeth each, being intermediates, and the internal gear B 80 teeth.

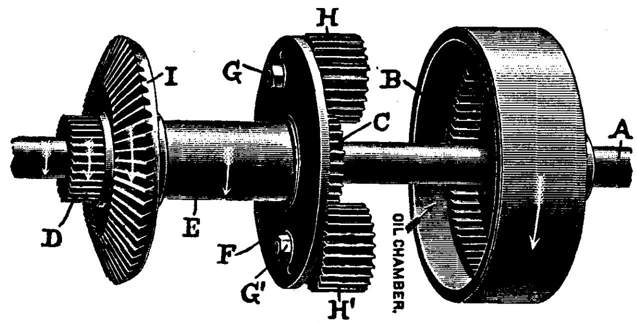


FIG. 205.

The value of the train of gears "**e**" will be negative or minus, since considering the three gears C, H (or H') and B as a simple train, the gear B will revolve in the opposite direction from the gear C, as will be plainly seen by following out the gearing thus: The gear C drives the gear H in an opposite direction and said gear H drives the internal gear B in the same direction as itself, and hence it is opposite also to the first gear C. There is scarcely a limit to the number of combinations of the two drives, but only those concerned in a thorough understanding of the motion will be given, since more would only tend to confuse the problem.

We will first consider that the gear B makes 400 revolutions in the positive direction, while the gear C remains stationary or "**n**" = 400, "**m**" = 0, and we wish to find the number of revolutions "**a**" of the disk F carrying the gears H and H'. Since the first gear C contains 28 teeth, and the last gear B contains 80 teeth, the value "**e**" of the train will be $28 \div 80 = \frac{28}{80}$, and as the two gears revolve in opposite directions, this quantity becomes $-\frac{28}{80}$.

We have the formula:

$$\mathbf{a} = \frac{\mathbf{n} - \mathbf{e}\ \mathbf{m}}{1 - \mathbf{e}}$$ and substituting the known values, we have:

$$\mathbf{a} = \frac{400 - (-\frac{28}{80} \times 0)}{1 - (-\frac{28}{80})}$$

$$= \frac{400 + 0}{1 + \frac{28}{80}} = \frac{400}{1\frac{28}{80}} = 296.29 + \text{revolutions.}$$

Say that the gear C makes the same number of revolutions as the internal gear B and in the same direction,

$$\mathbf{a} = \frac{\mathbf{n} - \mathbf{e\ m}}{1 - \mathbf{e}} \text{ and substituting, we have:}$$

$$\mathbf{a} = \frac{400 - (-\frac{28}{80} \times 400)}{1 - (-\frac{28}{80})}$$

$$= \frac{400 - (-140)}{1\frac{28}{80}} = \frac{540}{\frac{108}{80}} = 400 \text{ revolutions, or the whole train}$$

revolves together as if the gears were locked.

The gearing to the bobbins will afterwards be shown to be such that the disk, which is on the same collar with the bobbin driving gear, does not require to be driven as fast as the speed of the main shaft, and hence the required speed of the gear C will lie between the two examples given.

This differential motion is shown in diagram Fig. 206 in its proper position in the frame, in connection with gearing, given for the purpose of explaining the principle of calculating only. The gearing to the bobbins and spindles are not shown in the positions they would occupy in the frame, but instead are placed toward the top of the diagram in order to avoid confusion with the other gearing.

Referring to the diagram, we see that the spindles are driven from the main shaft A through a 35 gear on said shaft, which through an intermediate, drives a 35 gear on the end of the spindle shaft B. On the spindle shaft are 46 tooth bevel gears which drive the spindles through 24 tooth bevel gears secured on said spindles.

The bobbins are driven both from the main shaft and from the cones. The top cone C is driven from the main shaft through the twist gear, which we will consider as 31, said gear through an intermediate, driving a 56 gear on the top cone shaft D. On the bottom cone shaft E is the cone gear (*) which will be calculated, and this gear drives a 70 gear on the same stud with another 70 gear, which in turn drives the spider shaft F through an 80 gear. Secured also on the spider shaft is a 23 gear, which through an intermediate drives the 30 gear corresponding (see Fig. 205) to the gear D on the same collar with the gear C. This gear C, as mentioned before, has 28 teeth and gears into the two 25 gears H and H', which are in mesh with the internal 80 tooth gear B as fast on the main shaft A. The sleeve E, carrying the disk F on which the two gears H and H' are pivoted, as mentioned before, also has the bevel gear I secured to it, and which bevel gear in connection with diagram Fig. 206 is shown as a 57 bevel gear, driving in turn a 32 bevel on one end of an angle stud G; the other end carrying another 32 bevel, which in turn drives a 32 bevel on a vertical shaft H. On this shaft is a 32 bevel.

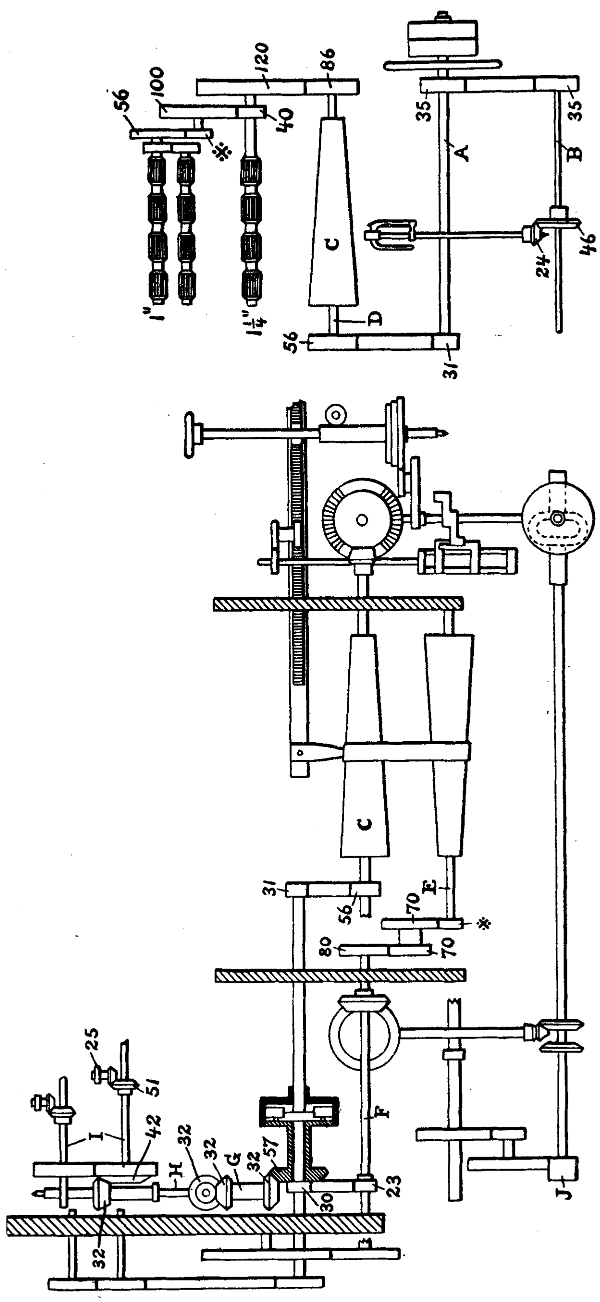

56
100
120
86
35
35
A
B
40
C
24
46
1"
$1\frac{1}{4}$"
D
56
31
31
56
70
E
70
80
C
F
25
51
I
42
H
32
32
G
32
57
30
23
J
32

Fig. 206.

driving a 42 bevel on the end of the bobbin shaft I. The bobbin shaft has the series of 51 tooth gears secured to it, which drive 25 tooth gears on which the bobbins rest.

The diameter of the front roll = $1\frac{1}{4}$ inches.
Diameter of empty bobbin = $1\frac{5}{8}$ inches.
Diameter of top cone (at start) = $6\frac{1}{2}$ inches.
Diameter of bottom cone (at start) = $3\frac{1}{4}$ inches.
Speed of main shaft = 450 revolutions.

The length of roving delivered per minute by the front roll is

$$\frac{450 \times 31 \times 86 \times 1\frac{1}{4} \times 3.1416}{56 \times 120} = 701.1 \text{ inches.}$$

The number of coils this length will produce on an empty bobbin is

$$\frac{701.1}{1\frac{5}{8} \times 3.1416} = 137.33 \text{ coils, excess revolutions of empty bobbin.}$$

The speed of the spindles is ascertained as follows:

$$\frac{450 \times 35 \times 46}{35 \times 24} = 862.5 \text{ revolutions, and}$$

$862.5 + 137.33 = 999.83$ revolutions of the bobbin per minute.

The speed of the sleeve (E in Fig. 205) necessary to produce this speed to the bobbin is:

$$\frac{999.83 \times 25 \times 42 \times 32 \times 32}{51 \times 32 \times 32 \times 57} = 361.13 \text{ revolutions, speed of the sleeve and disk.}$$

This speed is the value for "**a**", and as the value for "**n**" is 450, the problem now is to find the speed of the gear C in Fig. 205, or the value for "**m**" which is given to it by the cones. For this purpose, we will use the formula:

$$\mathbf{m} = \frac{\mathbf{e\,a + n - a}}{\mathbf{e}}$$

The value of "e" is $-\frac{28}{80}$ for the reason already given. Substituting the proper numbers, we have:

$$m = \frac{(-\frac{28}{80} \times 361.13) + 450 - 361.13}{-\frac{28}{80}}$$

$$= \frac{-126.4 + 450 - 361.13}{-\frac{28}{80}}$$

$$= \frac{-37.53}{-\frac{28}{80}} = 107.23 \text{ revolutions of gear } C.$$

We may find the speed of the bottom cone shaft or simply continue the train of gears to the 30 gear on the inside sleeve, which revolves at 106.2 revolutions per minute, and then solve for the cone gear:

$$\frac{450 \times 31 \times 6\frac{1}{2} \times \text{cone gear} \times 70 \times 23}{56 \times 3\frac{1}{4} \times 70 \times 80 \times 30} = 107.23$$

$$\therefore \text{Cone gear} = \frac{107.23 \times 56 \times 3\frac{1}{4} \times 70 \times 80 \times 30}{450 \times 31 \times 6\frac{1}{2} \times 70 \times 23} = 22.45 = 22 \text{ gear.}$$

Howard & Bullough's Differential.—This motion is shown in Fig. 207, separate from the rest of the gearing of the machine. It shows another method of combining two drives into one and at the same time also overcomes the disadvantage of excessive friction between the main and loose shaft, by causing all frictional surfaces to revolve in the same direction; and more than this, the main shaft which revolves faster than the differential motion helps instead of hinders, thus reducing the strain on the cone belt.

Referring to the illustration, *A* indicates the main driving shaft on which is loosely placed a collar carrying the gears *B* and *E*, the gear *B* being driven through a train of gears from the bottom cone of the machine. The gear *E* meshes into a gear *F* as secured to a small shaft or stud *G*, said shaft passing through a hole in the main shaft *A*, and having the gear *H* attached to its other end. An outer casing, as collared on the main shaft *A*, holds the small shaft and prevents it from sliding back and forth in the hole through the main shaft. The gear *H* meshes into a large gear *D* which is attached on an enlarged boss, also carrying a gear *C*, i. e., the bobbin driving gear, and thus the two gears are revolved at the same speed. Through a train of gearing, this gear *C* drives the bobbins in order to effect the winding on of the roving.

The object of having the enlarged boss is to provide a space for the extending portion of the gear *F*, in order to prevent any interference with the gear D, which is not in mesh with it. The boss is, of course, loose on the main shaft A, otherwise it could not receive the combined motions which are given to it. The two motions are gotten from the main shaft and from the cones, the former being obtained by bodily revolving the shaft carrying the gears F and H as the main shaft revolves, this being done by the fact that the small shaft passes through said main shaft, and consequently D is revolved by being in mesh with H. The other motion is obtained by revolving the gear B, which through gears

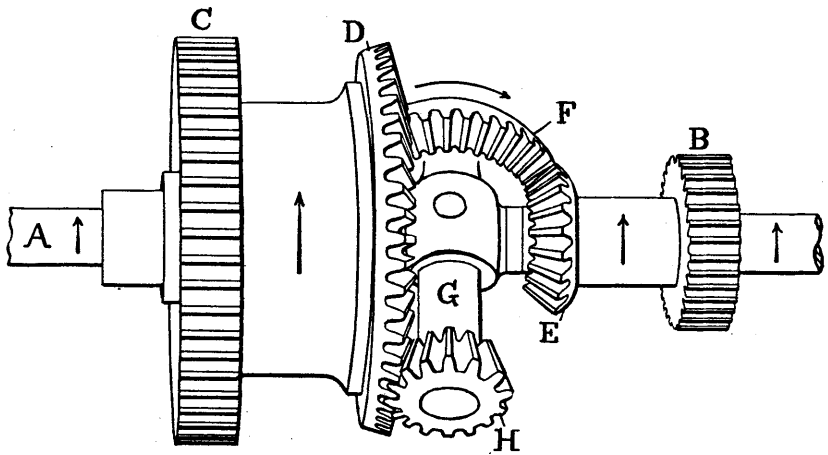


FIG. 207.

E, F and H revolves the gear D. When either of these two motions is working alone it is quite easy to trace through the gears the effect it will have on the gear D, but when combined it becomes more complicated, requiring a careful analysis to ascertain the correct result.

It will at once be seen that if the boss carrying the gear E were simply loose on the shaft without any gearing to the gear B, when the shaft carrying the gears F and H was revolved, no motion would be given to the gear D, but would simply spend itself through the gears of least resistance, which would be the gear E, because the gear D has the bobbins to drive, which necessarily means resistance. The gear E would not be revolved as fast as the simple train of gears would make it, provided there was no other condition, because the bodily revolution of the two gears F and H must be considered, and which tends to rotate the gear E in the opposite direction from the regular train and thus counterbalances somewhat the motion of the latter. By holding the gear E stationary, and revolving the shaft, the gear D will receive rotation, but not an equal number as the shaft itself, as will be seen later. By revolving the gear E in the same direction as the main shaft, we obtain the desired movement of the gear D for winding the roving.

In making the calculation for the motion, certain figures will be assumed, the same as done in the previously described diagrams.

The gear E contains 18 teeth and will have "**m**" revolutions. Gear F contains 30 teeth and H has 16 teeth, the shaft carrying these two gears to make "**a**" revolutions. Gear D has 48 teeth and will make "**n**" revolutions from the combined movements of the two drives.

The amount of movement of the gear D, when the main shaft makes 400 r.p.m., and the gear E is held stationary, is gotten as follows:

Value of train "**e**" $= \frac{18 \times 16}{30 \times 48} = \frac{1}{5}$ which will be a positive quantity, since gear D revolves in the same direction as gear E. We have the formula: $\mathbf{e} = \frac{\mathbf{n} - \mathbf{a}}{\mathbf{m} - \mathbf{a}}$ and substituting the known values we have:

$$\frac{1}{5} = \frac{\mathbf{n} - 400}{0 - 400}$$

$$-400 = 5\ \mathbf{n} - 2000$$

$$-5\ \mathbf{n} = -1600$$

$$\mathbf{n} = 320 \text{ revolutions.}$$

Now taking an example in actual practice, to find the speed of the gear E for giving the proper revolutions to the bobbins at the beginning of a set, we will assume the speed of the gear D (last wheel) to be $235 =$ "**n**" revolutions, and that of the main shaft $257 =$ "**a**" revolutions and which is also that of the shaft (arm) carrying the gears F and H. The gear E (first wheel) will make "**m**" revolutions, which must be solved for in the formula:

$$\mathbf{e} = \frac{\mathbf{n} - \mathbf{a}}{\mathbf{m} - \mathbf{a}}$$

$$\frac{1}{5} = \frac{235 - 257}{\mathbf{m} - 257}$$

$$\frac{1}{5} = \frac{-22}{\mathbf{m} - 257}$$

$$\mathbf{m} - 257 = -110$$

$$\mathbf{m} = 257 - 110 = 147 \text{ revolutions.}$$

The proper cone gear to give this speed may be calculated as before from the speed of the cone shaft, or by simply ascertaining the cone gear in the train of gears, from the main shaft to the gear B.

Gearing and Calculations of the Howard & Bullough Fly Frame.— Having given a thorough explanation of the construction and operation

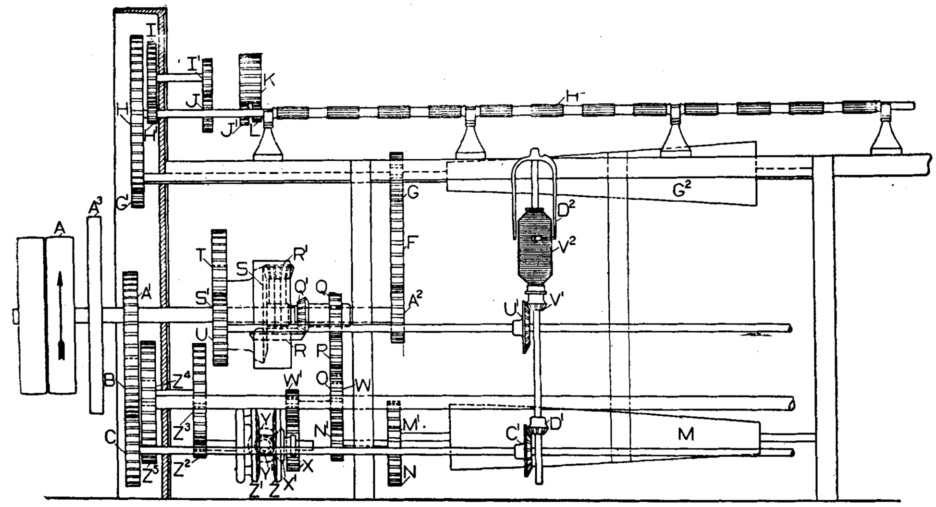


Fig. 208.

of the Howard & Bullough Differential, we will now show its application to its frame, as well as analyze the latter with reference to its gearing, and

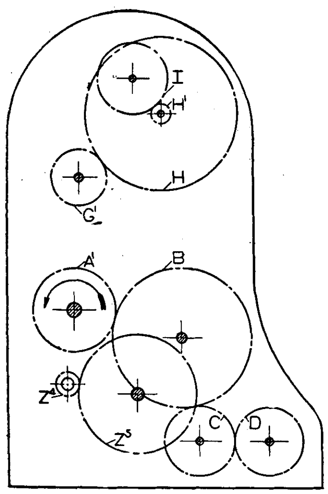


Fig. 209.

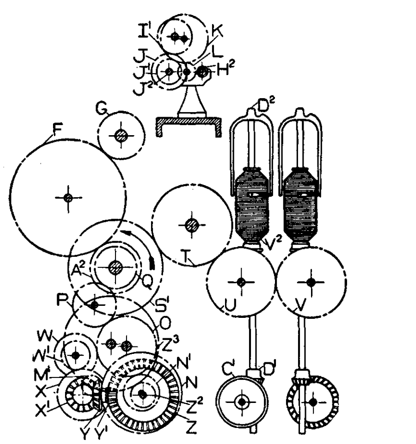


Fig. 210.

for which reason Figs. 208, 209 and 210 are given, showing respectively front elevation and two side elevations of the drive of the frame; Fig.

208 showing the differential motion, as previously explained, in its proper position in the frame. Fig. 211 shows this differential with its train of gears, i. e., the head stock of the frame, in perspective.

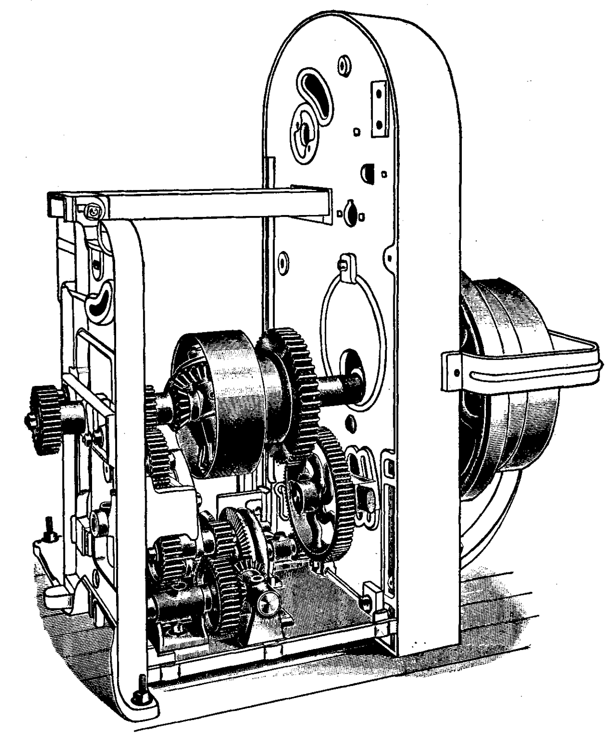


FIG. 211.

With reference to drive of this fly frame (see Figs. 208, 209 and 210) size and dimension of gears, pulleys, etc., are:

		Slubber and Intermediate.	Roving and Fine Roving.
A	Driving Pulley, 16″ dia. × 3″ face.		
A′	Spindle Shaft Driving Gear	40 T.	40 T.
A^2	Twist Gear, 20 to 70 T., advancing by 1 tooth.		
A^3	Balance Wheel.		
B	Spindle Shaft Intermediate Gear	75 T.	70 T.
C	End Back Spindle Shaft Gear	42 T.	37 T.
C′	Spindle Shaft Skew Bevel Gear	55 T.	55 T.
D	End Front Spindle Shaft Gear	42 T.	37 T.
D′	Spindle Bevel Gear	30 T.	22 T
D^2	Flyer.		
F	Back Intermediate Gear, 128, 120, 112, 104, 96, 88, 80, & 72 T.		
G	Middle Top Cone Shaft Gear 32, 40, 48 & 56 T.		

		Slubber and Intermediate.	Roving and Fine Roving.
G′	End Top Cone Shaft Gear	48 T.	44 T.
*G*2	Top Cone, driving Bottom Cone.		
H	Large Front Roll Gear	130 T.	130 T.
H′	Small " " "	20 T.	18 & 20 T.
*H*2	Front Roll	1¼″ dia.	1⅛″ dia.
I	Crown Gear	80 T.	82 & 120 T.
I′	Draft Gear, 33 to 66 T., advancing by 1 tooth.		
J	Back Roll Gear	52 T.	52 & 60 T.
J′	Middle Roll Driving Gear	30 T.	27 T.
*J*2	Back Roll	1¼″ dia.	1⅛″ dia.
K	Broad Top Intermediate Gear	70 T.	70 T.
L	Middle Roll Gear	20 T.	20 T.
M	Bottom Cone.		
M′	Bottom Cone Shaft Gear, 14 to 36 T. (16, 17 & 18 T. regular).		
N	Fender Gear	68 T.	68 T.
N′	Fender Shaft Gear	44 T.	30 T.
O	Fender Intermediate Gear	56 T.	56 T.
P	Differential Motion Intermediate Gear	44 T.	36 T.
Q	Differential Spur Gear	34 T.	34 T.
Q′	" Bevel Gear	18 T.	18 T.
R	Jack Large Bevel Gear	30 T.	30 T.
R′	Jack Small " "	16 T.	16 T.
S	Bell Gear Bevel Gear	48 T.	48 T.
S′	Bell Gear	50 T.	50 T.
T	Swing Gear	37 T.	42 T.
U	Back Bobbin Shaft Gear	42 T.	37 T.
U′	" " " Skew Bevel Gear	55 T.	55 T.
V	Front Bobbin Shaft Gear	42 T.	37 T.
V′	Bobbin Bevel Gear	30 T.	22 T.
*V*2	Bobbin.		
W	Swivel Bracket Gear	31 T.	31 T.
W′	Lift Change Gear, 12 to 30 T., advancing by 1 tooth (23, 24 & 25 T. regular).		
X	Gear on Stud Bevel Gear	44 T.	44 T.
X′	Bevel Gear driving Horizontal Bevel Gear	22 T.	22 & 15 T.
Y	Horizontal Bevel Gear	22 T.	22 & 30 T.
Y′	Bevel Gear, driving Reversing Bevel Gear	15 T.	15 & 13 T.
Z	Reversing Bevel Gear, short hub	70 T.	70 T.
Z′	" " " long "	70 T.	70 T.
*Z*2	Reversing Shaft Change Gear, 12 to 30 T., advancing by 1 tooth (generally fixed on frame for convenience, determined first by using *W′* = 24, and when all changes then are made in *W′*).		
*Z*3	Gear driven by Reversing Shaft Change Gear	80 T.	80 & 68 T.
*Z*4	Lifting Shaft Driving Gear	13 T.	13 T.
*Z*5	Lifting Shaft Gear	57 T.	73 T.

We will now in connection with Figs. 208, 209 and 210 quote a few calculations with reference to this fly frame.

To find speed (r.p.m.) of front roll: $\frac{\text{r.p.m. of } A \times A^2 \times G'}{G \times H}$

To find speed (r.p.m.) of spindles: $\dfrac{\text{r.p.m. of } A \times A' \times C'}{C \times D'}$

To find revolutions of spindles for one of front roll: $\dfrac{H \times G \times A' \times C'}{G' \times A^2 \times C \times D'}$

To find length in inches delivered per minute by front roll: Multiply speed of front roll by its circumference in inches

$$= \frac{\text{r.p.m. of } A \times A^2 \times G' \times \text{cir. of } H^2}{G \times H}$$

To find twists per inch: Divide the revolutions of spindles for one of front roll by circumference of front roll

$$= \frac{H \times G \times A' \times C'}{G' \times A^2 \times C \times D' \times \text{cir. of } H^2}$$

To find the number of teeth in twist gear A^2 to give required twists per inch:

$$\frac{H \times G \times A' \times C'}{G' \times * \times C \times D' \times \text{cir. of } H^2 \times \text{required twists per inch}}$$

To find constant for twist: Proceed as in previously given rule, omitting required twists per inch

$$= \frac{H \times G \times A' \times C'}{G' \times * \times C \times D' \times \text{cir. of } H^2}$$

To find total draft between front and back rolls:

$$\frac{J \times I \times \text{dia. of } H^2}{I' \times H' \times \text{dia. of } J^2}$$

To find number of teeth in draft gear for any required draft:

$$\frac{J \times I \times \text{dia. of } H^2}{* \times \text{required draft} \times H' \times \text{dia. of } J^2}$$

To find constant for draft: Proceed as in previously given rule, omitting required draft

$$= \frac{J \times I \times \text{dia. of } H^2}{* \times H' \times \text{dia. of } J^2}$$

To find layers per inch lift of bobbin:

$$\frac{Z^5 \times Z^3 \times Z \times Y \times X \times W \times Q' \times R' \times S' \times U'}{Z^4 \times Z^2 \times Y' \times X' \times W' \times Q \times R \times S \times U \times V' \times 6\frac{1}{3}}$$

(The distance traversed by the top rail for one revolution of the lifting shaft is $6\frac{1}{3}$ inches).

To find constant for layers per inch lift of bobbin: Proceed as in previously given rule, omitting reversing shaft change gear Z^2 and lift change gear W', i. e., thus:

$$\frac{Z^5 \times Z^3 \times Z \times Y \times X \times W \times Q' \times R' \times S' \times U'}{Z^4 \times * \times Y' \times X' \times * \times Q \times R \times S \times U \times V' \times 6\frac{1}{3}}$$

Substituting gearing, as is uniform for all their frames

$$= \frac{Z^5 \times Z^3 \times 70 \times Y \times 44 \times 31 \times 18 \times 16 \times 50 \times 55}{13 \times * \times Y' \times X' \times * \times 34 \times 30 \times 48 \times U \times V' \times 6\frac{1}{3}}$$

$$= \frac{Z^5 \times Z^3 \times Y}{Y' \times X' \times U \times V'} \times 18759.46$$

TABLE OF CONSTANTS FOR LAYERS PER INCH LIFT.

Frame	Back Bobbin Shaft Gear U	Bobbin Bevel Gear V'	Bev. Gear driv. Hor. Bev. Gear X'	Horizontal Bevel Gear Y	Bev. Gear driv. Rev. Bev. Gear Y'	Gear driven by Rev. Sh. Ch. Gear Z^3	Lift Shaft Gear Z^5	Constant
Slub & Int.	42 T.	30 T.	22 T.	22 T.	15 T.	80 T.	57 T.	4526.09
Roving....	37 T.	22 T.	22 T.	22 T.	15 T.	80 T.	73 T.	8972.58
Fine Rov..	37 T.	22 T.	15 T.	30 T.	13 T.	68 T.	73 T.	17600.07

To find number of teeth in change gears Z^2 and W', constant for layers per inch lift, and required layers per inch lift being given: Divide the constant for layers per inch lift by the required layers per inch lift; the quotient being equal to the product of the number of teeth in change gears Z^2 and W', from which the respective gears may be proportioned.

To find the layers per inch lift, number of teeth in change gears Z^2 and W' and constant for layers per inch lift being given: Divide constant for layers per inch lift by the product of number of teeth in change gears Z^2 and W'; the quotient being equal to the layers per inch lift.

To find the number of teeth in change gears Z^2 and W', when altering layers per inch lift: $\frac{\text{Present layers per inch lift}}{\text{Required layers per inch lift}} \times$ Present $(Z^2 \times W')$. For convenience in calculations, it is well to assume a value for W', for example 24 T. The product $Z^2 \times W'$ divided by 24 will give number of teeth in gear Z^2. Experience has proved that it is best to fix the number of teeth in gear Z in the above manner for the desired range of hank roving. Subsequent changes for varying layers per inch lift being made in gear W' which is quickly reached.

Curtis & Rhodes' Differential.—This is another type of differential, it being the one used in connection with the fly frames as built by Platt Brothers & Co., Ltd. Fig. 212 shows the arrangement of the gears of the motion. It appears somewhat similar to the Daly Differential, but differs from it in having the gears differently driven and a different one

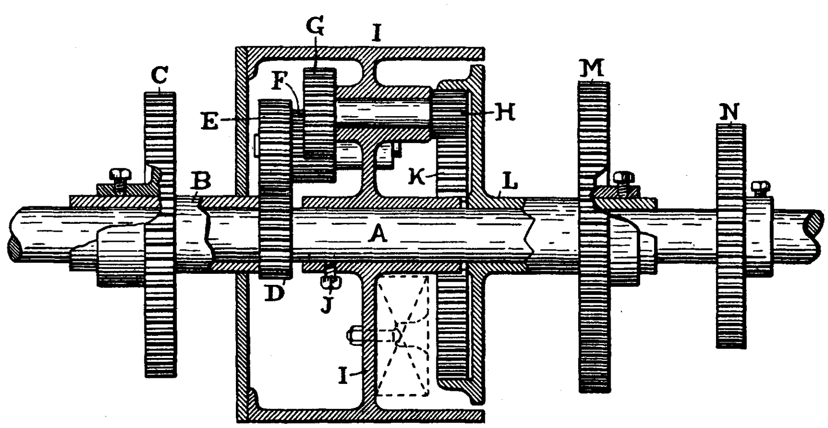


FIG. 212.

made fast to the shaft. More gears are used in this motion than in the others, but which is not a disadvantage but rather an advantage, since they may be kept well lubricated and prevent any excess friction among them, and also it will be shown that they do not revolve fast. Referring to the illustration, A indicates the main driving shaft, on which is loosely placed a collar B, carrying a gear C at one end, which is driven from the bottom cone through gearing. On the other end of the collar B is a gear D which meshes with a gear E on the same stud with a gear F, and this in turn meshes into the gear G on the same stud with a gear H. The studs on which the gears E, F, G and H are fastened, are carried in bearings, by a disk I, said disk being secured on the main shaft by means of a set screw J, and hence it revolves with it. The gear H meshes into an internal gear K, which is on a collar L, loosely placed on the main shaft, this collar also carrying a gear M from which, through a train of gears, the bobbins are driven. N indicates the spindle driving wheel.

In order to trace the motion of the gears, we will first consider that the disk I is loosened from the shaft A and held stationary, and the cones give rotation to the collar B through the gear C. Then the gear D will drive the gear M on the collar L through the gears E, F, G, H and K respectively in the same direction as itself, or in other words, the value of the train is positive.

If this were the case, the gears in the train would all revolve more or less rapidly to correspond to the speed of the gear D and consequently cause a corresponding amount of friction, due to the number of gears in the train, but in actual practice this would not occur, since the disk I is fastened to the main shaft and its revolution will carry the gears around in the same direction and almost as fast as the gear D, thus having the whole motion work with scarcely any axial movement of the gears as carried by the disk I. This condition of course reduces the friction, etc., to a minimum between the gears. The gear K through the gear H will receive rotation to correspond to that of the disk I and also a movement from the train of gears from the cone drive. As the bobbin builds, the gear D is driven slower from the cones, which causes the train in the disk to revolve faster, but never at such a rate as to make trouble from any friction among the gears. The weight of the train in the motion is counterbalanced by placing a dead weight (see dotted lines) on the opposite side of the disk from the gearing.

The calculation for the motion is made in a similar manner to those described in connection with former differentials, the chief points being to accurately find the value of the train, whether positive or negative, and giving to the gears their proper letters to represent the number of revolutions. The number of teeth in the gears of the train are as follows: Gear $D = 30$ teeth, gear $E = 25$ teeth, gear $F = 17$ teeth, gear $G = 30$ teeth, gear $H = 14$ teeth, gear $K = 90$ teeth.

The value "**e**" of the train is therefore:

$$\frac{30 \times 17 \times 14}{25 \times 30 \times 90} = \frac{119}{1125}$$

Say the gear D is held stationary or "**m**" = 0 revolutions, and the main shaft revolves at 300 r.p.m., or the disk (arm) has "**a**" = 300 revolutions, then the problem is to find the value "**n**" for the revolutions to the bobbin driving gear M on the same collar with the gear K.

$$\mathbf{e} = \frac{\mathbf{n} - \mathbf{a}}{\mathbf{m} - \mathbf{a}}$$

$$\frac{119}{1125} = \frac{n - 300}{0 - 300}$$

$$\begin{aligned} - 35700 &= 1125\,n - 337500 \\ - 1125\,n &= 35700 - 337500 \\ - 1125\,n &= - 301800 \\ n &= 269.1 \text{ revolutions.} \end{aligned}$$

Taking an example from a frame in working order, we will assume the values for the known revolutions, since they have been calculated to be approximately what are given. Say that the gear *M* has to make "**n**" = 299 revolutions, the main shaft "**a**" = 308 revolutions, and the question is to find the revolutions "**m**" of the gear *D*, from which the cone gear could be calculated.

$$e = \frac{n - a}{m - a}$$

$$\frac{119}{1125} = \frac{299 - 308}{m - 308}$$

$$\begin{aligned} 119\,m - 36652 &= - 3375 \\ 119\,m &= 36652 - 3375 \\ 119\,m &= 33277 \\ m &= 279.6 \text{ revolutions.} \end{aligned}$$

From this, in connection with the train of gearing from the bottom cone, the cone gear is easily calculated.

Gearing and Calculations of Platt Brothers & Co.'s Fly Frame.—Fig. 213 is a diagram of the fly frame as built by Platt Brothers & Co., Ltd., and to which frame as mentioned before, the Curtis and Rhodes' Differential refers to. Letters of reference accompanying the illustration indicate thus:

TWIST ARRANGEMENT.

		Slub.	Int.	Rov.
A	Twist change gear.			
B	Middle top cone shaft gear.			
C	Gear end top cone or back shaft gear	51 T.	42 T.	35 T
D	Front roll gear..................	130 T.	130 T.	130 T.
K	Spindle driving gear	39 T.	39 T.	33 T.
L	Spindle shaft or bottom coupling gears.................	39 T.	39 T.	33 T

DRAFT ARRANGEMENT.

		Slub.	Int.	Rov.
E	Front roller pinion	24 or 28 T.	24 or 28 T.	24 or 28 T.
F	Crown gear	90 T.	90 T.	90 T
G	Draft change gear.			
H	Back roller gear	48 or 56 T	48 or 56 T.	48 or 56 T.
I	Back roller pinion.			
J	Middle roller pinion.			

BOBBIN DRIVING ARRANGEMENT.

M	Top cone (concave).			
N	Bottom cone (convex).			
O	Spur wheel on bottom short cone shaft	54 T.	54 T.	54 T.
P	Stud gear	60 T.	60 T	60 T.
Q	Taking-up or winding change gear.			
R	Long socket gear (outside box)	106 T.	106 T.	106 T.
S	Long socket pinion	30 T.	30 T.	30 T.
T	Compound carrier (inside box)	25 T	25 T	25 T.
U		24 T.	24 T	17 T.
V	Single gear " "	24 T.	24 T.	30 T.
W	Stud pinion " "	14 T.	14 T.	14 T.
X	Internal gear (for bobbin to lead)	90 T.	90 T.	90 T.
Y	Bobbin driving or box gear	58 T.	58 T	47 T.

LIFTING ARRANGEMENT.

a	Bevel on short cone shaft	13 T.	13 T.	13 T.
b	Plate bevel on short horizontal shaft	50 T.	50 T.	50 T.
c	Small " " " "	14 T.	12 T.	10 T.
d	Reversing bevels	100 T.	100 T.	100 T.
e	Lifter change gear on reversing shaft	18 T.	16 T.	13 T
f	Compound carrier	40 T.	40 T.	50 T.
g		28 T.	18 T.	17 T.
h	Lifter shaft gear	90 T.	90 T.	90 T.
k	Lifter rack pinion	22 T.	22 T.	22 T.

Comparing illustrations Figs. 212 and 213 with reference to the differential, we find that:

R in Fig. 213 = *C* in Fig. 212	*V* in Fig. 213 = *G* in Fig. 212
S " " " = *D* " " "	*W* " " " = *H* " " "
T " " " = *E* " " "	*X* " " " = *K* " " "
U " " " = *F* " " "	*Y* " " " = *M* " " "

K in Fig. 213 = *N* in Fig 212.

We will now quote a few calculations with reference to this fly frame:

To find speed of spindles: $\text{Speed of pulley shaft} \times \dfrac{\text{K} \times \text{skew gear}}{\text{L}}$

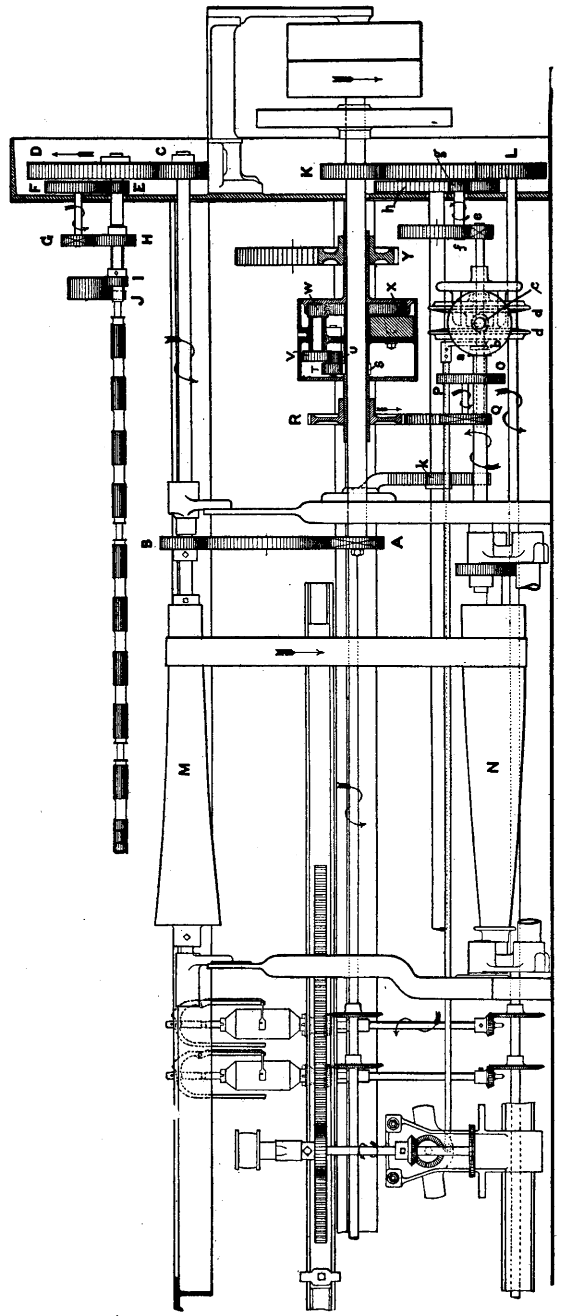


Fig. 213.

To find speed of front roller: Speed of pulley shaft $\times \dfrac{A \times C}{B \times D}$

To find turns of spindle for one turn of front roller:

$$\frac{D \times B \times \text{skew gear}}{C \times A}$$

To find turns of twist per inch: $\dfrac{D \times B \times \text{skew gear}}{C \times A} \div$ by circumference of front roller = Turns of twist per inch.

To find constant number for twist:

$$\frac{D \times B \times \text{skew gear}}{C \times \text{circum. of front roller}} = \text{Constant number.}$$

To find draft: $\dfrac{\text{Dia. of front roller} \times H \times F}{\text{Dia. of back roller} \times G \times E} = \text{Total draft.}$

To find constant number for draft:

$$\frac{\text{Dia. of front roller} \times H \times F}{\text{Dia. of back roller} \times \quad E} = \text{Constant number.}$$

To find draft between middle and back rollers, or breakage draft:

$$\frac{\text{Dia. of 2nd roller} \times I}{\text{Dia. of 3rd roller} \times J}$$

To find the layers per inch of lift:

$$\frac{h \times f \times d \times b \times N \times C \times \text{dia. of front roller}}{g \times e \times c \times a \times M \times D \times \text{dia. of empty bobbin} \times 6.9}$$

(6.9 is the distance traveled by the top rail whilst the lifting shaft makes one revolution. In this case the diameters of top and bottom cones should be taken at centre of strap when set for empty bobbin).

To find approximate speed of bobbins:

1st. To find speed of long socket wheel (*R*):

$$\frac{\text{Speed of pulley shaft} \times A \times M \times O \times Q}{B \times N \times P \times R}$$

2nd. To find speed of bobbin driving wheel (*Y*):

$$\frac{\text{Speed of R} - \text{speed of pulley shaft} \times S \times U \times W + \text{speed of pulley shaft}}{T \times V \times X}$$

3rd. To find speed of bobbins: $\frac{\text{Speed of } Y \times Y \times \text{skew gear}}{Z}$

Dobson & Barlow's Differential.—This motion is shown in its cross section in Fig. 214 and differs from the preceding differentials principally in the fact that the epicyclic train of gearing is absent. Its gearing being thoroughly immersed in oil, little power is required to drive it, the motion running with very little noise.

Referring to the illustration for the details of the motion, *A* indicates the driving shaft of the machine, having secured to it the straight faced bevel wheel *B* which does the entire driving of the bobbins, the variation in the speed of the bobbins being obtained by altering this drive between said bevel *B* and the bobbin driving gear *G*. Meshing into the bevel *B* is a larger straight bevel *C*, of a peculiar shape, being mounted loosely on a spherical shaped bearing *D*, so that it may be moved horizontally by the cam *E* pressing against the outer rim on said bevel *C*. This special form of bearing is used to allow a small portion of gear *C* to be in gear at a point with *B*, and a portion of the gear *H* to be also in gear at a point with *I*, but on the opposite side of the axis of gear *C* from the former point of contact.

Thus, the double toothed gear *C* works in an oblique position, which is obtained by the pressure of the cam against the rim of the gear *C*.

It will be noticed that the cam *E* is so shaped as to always keep a portion of the teeth on bevel *C* in mesh with bevel *B*. The cam is made by simply cutting the cylinder at a slant to its transverse vertical cross section. The bevel *I*, into which the gear *H* meshes at one point, is secured on the collar of the bearing *D*, which also carries the bobbin driving gear *G*.

The bevels *B* and *C*, when in mesh, act very much like a simple clutch arrangement, and provided they contained the same number of teeth, it would amount to the same thing as a clutch, in so far as transmitting motion was concerned. Such is the case with the bevels *H* and *I*, that is, they contain the same number of teeth and are used simply as a convenient way of transmitting the motion from gear *C*, the gear *B* revolving at the same speed as gear *H*.

Provided there was no cam arrangement to put different teeth of gear *C* in mesh with those of *B*, the two gears would then act as a clutch also, and both revolve at the same speed; but the cam arrangement is provided on the motion and it is this point which will need consideration. In order to keep the two gears in contact with each other and with the same teeth in contact, it will be necessary to revolve the cam *E* at the same speed as the gear *B* in order to have the same points of the cam and

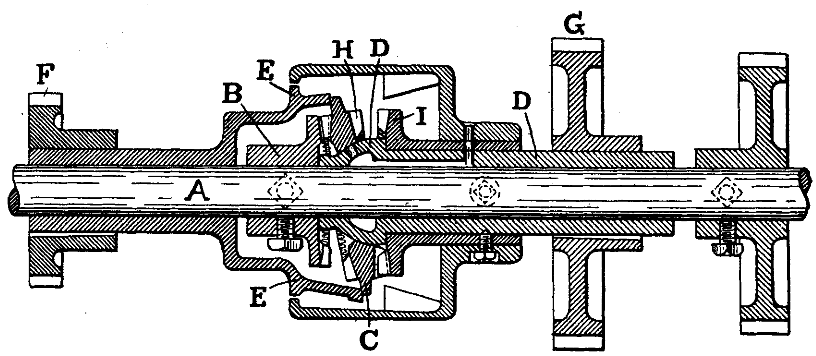


FIG. 214.

rim of the bevel *C* always kept together. When the cam revolves at a slower speed than the gear *B*, a new condition is made and the two gears are not locked, as in the case when the speed was the same. The cam is driven from the bottom cone of the machine through gearing to the gear *F*, as secured to the same cylinder on which the cam is cut, and consequently is capable of a variable motion with a corresponding variation being produced in the revolution of the gear *C*.

The result of the slower motion of the cam on the gears may now be seen. The first thing to be noticed is that different points on the cam will come in contact with different points on the rim of the gear *C*, and consequently different teeth will be successively pushed out of contact with the gear *B*. It is for this reason that the bearing of gear *C* is made spherical. Now if both gears *B* and *C* had the same number of teeth and the cam remained stationary, after all of the teeth of gear *B* had been meshed, all of the teeth in gear *C* would have been similarly meshed, and therefore gear *C* would not receive motion. For example, consider that gear *B* contains 32 teeth and gear *C* has 36 teeth, then when gear *B* has had all of its teeth in mesh once, say in one revolution, there would be 4 teeth in the 36 gear which had not meshed; or in other words, the last or 32nd tooth of gear *B* would be in gear with the 32nd tooth of the 36 gear, which would throw the remaining 4 teeth forward and thus give the 36 gear $\frac{4}{36}$ or $\frac{1}{9}$ of a revolution in a forward direction. Now it is the speed of the cam which determines how fast the change in meshing shall take place, and the faster this change takes place, the slower the gear *C* will revolve. The nearer the speed of the cam approaches the speed of the gear *B*, the slower the change in meshing takes place, so that the speed of the gear *C* is thus greater. As the speed of the cam is reduced, the change in meshing is quicker and consequently the speed of gear *C* is reduced. It, of course, requires a number of revolutions of the cam to effect any appreciable change in the speeds of the gears *B* and *C*, because of the speed of the gear *B* itself, and the two gears practically act as a clutch, as mentioned, with the slight variation from the cam. The gear *C* is thus continually rocked back and forth, and in order to transmit its revolutions into regular motion, the gears *H* and *I* are made use of, and further than this they do not affect the motion of the gears. It will be clear from the explanation that very little friction or noise can exist in the motion, since the difference in the two speeds of the gears is quite small.

The calculation for the speeds of the gears can readily be made by using formulas as previously used in connection with the other differentials, the only difference being in the method of finding the value of "**e**" of the train. In the motion, the gear *B* has 32 teeth, gear $C = 36$ teeth and the gears *H* and $I = 36$ each, and since they are the same, no account need be taken of them, except they be considered as a clutch.

The value of the train will then be $\frac{36 - 32}{36} = \frac{1}{9}$ which is positive, as has just been proved.

For an example to calculate, we will consider that gear *B* makes "**a**" = 165 revolutions, and the bobbin driving gear *G* (and consequently *I*) makes "**n**" = 188 revolutions, and the problem is to find the speed "**m**" of the cam *E*, in order to give the speed mentioned, to the bobbin driving gear *G*.

We then have the formula: $\mathbf{e} = \frac{\mathbf{n} - \mathbf{a}}{\mathbf{m} - \mathbf{a}}$ and substituting the proper figures: $\frac{1}{9} = \frac{188 - 165}{\mathbf{m} - 165}$

$\mathbf{m} - 165 = 207$ and

$\mathbf{m} = 372$ revolutions of the cam *E*, from which, in connection with the train of gearing from the bottom cone, the cone gear may be easily calculated, as explained in connection with gearings of fly frames given before.

Builder Motion.—As has been previously explained, only rotary motion is imparted to the spindles, whereas the bobbins receive besides a rotary motion also a vertical movement in order to build up the bobbins;

the latter with its respective gears being for this purpose carried in what is known as the carriage of the machine, and to which an up and down movement is imparted. The slubbing or the roving is placed upon the bobbin, in spiral laps lying closely side by side by the alternating vertical movement of the carriage, which rises or falls a distance equal to the diameter of the roving while the bobbin and flyer gain one turn, the one upon the other. The speed of the carriage thus always decreases as the bobbins fill. In the fly frames the decrease in speed of the carriage is effected directly by the cones, while the speed of the bobbin is regulated by the same cones combined with the differential motion.

The bobbins must be built up in such a shape so that they will permit handling from one machine to another without damage to the roving. For this reason these bobbins are formed into conical ends by the slubbing or the roving as it lays itself onto the bobbin.

On account of the weakness of the slubbing and the roving, very light bobbins should be made so that they may permit the slubbing or the roving, as the case may be, to be readily unwound when in the creel, at the next process. The bobbins as used are simply tubes without heads. In order that a firmly built bobbin may be obtained, and one in which the rows of slubbing or the roving will not ravel at the ends, the latter as previously mentioned are made conical in shape, the angle most suitable being about 45°, as shown in connection with bobbins in Figs. 184, 191, 194, etc. This build is accomplished by making each traverse of the builder a little bit shorter than the preceding one, i. e., shortening the traverse of the carriage in order to give this conical shape to the ends of the bobbins. The carriage thus must be made to reverse sooner after each successive layer of slubbing or roving has been added, and it is from this fact that the term "reversing motion" has been derived.

Working in connection with the reversing motion is an arrangement for moving the belt forward along the cones as the bobbins become filled. Since every additional layer requires a slower speed for the carriage than the preceding one, consequently each change of the traverse moves the belt automatically to the required position on the cones, such movement being equal for each layer.

As will be readily understood, the hank of the roving varies considerably in connection with different yarns spun in a mill, for which reason, when a coarse hank is dealt with, each layer will require a larger side movement of the cone belt than when a finer hank is made. To better explain the subject, let us consider that the cone belt starts and finishes the same for a coarse and a fine hank. It will be readily seen, that then the number of layers in the diameter of a full bobbin are more for the fine hank than if making a coarse hank, and for which reason the larger number of movements of the cone belt must be proportionally reduced in numbers so as to equal the fewer movements necessary for the building of the coarser hank.

Suppose for an example 2-hank roving is to be wound on a 5 in. dia. bobbin. Considering about 128 layers on top of each other, each layer (considering bobbin in its thickness) will require a movement of the cone strap. Considering cone drum 32 inches long, the answer will be $\frac{32}{128} = \frac{1}{4}$ of an inch for each layer wound.

Again, if for example dealing with a 5-hank roving, 5 in. dia. bobbin, and considering about 160 layers, consequently each layer will require a movement of the strap of $\frac{32}{160} = \frac{1}{5}$ of an inch. This lessened movement is arranged for in the reversing motion.

If such a change is to be made onto finer hank, the speed of the carriage must also be decreased in order that the coils may lie close together. This is done by changing the builder pinion in the inverse ratio of the square root of the hank of slubbing or roving, since this pinion is a driver. If changing onto a coarser hank, the reverse is to be done.

With reference to finding "Layers per inch lift" the following table, as furnished by the American Machine Co., may be used:

For 1 hank:	7.5 × square root of hank.
" 1.1 to 2 hank:	8.5 × " " " "
" 2.1 " 3 " :	9.5 × " " " "
" 3.1 " 4 " :	10.0 × " " " "
" 4.1 " 5 " :	10.5 × " " " "

Thus for example a 2-hank roving has $8.5 \times 1.4142 = 12.0207 = 12$ coils per inch lift. A 5-hank roving will have $10.5 \times 2.2361 = 23.479 = 23$ coils per inch lift, which will indicate to us that in connection with a 5-hank roving, the carriage will make its traverse at only about one half the speed as compared with a 2-hank roving.

Some overseers calculate these layers per inch lift at 10 times the square root of the hank for slubbing, and 12 or 13 times the square root of the hank for roving, whereas others use for both items 10 as the constant; the affair in practical work depending also on kind of stock, length of staple, amount of twist, temperature and humidity, all having their effect; again some overseers wishing a close and some an open lay. With reference to calculating "square root," the reader is referred to pages 132 to 136 of my work on "Textile Calculations," i.e., Posselt's Textile Library Vol. I.

With reference to our gearing plans of fly frames given, it will be seen that the layers per inch depend on the speed of the cones, the rack of the carriage (*k* Fig. 200) being driven from this point (through gearing *j*, *i*, *h*, *g*, *f*, *d* or *e*, *c*, *b*, *a*, *V* and *T'*, *T* and *S*, see Fig. 200) and, as this speed is a varying one, it would seem to follow that the layers per inch lift would vary. However we must not lose sight of the fact that although we get a slower traverse, at the same time the rotation of the bobbin is slowed down correspondingly, and when consequently the pitch of the layers remains constant throughout the bobbin.

The layers of the roving have to be maintained uniformly apart from one another throughout the building up of the bobbin, a feature accomplished by the lay gear (see *f* in Fig. 200) which moves the carriage the same distance every time that it travels one tooth. The interval occupied in moving from one coil to another occupies a longer time as the bobbin fills, for the reason that it then takes a longer time for the bobbin to wind on one layer of roving than when it was small. For this reason, said lay gear is indirectly driven from the cones, and which at the same time correspondingly influence the speed of the bobbins.

The raising and lowering of the carriage is performed by means of the builder, any time that the carriage reaches either the top or bottom of its traverse. As the bobbin gets larger, these changes in traverse of the carriage become less frequent in a given time, for the simple reason that it takes continually more and more time to wind a layer of slubbing or roving on the bobbin as it fills itself.

The lay gear regulates the speed at which the carriage moves up or down, and consequently governs the distance between the individual layers of roving in one complete layer.

The taper gear in turn regulates the distance between the jaws of the builder, and consequently regulates the taper at each end of the bobbin.

The tension gear regulates the distance that the cone belt moves along the cones.

The moving of the cone belt through the fixed distance, after each layer of slubbing or roving has been wound on the bobbin, is done by the "builder motion," the working of which is intimately connected with the up and downward traverse of the carriage. It will thus be best to first give a description of how the carriage is traversed: Referring again to Fig. 200, the connection between the main shaft *B* and the bottom cone *R'* will be seen at once. On the shaft with the bottom cone is pinion *S*, which meshes with the compound carrier *T T'*. This latter gear *T'* meshes with the gear *V*, on the end of the spider shaft *U*. A bevel gear *a* on the latter shaft meshes with another bevel *b*, fast on the upright shaft carrying on its lower end the "strike pinion" *c*, which meshes with either "strike bevels" *d* or *e*, fast upon the shaft *l*, which carries on its end the "lay gear" *f* as meshing in turn with the gear *g*. The latter carries on the same shaft a gear *h*, which in turn meshes with a large gear *i* on the lifter shaft *m*, as extends the whole length of the fly frame, having at a certain distance apart, several pinions *j*, which mesh with racks (*k* = one of these) attached to the carriage. Gearing thus explained is the means for the traverse of the carriage. At the end of the winding of each layer the strike pinion *c* is thrown out of gear with *d* and into gear with *e*, or vice versa, the direction of traverse of carriage depending upon which strike bevel (*d* or *e*) the strike pinion (*c*) happens to be meshing with.

The weight of the carriage is either counterbalanced by several heavy weights, attached at suitable distances apart throughout the entire length of the frame to the carriage by chains; or what is known as a self balanced carriage is introduced.

The use of balance weights, for balancing the weight of the carriage, will be readily seen by consulting Fig. 219 (see page 257). Balance weights for rails should be either lighter than the rail with bobbins empty or heavier than the rail with the bobbins full, as it is bad when they balance each other, for when the latter is the case, the rail will run unsteady, bobbins will not wind well, nor will the full bobbins present a smooth appearance.

With reference to the self balanced carriage (or rail) this affair refers to fly frames as built by the Providence Machine Co.; in this case the carriage (or bobbin rail) being cut into two equal sections, and when running, one section rises while the other descends, one section thus balancing the other, in turn making the use of weights unnecessary. Each section of the carriage is worked from independent builder racks, as are placed on opposite sides of the lifter shaft and are worked from lifter shaft pinions all fast to said lifter shaft. Each section in turn also requires its own train of gearing for driving the bobbins, from main shaft to bobbin shaft, technically known as the "horse head," one being placed as usual towards the driving end of the machine, while the other is placed in the centre of the frame; this second horse head being driven from an extra gear placed between the gear driving the first horse head. This gear drives another gear situated on a shaft which extends to the second horse head, at which place there is another gear meshing with the horse head gears. This self balancing carriage permits a larger number of spindles per frame to be used, it will however cause a break in the front roll, i. e., for a space of several inches no roving can be delivered. The bottom rolls are similar as in other frames, in one piece, the only difference being that where said break occurs in the rail, they are smooth in place of being fluted.

The function of the builder motion is to make all the changes that occur after one layer of slubbing or roving has been wound, viz: Changing of the direction of motion of carriage, moving the cone belt a certain distance, and last, shortening of the traverse of the carriage.

Fig. 215 shows what is known as the "Hill-builder" and its relation to the rest of the fly frame. Examining said diagram we see two rectangular plates or jaws *A* and *B*, the same being threaded upon a screw *C*, supported by a casting made fast to the carriage, and which screw for one half of its length has the inclination of the thread running opposite to that on the other half portion of the screw. For this reason, when said screw is revolved, the plates *A* and *B* are moved either towards or away from each other, according which way screw *C* revolves, a feature which in turn when plates are moved toward each other results in shortening the traverse of the carriage, i. e., bobbin rail. Both, the screw and plates, move up and down with the carriage. The plates (or jaws, as sometimes called) occupy the position shown in the illustration, and form a bearing surface for the "tumbling dog" *D*, as keyed to the upright (tumbler) shaft *E*. Fastened to the latter is the horizontal disc *F*,

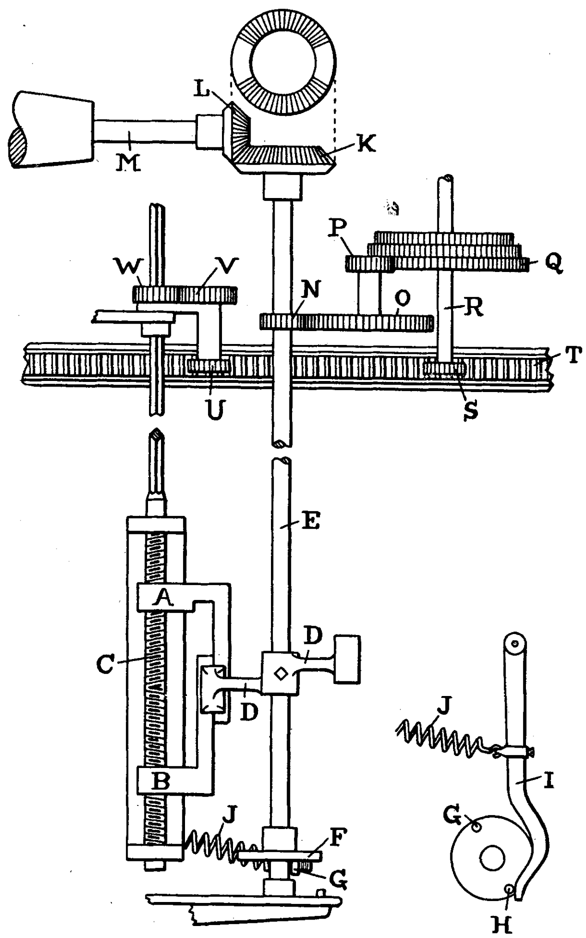


FIG. 215.

downward from which extend two pins *G* and *H*, a finger *I* being held in contact with *G* or *H*, as the case may be, by the spring *J*, this arrangement holding one or the other part of the tumbling dog against the plane surface formed by the plates *A* and *B*. The latter move up and down with the carriage, thus the surface against which one or the other arm of the tumbling dog *D* rests, will at one time be removed entirely from said arm, which then will slide off the bottom or the top, as the case may be. Since said arm then has nothing against which to bear, the pressure of the spring *J* will tend to revolve the upright shaft *E*; its pressure however not being sufficient to turn shaft *E* through a half revolution, for which reason there is placed on the top of said upright shaft a gapped bevel gear *K*, which meshes with a solid bevel gear *L*, fast on the top cone shaft *M*. When the builder motion is idle, i. e., shaft *E* not revolving, then gear *L* fits into the gap in the gear *K*; but when shaft *E* is partially revolved by the pressure of the spring *J*, as previously referred to, then the teeth in the gapped bevel gear are brought into contact with those in the solid bevel, thereby turning upright shaft *E* quickly through half a revolution, being prevented from moving farther by the pressure of the other arm of the tumbling dog *D* against plates *A* and *B*, finger *I* and spring *J* acting as a sort of brake to the tumbling dog, preventing its arms from striking plates with unnecessary force.

On the bottom of shaft *E* is a cam which fits into an elliptical slot in a casting fastened to the rod *n* (see Fig. 200). In the end of this rod is formed a swivel joint *t*, so as to connect the rod *n* with the moving shaft *l* (Fig. 200). When thus the upright shaft *E* makes its half revolution, previously referred to, the cam presses against one side of the elliptical slot in the end of *n*, in turn thereby moving *n* either to the right or to the left, and with it also the shaft *l* and the gears thereon. This will throw one of the strike bevels *d* or *e* (Fig. 200) into contact and the other out of contact with the strike gear *c*. Lay gear *f* on account of its width will never be out of gear with the gear *g*.

Coming back to Fig. 215 we find near the top of the upright shaft *E*, a pinion *N*, which meshes with a gear *O*, carried in a movable arm. On the stud with *O* is a pinion *P*, which in turn meshes with a gear *Q*, on a second upright shaft *R*. A small pinion *S* on this shaft engages with the cone rack *T*, as has attached to it the fork for moving the cone belt (see R^2 Fig. 200). In this manner the cone belt is moved along the cones at a certain distance, at the end of the winding of each layer of slubbing or roving. By changing the rack gear *U* (see Fig. 215) to a smaller gear, the rack *T* is moved a shorter distance, thus causing the builder to be closed slower; also the belt to be moved along the cones slower.

The last change previously referred to, i. e., the shortening of the traverse of the carriage, is accomplished thus: A casting carrying the two small gears *U* and *V* is secured to the frame work of the machine, and of which *U* meshes with the cone rack *T*, whereas *V* is on the stud with *U*, and in turn meshes with gear *W*, mounted onto the upward extending shaft from screw *C*, which for this purpose is square in cross section and protrudes through a square hole in the gear *W*. This shaft is consequently free to move up and down through gear *W*, when the screw *C* is carried up and down by the traverse of the carriage. Gears *U*, *V* and *W* are set in motion by means of the lateral movement of the cone rack T, screw C thereby partially revolving on its own axis and moving the plates A and B a short distance toward each other, with the result that at the next traverse of the carriage, the tumbling dog will not have such a long surface upon which to bear, therefore making its half revolution somewhat sooner. Both plates, A and B, by means of screw C, are moved towards each other the same distance, for which reason each layer of slubbing or roving will be wound on the bobbin somewhat shorter than the preceding one, in this way giving the characteristic cone shape to the bobbin at both ends.

It might be mentioned that all three changes thus explained occur simultaneously every time the carriage reaches either its highest or lowest point of its traverse.

Changing the contact of gear P to one or the other of the three contacts shown, causes the roving delivered by the front roll to become either slack or tight, according to the number of teeth in gear Q. The belt guide, which moves the belt on the cones, is fastened to the rack T, consequently any movement of the rack simultaneously moves the belt on the cones.

Bobbins Z (see Fig. 200) are driven by the bevel gears M and L, and the train of gears H, I and J.

The carrier gear I, as situated between gears H and J, is sustained in what is known as the horse head and which is centred on the main shaft B of the frame. The horse head frame is made double, in order to provide bearings for the arbors of the gears, it being secured to the carriage, as extending the whole length of the frame, and which contains the bobbin driving shafts and gears previously referred to, sustained in suitable bearings.

The Horse Head.—As previously mentioned, a vertical traverse for a certain distance in each direction, known as the "lift," is given to the carriage, and during this traverse the bobbins slide upon their respective spindles. The extent of this traverse varies, it being from 9 to 12 inches in slubbing frames, from 8 to 10 inches in intermediate frames, from 6 to 8 inches in roving frames, and from $4\frac{1}{2}$ to 7 inches in jack frames. At the same time that the bobbins are traversed vertically on their respective spindles, they at the same time must be rotated. It will be at once understood, that on account of the traverse motion given to the carriage, i. e., its shafts and gears, the latter (and thus indirectly the bobbins) cannot be driven by means of a stationary drive, it being done by means of what is known as the "horse head drive," which properly considered is nothing else but a flexible drive connection between the main shaft of the frame and the bobbin gear, so that as the carriage rises and falls, it carries the gears composing the horse head with it, and thus no break in the driving connection takes place. By consulting Fig. 200, it will be seen that the horse head thus fastened at one end to the carriage and centred to the main shaft of the frame at its other end, is caused to swing on its centre, the gear J and the carrier *I* being made to rotate round a part of the circumference of *H*. In this way the necessary constant driving of the bobbin is obtained during any position of the carriage in its traverse, and which is imparted by another train of gears previously explained. In some frames two carrier or intermediate gears in place of the one described (*I*) are used, but the result is the same. Using an additional carrier, as will be readily understood, requires an additional link connection.

In order to give a clear understanding of the working of a horse head drive in connection with a fly frame, illustration Fig. 216 is given, the same representing a portion of the head end of a fly frame, shown broken out, in order to show a view of this flexible driving mechanism,

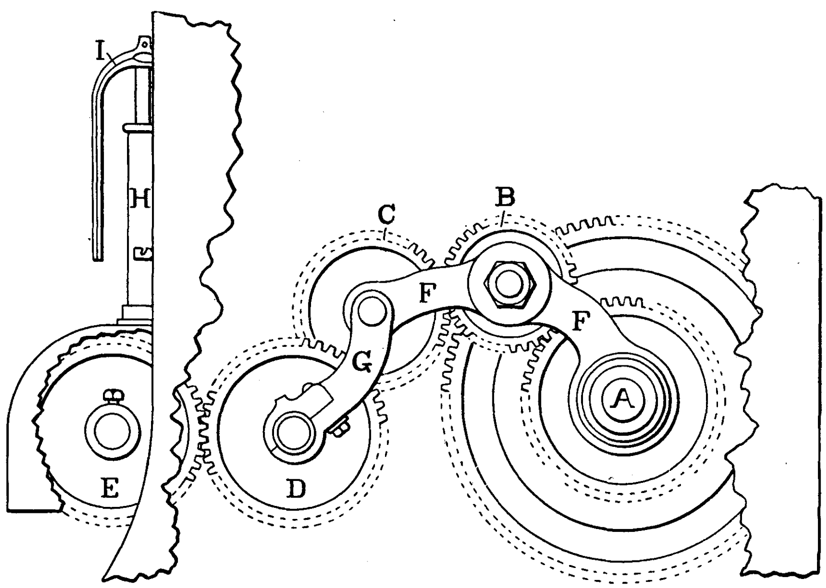


FIG. 216.

and which at once will explain itself by quoting letters of reference accompanying the illustration. The same refers to a two carrier arrangement, explaining at the same time the principle governing a single carrier arrangement.

A is the main shaft of the fly frame (= *B* in Fig. 200). *B* and *C* in our illustration Fig. 216 are the two carrier gears of the horse head. *D* is the back bobbin, and *E* the front bobbin shaft gear. *F* and *G* are the links for carrying the carrier gears as transmitting rotation from the main shaft of the frame to the bobbin shaft driving gears. *H* shows a portion of the bobbin, and *I* that of the flyer.

A is the centre or fulcrum for the horse head, *D*, *E* and *H* being the parts of the frame which receive a traverse motion, i. e., lift of the carriage, links F and G, and gears B and C being the means for transmitting the rotary motion to them. For the reason that gear B will transmit motion irrespective of position of link F, gear C will transmit motion from gear B to gear D irrespective of the position of the link G.

Considering the working of the horse head drive from a technical point of view, we will be convinced that a slight change in the bobbin drive must take place considering the up and down motion of the traverse, for the fact that when gear B, as held in its proper place by means of the stud in the middle of the link F, travels on the gear fast to the main shaft, it receives during the rise of the carriage an additional speed, which is gotten from the link F moving on its centre, as well as the gear B rotating on its own axis.

The gear on main shaft A travels in one direction, and consequently gear B revolves in the opposite direction. Provided arm F was stationary, uniform motion would then be imparted to gear B, but when this link, caused by the traverse of the carriage, changes to a more vertical position, the number of teeth required to get it into that position, will be the excess speed in this instance, as compared to the main speed of the frame, and which excess speed is in turn transferred to the bobbin gear. The reverse effect takes place when the carriage descends.

It follows, therefore, that during the ascent of the carriage, the bobbin will be slightly speeded up, the reverse being the case during its descent, a feature which in turn will have a tendency to somewhat stretch or thicken the roving alternately. This variation in speed from the normal speed, will be more pronounced in the later part of the lift of the carriage, although there is a certain amount present during the entire traverse. To overcome this disadvantage of "back lash," and which in turn will result in slight inequalities in the roving, we find in one make of frames the horse head drive done away with, using in its place a positive drive between the main and bobbin shafts, through an angle shaft, twin vertical shafts, and sliding gears, thereby giving an even tension to the roving at all points of the traverse of the carriage.

Fig. 217 is a section taken between the head end and first sampson showing spindle and bobbin shaft gearing in connection with the twin vertical shaft arrangement.

Examining this diagram, we find on a sleeve on the main shaft a bevel gear, driving another bevel gear on the lower end of the angle shaft; at the upper end of which there is another bevel gear, driving a bevel gear fast on the back vertical shaft, and it is from these gears that the shaft gets its motion. Below this bevel gear, on the vertical shaft, is seen a regular gear, which in turn meshes with a similar gear fast on the front vertical shaft, and from which gearing the latter gets its motion.

These vertical shafts extend from the under side of the roller beam almost to the floor, having their lower ends pointed and resting in a foot step, the upper ends resting in bearings secured by bolts to the under side of the beam of the fly frame. On the vertical shafts are sliding gears, adjusted so as to be always in contact with the bobbin gears, thus giving an even, positive motion to the bobbins. A groove is cut along the side of the vertical shafts, the inside of the sliding gears carrying a key fitting into these grooves; these sliding gears thus being

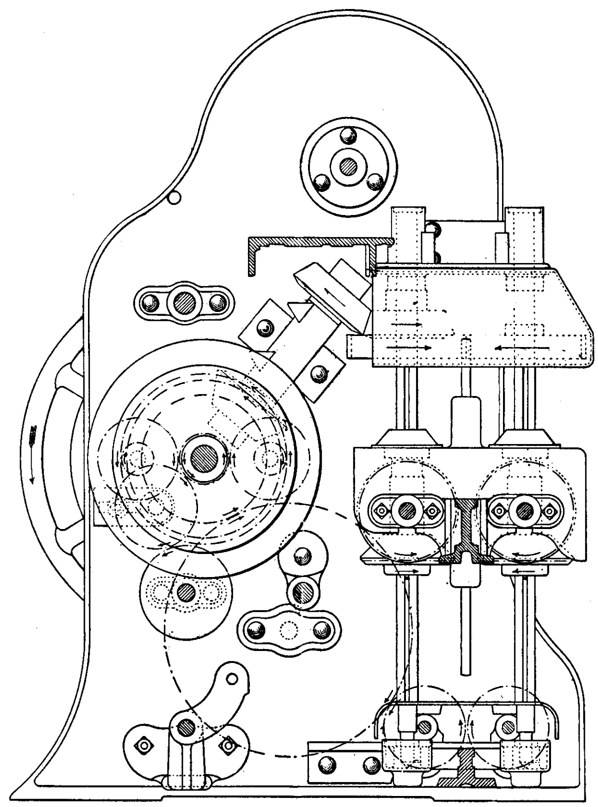


Fig. 217.

capable of traversing either up or down on the shafts, at the same time imparting motion to them and thus in turn to the bobbin driving shafts.

Tension Gear.—The tension gear has for its object to change the position of the belt on the cones at each change of the traverse of the carriage, i. e., as a new layer of slubbing or roving is wound upon the bobbin. Since the diameter of the bobbins thus increases with every layer, the speed of the bobbins must be decreased in proportion to its increase in diameter. It of course has no work to perform until the first layer has been wound upon the bobbin.

The tension gear lends itself less readily to mathematical calculation than any other gear on the fly frame, for the fact that temperature, humidity, twist and number of turns around the presser finger of the flyer influence calculations. Fig. 215 shows the position of the tension gear on the frame. The tension gear must be changed every time the hank of slubbing or roving is changed, for the fact that if roving of a finer hank is handled by the frame, the bobbin will less quickly get filled than when dealing with a coarser hank, for which reason the excess speed of the bobbin over the flyer must be decreased by a smaller amount at the end of each layer, said decrease being controlled by the movement of the cone belt, and the tension gear directly controls the required distance the belt has to be moved. In order to get as much slubbing or roving as possible on a bobbin, consistent with good work, attention should be paid to the action of the presser foot rather than upon the tension on the roving. As the roving is pulled away from the front roll, its tension on the presser foot tends to hold the latter close onto the bobbin. Consequently the more times we wrap the slubbing or roving around the presser foot, the tighter the bobbin will become, three coils around the presser foot, as a rule, giving the most satisfactory results, permitting in this way to wind about as many layers of slubbing or roving in an inch on the bobbin, as could be laid side by side in an inch, provided said slubbing or roving were perfectly cylindrical bodies.

Tension Regulating Device.—It is very difficult at times to get just the proper tension of the cotton on fly frames, on account of the atmospheric changes and also by the extreme change, made by changing one tooth of the small contact gear *P* (see Fig. 215). Usually this change is about one twentieth. This would either cause the cotton to run too tight or too slack, as the case might be; therefore, either stretching the cotton and making it run light, or slacken to such an extent as to cause it to run heavy, which, of course, means to the manufacturer an uneven weight of cloth, besides smaller productions from his frames.

To overcome this disadvantage as far as practicable, and at the same time make it handy for the overseer or second hand to make the required change with the least amount of labor on his part, the Woonsocket Machine Co. incorporate with their frames a tension regulating device, the same being shown in perspective in Fig. 218, and which in connection with diagram Fig. 215 will explain itself at once, since the reader can trace every gear or shaft between both illustrations, and when explanation given before in connection with diagram Fig. 215 will apply at the same time to such portions of the builder motion as shown in connection with Fig. 218. With this tension device, the change is all made at the front of the frame, and all that is required to be done by the person in charge of the frame is to unlock the controlling wheel, as prominently visible in the upper left hand part of the illustration, and turn the handle either to the right or left, as the case may require, which will make a change on intermediate or roving frames of one eightieth, and on jack frames a change of one ninety fifth. The change made is very fine, and the tension of the roving can be controlled to a nicety. It will be readily seen that the strong points in favor of

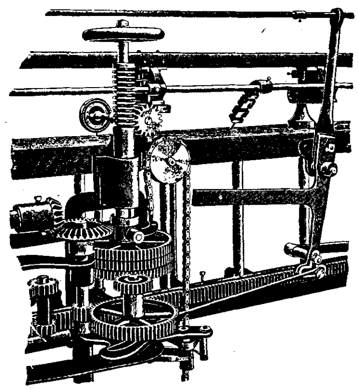


FIG. 218.

this device rest more particularly with the finer frames. With this arrangement, the cone belt always returns to its proper starting point, so that the tension will be proper when starting on empty bobbins.

The Saco & Pettee Lifting and Reversing Motion, as is characteristic to their make of frames, consists of a stiff lifting shaft supported by the bearings close to each lifting pinion; also at every sampson. This shaft runs the whole length of the frame, and is driven from the centre of the frame, thereby diminishing the liability to torsion. The pinions on this shaft are connected with a segment lifting arm, and a suitably curved extension of this arm supports a carrier truck which is held near the centre of gravity of the rail; thus overcoming all tendency of binding, either of the connecting arms against the sides, or of the bolsters and spindles. The object of this is to have the lift nearly under the centre of the load, i. e., the carriage, thus having a steady and easy movement of the rail. This lifting arrangement is shown in Fig. 219, showing also weights and method of driving the bobbins and spindles in this make of fly frames. From this illustration it will be seen that the main shaft of the machine is supported by bearings placed very close to the gears. It will be readily understood that when the lifting shaft is rotated in one or the other direction, the segment lifting arm, which has its teeth in engagement with the pinions as fast to the lifting shaft, will be either raised or lowered, according to which way the shaft is turning. The chain, as seen in the illustration, is fastened at one end to a pulley as fast on the lifting shaft, while its other end is secured to the weight, said chain being held in proper place by means

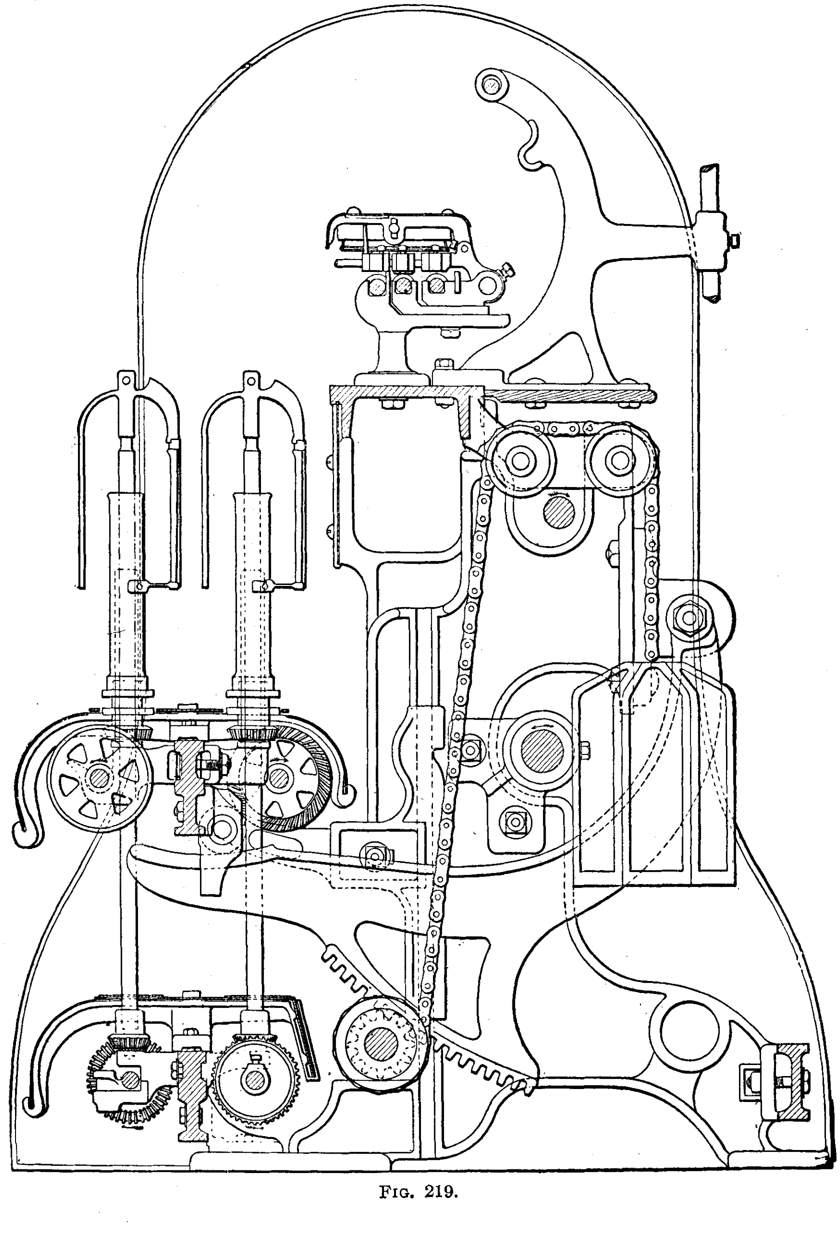


FIG. 219.

of two guide pulleys. The purpose of these weights is to balance, and thereby assist the carriage in its traverse; three or more according to length of frame, placed near the sampsons, being used for this purpose.

Stop Motions.—Fly frames, the same as combing, drawing, etc., machinery are provided with stop motions in order to facilitate the work to the operator, the same being provided for various purposes, viz: To stop machine when the bobbins have reached the required size; or when for some reason the carriage should move too far up or too far down; again to prevent the ends from breaking down in front should the cone belt break, etc.

A stop motion for stopping the frame when bobbins become full has been shown in its perspective view in connection with Fig. 218, at the right hand side of said illustration, the same being fastened to the cone rack with set screws. As the bobbins become full, the cone rack moves along and comes in contact with a lever, which is kept in position by a weight (not shown in this illustration). This lever is fastened on an upright rod, and at its upper end has an eye (see top of illustration) through which the shipper rod projects. On the latter is shown an egg shaped collar, which is capable of being adjusted along the shipper rod by means of a set screw. When the knock-off motion, on the rack, comes under the lever (of which only an end is shown) it swings the eye of the upright rod, previously referred to, slowly towards the collar, also previously mentioned, and in turn moves the shipper rod until the belt is on the loose pulley of the machine.

In order to give a detail description of this stop motion, diagrams Figs. 220 and 221 are given. With reference to Fig. 220, *A* is the lever shown also at the right hand side in Fig. 218, the same being fulcrumed at *B* to the frame of the machine. One arm of this lever extends upward, and by means of its eye *C*, formed in the end, engages with the egg shaped collar *D*, as movably secured to the shipper rod *E*. Pivoted to the lower end of lever *A* we find a flat rod *F*, the end of which is formed at *G* with a notch. *H* is the weight and *I* the cone rack. The illustration shows the device in normal position, i. e., while the frame is running the notch *G* engages with casting *J*, thereby holding the weighted lever *A* in position shown. Attached to the cone rack *I*, is an adjustable casting *K*.

The operation of the motion is thus: During the building of the bobbins, the cone rack moves gradually in the direction shown by the arrow *L*, consequently the curved projection *M*, on the casting *K*, gradually approaches the curved part of the rod *F*, and finally raises the rod, thus disengaging the notch *G* from the casting *J*, and in turn releases the lever *A*, which then by means of weight *H* swings around its fulcrum *B*, thereby moving the belt shipper rod *E* (on account of collar *D*) to the left, in turn transferring the driving belt from the fast to the loose pulley.

The stop motion as thus far explained, at the same time actuates the mechanism shown in detail in Fig. 221, and which represents a top view of the gearing which connects the tumbling dog shaft with the cone rack. Letters of reference accompanying the illustration indicate: *A* is the pinion on the tumbling dog shaft, and *B* and *C* are gears on one stud with each other, being carried on the arm *D*, which may swing

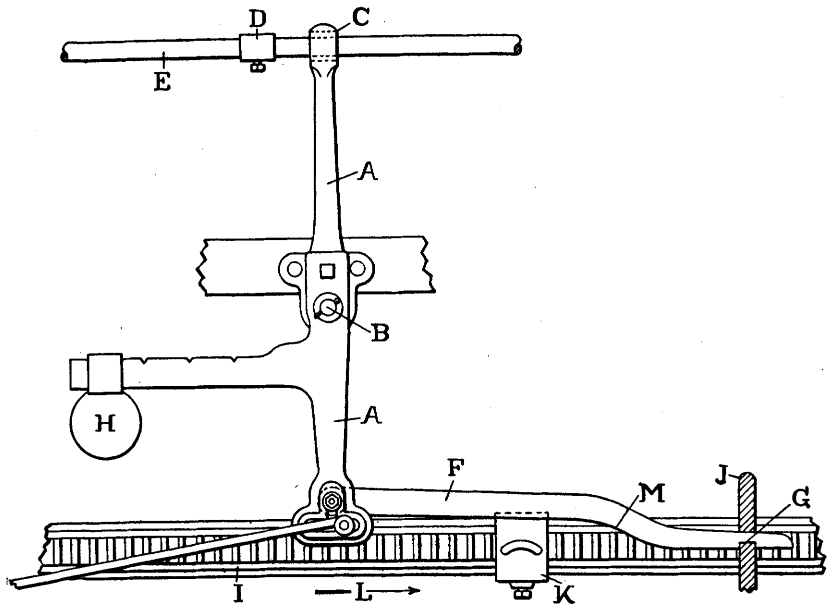


FIG. 220.

around the tumbling dog shaft. Gear *C* meshes with gear *E*, which, together with gear *F*, is on one upright shaft. The teeth of gear *F* mesh with those in the cone rack. Spring *L*, as is attached to the frame of

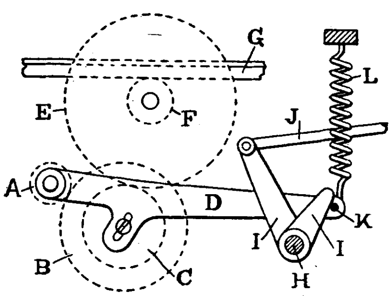


FIG. 221.

the machine and to the arm *D*, holds gear *C* in mesh with gear *E*. Stud *H*, as attached to the frame of the machine, has pivoted to it a bell crank lever *I*, the long arm of which in turn is connected by the connecting rod

J, a part of which is shown in our illustration, to the weighted lever (*A* in Fig. 220) of the device. The short arm of bell crank lever *I* rests against a pin *K* fastened to the arm *D*.

When the stop motion is actuated, as previously mentioned, the connecting rod *J* is moved to the right, and thus the arm *D* turned about the tumbling dog shaft by the pressure of the short arm of bell crank lever *I* upon the pin *K*, in turn moving the gear *C* out of mesh with gear *E*, thus stretching spring *L*. The purpose of motions described is to free the upright shaft which carries gears *E* and *F*, in turn permitting by means of a hand wheel on top of the upright shaft to move the cone rack back to its starting position.

Another stop motion, provided for another purpose to the machine, is shown in Fig. 222. The same has for its object to prevent accident to the machine. Should the reverse motion fail to work, the rail would travel beyond its limit, which in turn would allow projections *B* and *E*

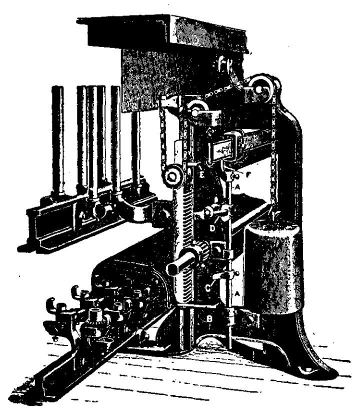


FIG. 222.

on the lifting rack to come in contact with fingers *C* or *D*, as are secured to rod *A*, which would cause the latter to move upward and come in contact with and lift the knock-off latch by means of projection *F*, thereby stopping the frame and prevent break-downs.

Fig. 223 shows the Erskine's cone stop motion, which has for its object to prevent the ends breaking down in the front provided the cone belt breaks. The motion consists of a chain and rod, which passes over pulleys *A* and *B*, and in turn connects the bottom cone and its cone frame with the knock-off latch. An auxiliary cone belt hangs loosely over the pair of cones and is carried along by and with the regular cone belt shipper.

If for one reason or other the cone belt breaks, the auxiliary belt, as is continually hanging loosely near it, then allows the cone frame to drop sufficiently to lift the knock-off latch, which in turn throws the driving belt of the machine onto its pulley, at the same time keeping the cones in motion until the machine is stopped.

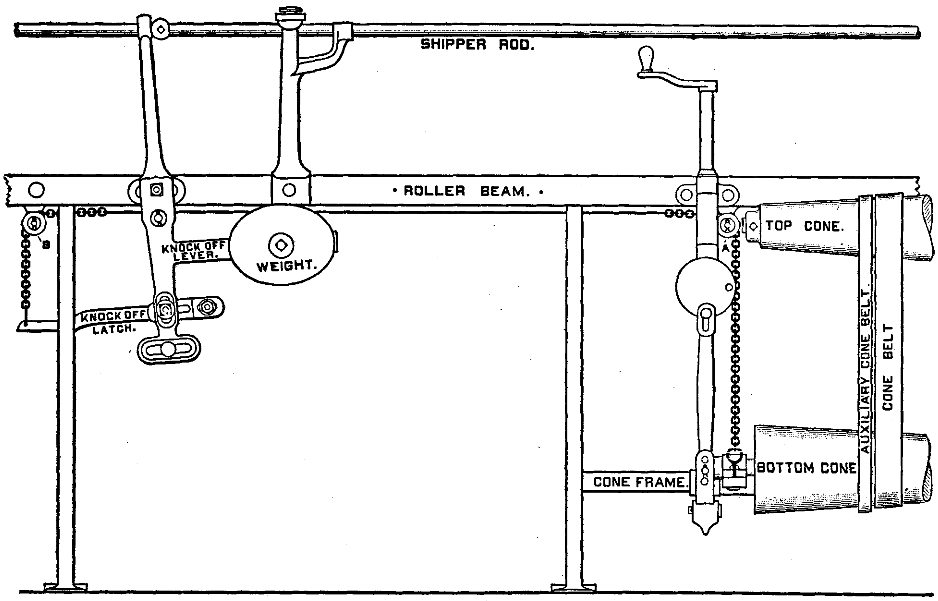


FIG. 223.

Hank Clock.—The foot end of the front drawing roll carries a worm for the purpose of driving through suitable gearing connection the hands of the hank clock, which in turn registers the hanks that are being turned off by the fly frame. The dial of a hank clock resembles the dial of a regular clock, only that in place of hours and minutes as on the regular clock, the hank clock is divided into spaces for measuring off 1 to 100 hanks, and fractions thereof. The dial of the hank clock is first divided into ten equal parts and which are indicated respectively by 10, 20, etc., i. e., multiples of 10 up to 100. Each of these divisions is then subdivided into halves, giving us in turn multiples of 5 up to 100 for the dial. Each of the latter divisions is then again sub-divided (less prominently marked on the dial so as to simplify reading off) in five parts, thus dividing the dial of the hank clock into 100 equal distanced parts. The hands in front of the dial are similar to the hands found on a regular clock, i. e., a short and long hand. The short hand is known as the hank hand and travels for every hank turned off by the machine, to which the clock is fastened, a distance between two of the points marked off on the dial of the clock. The large hand of the clock travels completely round the dial for every hank produced by the front roll of the fly frame. As will be readily understood these clocks are a fixture to the machine, hence no special reference necessary. They are provided to indicate the amount of work turned off by the operator, hence clocks and the parts that belong to them, must be so constructed as to prevent any possible tampering with them.

Doffing.—This in connection with fly frames refers to the process of removing the filled bobbins and placing empty ones in their place on the spindles. Before this is done everything should be put in readiness that can be done so as to lessen the time required to doff, which actually is a dead loss of production to the mill. By this we mean, get the empty boxes ready as required for holding the filled bobbins, also place empty bobbins between the spindles on the carriage so as to have them handy when needed afterwards. Provided persons are employed specially to help the regular tender of the frame, see that they are at the machine before the latter is stopped for doffing. The procedure is best explained in connection with diagram Fig. 224. The handle *A* (and which corresponds to the handle shown in Fig. 223) is placed at the top of upright shaft *B*, said shaft carrying at its bottom a bevel gear, which in turn meshes with another bevel *C*, fast upon a short horizontal shaft *D*, which also carries a disc provided with a pin *E*, around which is a slot in the connecting rod *F*. The latter has hung to it, at its lower end, a casting *G*, as in turn is loosely hung upon the lifter shaft beneath an extended part of the bottom cone shaft. By this arrangement it will be seen that by turning the handle *A*, the connecting rod *F*, and consequently the casting *G*, is raised and pushes up under the bottom cone shaft, in turn raising the latter, thereby slackening the cone belt. This will throw the train of gearing as driven from the bottom cone shaft (and which gives the bobbins their excess speed over the flyers) out of action, and when in turn starting the machine, the bobbins will then revolve at the same speed as the flyer and consequently no roving wound on the former, in turn producing a surplus slubbing or roving as delivered by the front roll and not taken up by the bobbin, and which later on is used for starting the next set of empty bobbins.

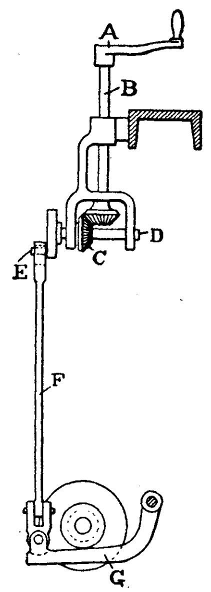


FIG. 224.

After the required amount of surplus slubbing or roving is delivered, the operator stops the machine, turning then by means of hand wheel, shown on top of illustration Fig. 218, the cone rack back to its original position with the belt at the end of the cone. Handle *A* as seen in Fig. 224 is then turned back by the operator, in turn permitting the bottom cone and its frame to be lowered to its normal position, after which the lever *A*, which operates the shipper rod *E*, in

Fig. 220 (see also Fig. 218 for it), is then pushed back to allow the catch *G* in the rod *F* to engage with the casting *J*, and when the machine is ready to be started after the full bobbins have been removed and empty ones taken their place.

The removing of the full bobbins and the threading of the delivered surplus of roving (previously referred to) onto the empty bobbins is done thus: The fly frame is adjusted by the operator to have its flyers parallel with the front roll. In order to permit easy access to the back row of flyers and bobbins, the front row of flyers is then removed by the operator and placed by him upon the top roll stand, the slubbing or roving being broken at the point where it leaves the flyer eye. The operator, starting at one end of the frame, then takes off a full bobbin from the front row, and places an empty one in its place on the spindle. He then raises the corresponding back flyer from its spindle, removes the full bobbin and replaces it by an empty one, after which he puts the back flyer again into its place on the spindle. He follows up this method of procedure until all the bobbins (front and back row) have been doffed, after which the ends for the back row of bobbins are pieced up thus: The end of slubbing or roving as protruding from the flyer eye is wound around the bobbin, the latter is raised a little to allow the slubbing or roving to overlap, and the winding is continued until all the slack is taken up. After the back row has been pieced up, the front flyers are put on their spindles and the ends pieced the same as explained with the back row, after which the machine will be ready for starting. Sometimes when flyers stick tightly to the spindles they have to be knocked off, which, if necessary, should be done with a piece of brass, or some softer metal that will not damage the flyers. It may here be stated that the carriage must not be at the bottom of its traverse when stopping the frame for doffing, the flyer at this point delivering at the top cone of the bobbins, the slubbing or roving therefore offering no resistance for breaking it when the flyer is taken off of the spindle, but instead of breaking would unravel it, for which reason the frame should be left running until the carriage is traversed about a quarter or a third of its entire distance, and then the machine stopped, when the flyers can then be removed, and the roving consequently be broken, without causing any damage to the bobbin. It is customary, except when dealing with very coarse hanks, to oil the spindles during each doffing.

NOTES.

Worn Rolls.—The replacing of worn drawing rolls with new ones is a most important affair for the overseer, a usual system observed being to allow the replacement of so many rolls per hundred spindles in a given time, the number depending upon the condition of the fly frames in the mill, the care given them, the kind of cotton and counts of hank handled; for the reason that a coarse grade of cotton and naturally a low hank will wear out the rolls quicker than a high or fine hank, again that new fly frames will be less hard on their rolls than old or run down machines. The guides should be set so as to traverse the sliver or the roving as close to the ends of the rolls as possible. By thus properly adjusting the guides, rollers can be used much longer than if not using all their surface available. All rollers in the room should be at least once a month examined by the overseer or his assistant and any defective ones replaced by newly covered ones. Considering spinning medium counts of yarns, an average of 3 new rolls per week for each slubber and intermediate frame, and 4 for each roving frame is a fair allowance.

Bad and Uneven Roving.—Carelessness, of course, in many instances is responsible for faulty rovings. Uneven laps from the scutcher and as fed to the card will transmit this inequality to all future processes in cotton spinning, so will also bad carding and "single" in the drawing frame lead to inequalities, which the fly frame never can completely eradicate. If the top rolls are not regularly oiled or a sticky oil is used for this purpose, this may cause the rotation of the rolls to become momentarily arrested, in turn stretching the slubbing or the roving and producing a thin place in the delivered strand. Similar trouble will result if one or the other tooth from a gear in the drawing roll drive gets broken out, and is not noticed, or neglected to be noticed, and then when the blank space comes around the middle or back roller will momentarily stop while the others go on. If dealing with fly frames where shell rollers are used, it may happen that the tender of the machine puts two of an unequal size on the same arbor, and when on account of the larger part of the weight evidently being on the ends, the draft of the slubbing or roving during its traverse over the heavily and lightly weighted parts is affected.

Bad work, besides shortening the life of the rolls considerably, will also occur provided top and bottom rolls are not in line with each other. Always be careful when replacing any worn out gears, that the right gear is substituted, for if a slightly different size gear thus used, it may be the cause of throwing the distribution of the drafts wrong, and be the means of trouble and annoyance to the overseer. If for one reason or the other, roller weights are taken off, be sure to replace them in their proper place, since if they are put back in wrong places, for example the heavy ones on the rolls where the light ones were, and vice versa, it will cause trouble in the roving.

Be careful not to use an excessive draft on fly frames, for it will cause uneven roving, however at the same time remember that too little draft on a fly frame will result in hard ends or undrawn roving. Roller laps increase or reduce the draft, and consequently slightly alter the hank. Be careful that the flyer has dropped in its slot properly before the machine is started. See that the clearers, especially if dealing with frames set for handling long staple cotton, are picked sufficiently often, otherwise this clearer waste will occasionally be licked up by or drop into the slubbing or roving, in turn making a heavy slub, which in turn, as a rule, will break at the back of the mule or ring frame and thus be the cause of waste in material, loss of time, and annoyance to the spinner; again should it pass there, a long thick place is the result in the yarn, and in turn (except the thread breaks in the loom) in the woven cloth.

When roving is cut (thin places) at regular intervals and such places are about $3\frac{1}{2}$ inches apart, a bad lap on the top roller (circumference of said roller about $3\frac{1}{2}''$) in most cases is at the bottom of the trouble, again if such thin places are about 12 inches apart, a bad middle roller very likely is at the bottom of the trouble.

Long and Bad Piecings are a Distinct Evil.—For this reason when putting bobbins in the creel, or making piecings at the front, make them short and not too hard, for if they are made long it will cause the roving to be too thick at this place; whereas hard piecings will not draw when in turn passing between the drawing rolls, resulting in a lump which at the next process will cause trouble. Wet piecings will also cause trouble, they having their origin in that when an end breaks, the operator in piecing it up frequently wets and slightly twists the end (the same as you would thread a needle) in order to more readily thread said piecing through the eye of the flyer. This wet and twisted end should be broken off by the operator before piecing up, for when this is not done, remember that this wet piecing will not draw in the next process. Never twist the end for threading through the flyer eye more than absolutely necessary, for the fact that even if the wet end is broken off, the thus heavy twisted roving end will frequently fail to draw properly.

Mending Broken Ends.—When for one cause or the other, possibly on account of a bobbin being under the bobbin rail of the carriage, the cone belt breaking, teeth in draft gear worn out or breaking, draft gear slipping, or collars not fast on spindle rails, etc., an end breaks between the front drawing roll and the bobbin, it generally winds itself more or less around the boss of the flyer, and when in turn the machine has to be stopped for piecing it. The operator then unrolls about $2\frac{1}{2}$ feet of slubbing or roving from the bobbin, and after slightly twisting it, winds it round the presser foot as many times as before, then up the leg of the presser, through the eye in the boss of the flyer, twisting, i. e., piecing it then on to the other end as projecting through the front rolls, and when after adjusting the bobbin so as to leave as little slack as possible, if any, he in turn then starts the machine. To see if proper tension is in the roving, while the frame is running, get your eye on a level with the flyer, and look from the boss of the flyer to the front roll, thus readily noticing slack roving. Slubbing or roving only slightly slack will run all right for a short time, when it will curl around the boss of the flyer, and then run smooth, if however too slack it will then break.

Empty and Full Bobbins.—The use of the proper size bobbin for a fly frame is a most important item, for only in that way quality and production of work can be obtained. Provided different makes of fly frames are met with in one mill, bobbins will get mixed except proper care is exercised to keep them separate, and with two sizes of bobbins on one frame it is next to impossible to keep the tension right, for the fact that if the operator tightens the tension on account of the slack running end, he thereby will strain the roving on all the other spindles of the frame. All bobbins should be wired, and in a mill running on low hank work and where they are handled frequently, bobbins with a metal base are the ones to use, for although more expensive at first cost, they, on account of lasting longer than common wooden bobbins, will be the cheaper ones in the end.

Bad bobbins with reference to full bobbins are such as contain "single" or "double," or such as are soft in consequence of the slubbing or roving having been broken down too long before noticed. By unwinding these bad places in the waste, except if dealing with too bad a case, such bobbins then can be used in the creel of the next process machines. Oil or dirt from the machine dropping on slubbing, roving, or bobbins, will also result in spoiled bobbins. Running over and under of the roving on the bobbins may now and then occur, and if such is the case see that all the gears from builder to carriage, as well as the twin gears and their clutch gear, are not badly worn in the teeth or slack in the studs, also see that these gears are geared sufficiently deep. Improper taper given to the bobbins by the builder motion may in turn result in tangled bobbins, for if the taper is too steep, with rough treatment some of the strands will slip off.

On frames using the Hill builder, the spring may be out of order, or more frequently the end of the sliding jaws worn down, so that the motion does not change at the proper moment. If this is the case, file the arms and put on a steel plate having a square end. If the bevel gears on the top cone shaft or those on the upright shaft are worn to such an extent that the teeth fail to engage, a temporary remedy is to raise the upright shaft and put a cent piece in the step. If the large or skip gear is worn, and two or three teeth are only affected, change it to a reverse frame, in this manner bringing the teeth on the opposite side of the skip, and consequently those which are not worn, into use.

In connection with a ratchet gear builder motion, the triggers may have become worn at the corners, a feature which will cause the motion to change at irregular times, resulting in turn in a bad taper. When setting this motion, its tooth lever must be level when the carriage is in the centre of its traverse. Sometimes bobbins run off owing to the frame being stopped just at the change, or possibly owing to the winding being very slack.

If the coils on the bobbin are laid too widely apart, the speed of the top rail or lifter must be reduced in proportion, the rate of delivery and the winding on of the roving remaining the same. In some instances a less teeth strike wheel may suffice, whereas in other cases a wheel belonging to the short lifter shaft train of wheels has to be changed.

Flyers must be kept smooth at all points where cotton comes in contact with any part of them, they must fit perfectly on the top of the spindles, and the wires kept in good condition to prevent hammering down in position by the operator, which in turn will roughen them at their top. Soft bobbins and a weak roving may have their origin in a stiff flyer leg, which will not properly submit to the centripetal force produced by the revolution of the flyer.

Empty as well as full bobbins should be kept in boxes or baskets and not lying around on the floor. Keep one process of fly frames as close up to the preceding one as possible, also the last process in the same way to the spinning room, for the reason that old roving sizes somewhat different from new. When bobbins are returned from the creel of fly frames, or from the spinning room, they are then not always entirely empty of all the roving, which then is either cut off, or more properly, pulled or twisted off the bobbins.

There is always some difficulty met with in re-setting the builder motion at the completion of a set, for which reason it is customary to allow the first layer to be an incomplete one, and therefore a portion of the slubbing or roving, as wound in the second lift, after commencing, is laid upon the bare bobbin, requiring in turn the bobbins to revolve (whilst winding on the bare portion) at the speed most adapted for its diameter, or otherwise the winding on the bare portion could not be satisfactorily accomplished, because the rollers would deliver the slubbing or roving at a quicker rate than that at which the winding proceeds. While some overseers do not consider the affair worth while of attention, others in order to minimise the defect, set the cone strap before starting, in order that during the second lift the winding tension is the lowest practicable when the winding is proceeding on the bare portion of the bobbin.

Speeds of Spindles for the various standard sizes of American built fly frames are given in the table following, however it sometimes may be found advisable to slightly vary this speed to suit a certain grade of cotton, condition of machine, or hank under operation, in turn running the machine somewhat slower or faster, as the case may be. Old fly frames, or such as running on coarse work, or where a low grade of cotton is used, are run slow as compared to new frames, fine work and when a good quality of cotton is used, and when such frames then can be run at a higher speed as compared to former conditions.

Do not overspeed your frame, since there is a limit to the speed of every machine, beyond which it is not advisable to go on account of excessive speed being the means for developing defects, again unnecessary wear and tear to the machine will result, ends will break down more frequently, and we must remember in connection with the latter item, that the frame has to remain stopped for piecing up, even if only one end breaks, hence loss in production.

Revolutions of Spindle and Pulley per Minute.

		Howard and Bullough		Woonsocket		Saco and Pettee		Providence		Lowell	
		Spindle	Pulley	Spindle	Pulley	Spindle	Pulley	Spindle	Pulley	Spindle	Pulley
Slubber's	12×6	630	361	660	344	609	275	650	320	625	307
	$11 \times 5\frac{1}{2}$	700	401	750	391	689	300	700	344	700	344
	10×5	750	430	800	392	746	325	750	368	750	319
	$9 \times 4\frac{1}{2}$					803	350	800	314	800	340
Intermediate's	10×5	850	487	900	441	803	350	850	418	825	350
	$9 \times 4\frac{1}{2}$	950	544	1000	490	918	400	950	374	950	404
	8×4	1050	388	1150	441	998	325	1050	393		
	$8 \times 3\frac{1}{2}$	1100	408					1100	376		
Roving's	8×4	1050	388			1075	350			1100	376
	$8 \times 3\frac{1}{2}$	1100	408	1200	460	1152	375			1250	400
	$7 \times 3\frac{1}{2}$	1150	426	1300	423	1260	410	1150	367	1250	400
	7×3	1200	444	1350	439			1200	383		
	6×3	1250	462					1250	399		
Jack's	7×3	1200	444			1383	450				
	6×3	1300	481	1400	456	1460	475			1400	447
	$6 \times 2\frac{1}{2}$	1400	518	1600	524	1613	525	1350	431		
	$5 \times 2\frac{1}{2}$			1700	556			1500	479	1600	511
	$5 \times 2\frac{1}{4}$					1767	575				
	$4\frac{1}{2} \times 2\frac{1}{2}$									1800	574
	$4\frac{1}{2} \times 2\frac{1}{4}$							1600	510		

Spindles per Roll.—When calculating as to number of spindles wanted per frame, remember that this number must be exactly divisible by the number of spindles per roll in the frame in question, for which reason we herewith quote the number of spindles fly frames given in the table before contain, viz:

Howard & Bullough Frame.—Slubber's = 4 spindles per roll.
Intermediate's 10×5 and $9 \times 4\frac{1}{2}$ = 6 spindles per roll.
Intermediate's 8×4 and $8 \times 3\frac{1}{2}$ = 8 spindles per roll.
Roving's = 8 spindles per roll.
Jack's = 8 spindles per roll.

Woonsocket Frame.— Slubber's = 4 spindles per roll.
Intermediate's 10×5 and $9 \times 4\frac{1}{2}$ = 6 spindles per roll.
Intermediate 8×4 = 8 spindles per roll.
Roving's = 8 spindles per roll.
Jack's = 8 spindles per roll.

Saco & Pettee Frame —
Slubber's = 4 spindles per roll.
Intermediate's 10×5 and $9\times4\frac{1}{2}$ = 4 spindles per roll.
Intermediate 8×4 = 8 spindles per roll.
Roving's = 8 spindles per roll.
Jack's = 8 spindles per roll.

Providence Frame.—
Slubber's = 4 spindles per roll.
Intermediate's 10×5, $9\times4\frac{1}{2}$ and 8×4 = 6 spindles per roll.
Intermediate $8\times3\frac{1}{2}$ = 8 spindles per roll.
Roving's = 8 spindles per roll.
Jack's = 8 spindles per roll.

Lowell Frame.—
Slubber's = 4 spindles per roll.
Intermediate's = 6 spindles per roll.
Roving's = 8 spindles per roll.
Jack's 6×3 and $5\times2\frac{1}{2}$ = 8 spindles per roll.
Jack's $4\frac{1}{2}\times2\frac{1}{2}$ = 12 spindles per roll.

Weight of Cotton on Bobbin, Expressed in Ounces.

		Howard and Bullough	Woonsocket	Saco and Pettee	Providence	Lowell
Slubber's	12×6	44	46	44	44	44
	$11\times5\frac{1}{2}$	32	33	32	32	32
	10×5	24	27	26	24	24
	$9\times4\frac{1}{2}$			20	18	18
Intermediate's	10×5	24	27	26	24	24
	$9\times4\frac{1}{2}$	18	21	20	18	18
	8×4	14	16	15	14	
	$8\times3\frac{1}{2}$	12			12	
Roving's	8×4	14		15		14
	$8\times3\frac{1}{2}$	12	14	13		12
	$7\times3\frac{1}{2}$	10	$10\frac{1}{2}$	10	10	10
	7×3	$8\frac{1}{2}$	$8\frac{1}{2}$		$8\frac{1}{2}$	
	6×3	7			7	
Jack's	7×3	$8\frac{1}{2}$		8		
	6×3	7	$6\frac{1}{2}$	7		7
	$6\times2\frac{1}{2}$	5	$5\frac{1}{2}$	5	$5\frac{1}{2}$	
	$5\times2\frac{1}{2}$		4		4	4
	$5\times2\frac{1}{4}$			3		
	$4\frac{1}{2}\times2\frac{1}{2}$					3
	$4\frac{1}{2}\times2\frac{1}{4}$				3	

Management of Bobbins on Creel.—Never have the bobbins on the creel of one size, but have them of two or more different sizes, so that the tender will not have to fill the creel with new bobbins all at one time. A good plan is to run the bobbins in two sections, i. e., have one half of them about half full while the other half of the bobbins in the creel are either completely full or about empty. When in this case meeting with some extra large bobbins and which are not running out with the rest, they may be taken out of the creel before they have become empty, in order to equalize its set in creel. These short pieces of bobbins, in turn are then used up at the end of the creel, and where they are more conveniently under the eye of the tender of the machine. Following up the procedure thus referred to, will be the means of preventing chances of making singles. In place of dividing the running out of the bobbins into two sets, the same can be split up into three or four sets or sections if so desired. About 3 rows of full bobbins are kept in reserve on the top board of the creel, so as to be handy for the tender and at the same time prevent frames from running short of slubbing or roving. See that full bobbins, when in the creel, do not touch each other, since friction thus created would prevent the ready unwinding of the bobbins. To prevent too hard twisted bobbins (provided such are met with) from over-running, retard rotation of the skewers by inserting under their feet some cotton, again if meeting with bobbins containing insufficient twist and in consequence of which they continually break, insert skewers having a sharp point, so as to lessen friction.

Clean Machines Regularly.—Only in this way, may quantity and quality of work be produced. Brush off the creel twice a day, and pick flyers on medium work at every doffing, and oftener in connection with fine work; never fan them off, since this causes bunches to catch with the work. Clean gearing of head end of machine twice a week, and spindles and bobbin gears, etc., once a month.

Keep head of flyer clean, also slot in top of spindle, in order to provide a perfect fit for the pin in the slot. Never permit hammering down of flyers in order to bring them in proper position on their spindles, for the reason that this will produce rough places, which in turn will catch lint and consequently strain the roving. Broken or worn pins must be promptly replaced by new ones, i. e., perfectly fitting pins, since otherwise the flyer will be loose on its spindle. Rolls and clearers must be also kept clean, or coarse threads or lumpy yarn will be the result. The steel rolls should be scoured at least once a month or oftener if possible.

Gears.—Previously to starting any fly frame, after gears have been changed to suit a certain hank, examine carefully that none of them will slip, after which start the machine slowly. Draft and twist gears generally are alike in every frame of one make, provided hank fed and delivered corresponds, whereas lay and more particularly tension gears, vary with individual frames, and when the proper size of the gear has to be decided upon by practical experience on the part of the overseer or his second hand, and when in many instances, even if dealing with one kind of hank and one make of machinery, a difference of from one to three teeth may be necessary.

Oiling.—In large corporations this is in the hand of a mechanic specially hired for this work, whereas in smaller concerns it has to be done by the section hand or assistant to the overseer, and never should be left in the hands of the operator of the frame.

The front rolls, as well as any rolls or gears run at about a similar speed, both cones, the horse head, the jack shaft, the carriage slides, as well as particular parts of the differential motion and all bearings around it, should be oiled daily. The frame tenders, on Saturday before leaving work, should unhang the weights on front rollers, take off the shells and wipe the arbors dry, oiling them as well as the middle and back rollers carefully Monday morning before starting. Thus the oiling of the rollers cannot be neglected, neither will they run dry, and in turn be the cause of cut and uneven roving. It now and then may occur, from the lack of oil on previous occasions, that saddles and stirrups have worn to an exact fit, and if then the rollers get the least bit out of alignment, they will bind and momentarily stop, and in turn also be the cause of cut roving.

The screws in such differential motions whose construction will permit it, should be taken out and oil applied, and once a month the differential motion itself slipped apart and cleaned and oiled, using tallow in connection with the internal gears of the differential, provided they are run at high speed. All other revolving parts of the machine should be oiled weekly or oftener. The spindle feet should be oiled at least once a month.

An improved self oiling step is used in connection with the Woonsocket fly frames, which step contains a reservoir for oil, the latter requiring refilling but twice a year. By holes drilled through partitions between reservoir and bearing, oil enters bottom of bearing, and is siphoned back into the reservoir through the top; hence the chief loss of oil is only by evaporation. Owing to the quantity of oil thus able to keep constantly in bearing and reservoir, the bottom of spindle is never without a cushion, which guarantees a steady running spindle. A large plug in back of the reservoir admits of its being cleaned out should the oil become thick from long usage, and at the same time allows the spindle gear to lift out of connection with the spindle shaft gear, allowing the spindle to stop should any foreign matter clog up the bolster, or in case the same should become dry for want of oil. A hook is also applied, and which prevents unstepping of spindle in doffing, also damage to casings. Fig. 225 shows this self oiling spindle and the adjoining parts of the frame in its section, diagram *A* showing the spindle as it appears when running, and diagram *B* representing the spindle raised as it should be when filling reservoir with oil.

Spindles are oiled twice or three times a day (very little oiling will do) at the places where borne in the collars, it being usually done after each doffing, except if dealing with very coarse or very fine hanks, and when doffing occurs either too often or not often enough during the day. Each spindle on a frame must get its proper attention, hot spindles, if there are any, being taken out and oiled each doffing, since they will

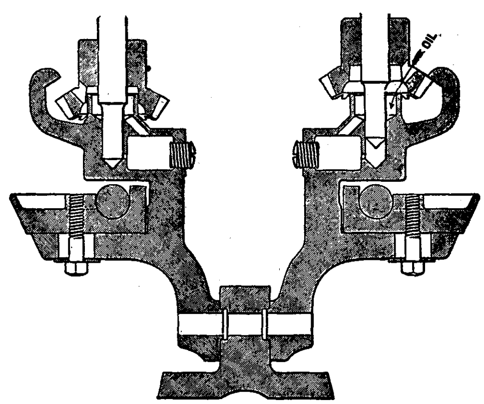


Fig. 225.

heat the shellac on the bobbin and cause it to melt, in turn making the slubbing and roving adhere to the bobbin, ruining the latter, besides being the means of waste in material.

If the ends, as coming from the front roller, suddenly slack down and tangle at the flyer, either the cone belt is broken, or a gear slipped. Provided this trouble is not too pronounced, i. e., the ends do not tangle badly, the slipping of the cone belt may be at the bottom of the trouble, or the slipping of a set screw may be the cause. If the trouble occurs continually at a certain point in the lift of the carriage, then this is a sign that a motion somewhere is binding and in turn causes the cone belt to slip. The chief cause for such trouble, in most instances, will be found in careless oiling of the frame, or not properly keeping all its vital parts cleaned, since it takes only a short time for oil-holes to get choked with lint, and the oil as applied to it consequently wasted.

Be careful that no oil gets on the slubbing or roving when oiling the rollers, also that no oily lint, as accumulates around the spindle at the top of the bobbin, is carelessly thrown in the box with good slubbing or roving, for it will stain the good waste; hence remove this oily waste before doffing, especially when dealing with roving intended for fine yarns and fabrics, and where a thus stained (black) thread, if not detected and taken out, may be the cause of making the piece of cloth "second." In connection with roving intended for cheap yarns and fabrics, i. e., low hanks of roving, this trouble will be of less consequence, since in this instance doffing is done too frequently to permit the accumulation of waste. Be careful not to use dark color crayons for marking roving, since places thus marked will show in the yarn, and if not removed, in the cloth.

The horse power required to drive fly frames varies somewhat with reference to build, as well as size of machine under consideration, a fair average estimate being: Slubbers about 50 spindles per h. p., Intermediates about 60 spindles per h. p., Roving frames about 75 spindles per h. p. and Jack frames about 100 spindles per h. p.

In some instances it may happen that for one reason or the other, we may have to run white and colored stock on one machine. Since colored stock, as a rule, has not the same elasticity as cotton spun in its natural state, if running both on same machine, proper care must be exercised in regulating the proper tension for each, and for which reason it may be found advantageous to give the colored ends a coil less or more on the presser, in order to help to regulate the tension. Whenever possible keep colored work as much as possible away from frames running on white work on account of flyings and waste getting mixed.

The number of spindles on slubbers vary between 36 and 104, 72 being a usual number of spindles used. The number of spindles on intermediates vary from 48 to 144, 120 being a usual number of spindles used. The number of spindles on roving frames vary between 64 and 168, 140 being a usual number of spindles used. The number of spindles on jack frames vary from 80 to 208, 200 being a usual number of spindles used. Numbers given, do not indicate the extreme amount of variation in the number of spindles which may be used, indicating however the limit of spindles within which it is well to keep.

CALCULATIONS.

The Grading of Slubbing and Roving.—The weight of the cotton, when leaving the scutcher is expressed in ounces per yard or in pounds per lap, when leaving the carding engine, comber or drawing frame in the form of a sliver it is expressed in grains per yard, whereas upon leaving the slubber and roving frames and where it is wound on bobbins, it somewhat resembles yarn, hence is calculated in the same manner as yarn, i. e., at so many hanks per pound.

A hank equals 840 yards, and the "size" or "count" given to slubbing or roving is the number of hanks that a certain slubbing or roving under consideration would require to make one pound or 7000 grains in weight. Consequently 2 hank roving means that 2×840 yards of roving, i. e., 1680 yards of it, will weigh one pound; 3 hank roving means that $3 \times 840 = 2520$ yards of it will weigh one pound, etc. Fractions of hanks, to weigh one pound, are also used, and for which reason 0.55 hank slubbing means that 0.55×840, i. e., 462 yards of it will weigh one pound; 3.50 or 3.5 hank roving means that $3.5 \times 840 = 2940$ yards of it will weigh one pound, etc. These fractions, as will be readily understood, are less prominently used the finer in count the roving we deal with, whereas in connection with slubbing they are the most extensively used grading, running in very coarse slubbing as low as 0.2 hank, the unit, i. e., 1 hank, referring to a somewhat fine slubbing, intended for higher counts of yarn. When the roving is finally spun into yarn, the same method of grading is used, i. e., the number of hanks (840 yds.) necessary to weigh one pound; however yarn is not referred to as hank, but as number. Both terms mean the same, it being only custom that dictates the use of the word "hank" for slubbing and roving, and the word "number" for yarn. Having thus given a definition of the hank, i. e., the grading as to counts or numbers of slubbing or roving, it now remains to explain the methods in use to determine the hank of any particular slubbing or roving under consideration.

It will be readily understood that it would not only be inconvenient to weigh up a whole pound of slubbing or roving and measure it, but that at the same time an immense amount of waste to a mill would be the result. It certainly would be more convenient to measure one hank (840 yards) of the slubbing or roving under consideration and weigh it, and ascertain its hanks by calculation; i. e., if it weighs one pound, it naturally would be one hank slubbing or roving; but again if it weighs only $\frac{1}{2}$ pound, it would be 2 hank roving, because it would require 2 hanks to weigh a pound. For the same reason if said hank weighs $\frac{1}{10}$ of a pound it would be ten hank roving, if weighing $\frac{1}{16}$ of a pound it would be 16 hank roving, etc., etc. By these calculations it will be seen at once that we can obtain the hank of a given slubbing or roving by dividing its weight of 840 yards, expressed in pounds, into 1 (one pound).

Other examples: 840 yards of a slubbing weigh 5 lbs., what hank it is?

$1 \div 5 = 0.2$ hank slubbing. Ans.

840 yards of roving weigh $\frac{3}{4}$ lb., what hank is it?
$1 \div \frac{3}{4} = 1\frac{1}{3}$ (1.33) hank. Ans.

There are 7000 grains to a pound, consequently the same result as to its hank will be obtained if dividing the weight of 840 yards of slubbing or roving expressed in grains into 7000, a feature proven by solving previously given six examples in this manner.

1 lb.	=	7000	grains	and	7000	÷	7000	=	1 hank.
$\frac{1}{2}$ lb.	=	3500	"	"	7000	÷	3500	=	2 "
$\frac{1}{10}$ lb.	=	700	"	"	7000	÷	700	=	10 "
$\frac{1}{16}$ lb.	=	$437\frac{1}{2}$	"	"	7000	÷	437.5	=	16 "
5 lbs.	=	35000	"	"	7000	÷	35000	=	0.2 "
$\frac{3}{4}$ lb.	=	5250	"	"	7000	÷	5250	=	1.33 "

Weighing slubbing or roving thus by grains in order to get the hank, will at once tell us that on account of the fineness of the grain as a weight, it would be useless waste of material to measure off for this purpose 840 yards of material, and when a convenient fraction of a hank only measured off will suffice. Thus in practice we measure off either

120 yards = $\frac{1}{7}$th of a hank, and multiply result by 7, or
60 " = $\frac{1}{14}$th " " " , " " " " 14, or
24 " = $\frac{1}{35}$th " " " , " " " " 35, or
12 " = $\frac{1}{70}$th " " " , " " " " 70

We will now work out these four measures in connection with one example and quote rules which may be applied in place of calculations if so desired.

(1) 120 yards roving weigh 80 grains, find its hank?
$80 \times 7 = 560$ and $7000 \div 560 = 12.5$ hank. Ans.
or use rule: Divide 1000 by the weight in grains of 120 yards.
$1000 \div 80 = 12.5$ hank. Ans.

(2) 60 yards roving weigh 40 grains, find its hank?
$40 \times 14 = 560$ and $7000 \div 560 = 12.5$ hank. Ans.
or use rule: Divide 500 by the weight in grains of 60 yards.
$500 \div 40 = 12.5$ hank. Ans.

(3) 24 yards of roving weigh 16 grains, find its hank?
$16 \times 35 = 560$ and $7000 \div 560 = 12.5$ hank. Ans.
or use rule: Divide 200 by the weight in grains of 24 yards.
$200 \div 16 = 12.5$. Ans.

(4) 12 yards of roving weigh 8 grains, find its hank?
$8 \times 70 = 560$ and $7000 \div 560 = 12.5$ hank. Ans.
or use rule: Divide 100 by the weight in grains of 12 yards.
$100 \div 8 = 12.5$ hank. Ans.

As will be seen, rules quoted produce the same result; which to use being at the option of the carder, keeping in mind that if using 120 yards it will bring him nearer to the actual hank, a better average, than if using 12 yards only; however 120 yards of slubbing or roving are generally too bulky to manage conveniently on the small scales in use in the mills for this purpose, hence frequently only 60 yards are measured off, and more often only 24 or 12; to weigh a good average sample being all that is required. For this reason some carders, in order to be very exact, reel off 12, 24 or 60 yards of roving from two, three or four different bobbins and ascertain the proper average weight for calculation. This also will show to him any degree of variation between the different bobbins, an important item to him when found.

Sometimes we meet with another method of calculation, or rule for ascertaining the hank of a slubbing or roving under consideration. The same is readily explained by quoting the last example:

12 yards roving weigh 8 grains, find its hank?

If 12 yards weigh 8 grains, then 1 yard weighs $\frac{1}{12}$ of 8 grains, and 840 yards will weigh $840 \times \frac{1}{12}$ of 8 grains. Since there are 7000 grains in one pound, one hank of the roving in question weighs $840 \times \frac{1}{12} \times 8$ grains, and the number of hanks in a pound will $= 7000 \div (840 \times \frac{1}{12} \times 8)$

$$= \frac{7000 \times 12}{840 \times 8} = \frac{8\frac{1}{3} \times 12}{8} = 12.5 \text{ hank. Ans.}$$

Considering the last fraction in the example, it will show us that the numerator consists of the number of yards (12) weighed, times $8\frac{1}{3}$; the denominator being the weight in grains. This will give us the following rule: Hank of slubbing or roving equals number of yards measured off, times $8\frac{1}{3}$, and divided by the weight of yards measured off, expressed in grains.

To find weight in grains of 1 yard of any hank: Divide $8\frac{1}{3}$ or 8.33 by the number of hank, the quotient being the weight in grains of 1 yard. For example, Find weight in grains for 12.5 hank?

$$8\tfrac{1}{3} \div 12\tfrac{1}{2} = \tfrac{2}{3} \text{ grains. Ans.; or}$$
$$8.33 \div 12.5 = 0.66 \text{ grains.}$$

For measuring off the slubbing or roving for purposes of weighing and ascertaining its hank, a roving reel is used, the same consisting of a wheel either $\frac{1}{2}$ or 1 yard in circumference and turning on an axis. On top of this wheel rests a small heavy roller, whose axis runs in slots in the framing of the reel, so that this roller has play up and down. The bobbin must be so placed that the slubbing or roving will freely unwind without turning bobbin. The end of roving is then fed between the wheel and roller, and the wheel by means of a handle then slowly turned 24 revolutions if dealing with a wheel $\frac{1}{2}$ yard in circumference; or 12 revolutions if dealing with a wheel 1 yard in circumference. Provided more yards have to be measured off, turn wheel the corresponding number of times if dealing with a wheel one yard in circumference, or twice the number of times if dealing with a wheel only $\frac{1}{2}$ yard in circumference.

Having given a proper definition of "hank" as used in connection with slubbing and roving, we will next turn our attention to calculations for the fly frames proper, and when we will be soon convinced that there are more calculations to be made on these machines than on any other machine in the mill, the same being also somewhat difficult to solve. We will now try and give rules, with explanations, making them as plain as possible for the reader, at the same time using practical examples to clearly demonstrate them.

In changing from one hank to another, or when starting up a new fly frame, some or all of the following six principal calculations will have to be considered in order to produce a certain slubbing or roving required to be made.

1st. The draft gear, which changes the hank of the slubbing or roving.

2nd. The twist gear, which changes the speed of the drawing rolls, and consequently regulates the turns per inch in the slubbing or roving.

3rd. The cone gear, which is the driver for the differential motion and the lifter rack, and which is rotating at a varying speed, to suit size of bobbins, according to the position of the belt on cones.

4th. The lay gear, by means of which the fundamental speed of the traverse of the carriage is regulated.

5th. The taper gear, by means of which the taper of the bobbin is varied.

6th. The tension gear, which regulates the movement of the cone belt and thus drives the cone gear at the varying speed necessary.

In all calculations, two distinct divisions of factors are involved, viz: Such as known or given or standard facts, and such as are unknown or have to be calculated for. For instance, directions for draft and twist required for any new lot of yarn to be spun are given to the carder from the office of the superintendent; whereas the speed for the spindles, i. e., the one most advisable to run them by, is given by the builder of the fly frame in question. The speed of the front drawing roll depends upon the twist required to be put in the slubbing or roving as the case may call for, both items referred to depending also upon the speed of the spindles. The excess speed of the bobbins over that of the spindles must be decreased properly in order to take up the slubbing or roving, as is delivered at a constant uniform speed by front roll.

The layers of slubbing or roving most advisable to put on the bobbin in a longitudinal direction have been given in a table under "Builder Motion," it being from 10 to 13 times the square root of the hank made for layers per inch, according to machine and climatical conditions as well as preference of the overseer for open or close layers.

The transverse layers of slubbing or roving to be used on the bobbin depend upon the condition of the weather, the smoothness of the flyers, the character of the cotton as well as upon the tension put on the slubbing or roving in winding it on the bobbin, i. e., the number of times it is wrapped around the presser foot in threading up the flyer, since the more times it is wrapped around said presser foot, the more tension or stretch is put upon it, hence the more transverse layers per inch put on the bobbin. With a new frame, i. e., before the flyers have become burnished, two wraps around the presser foot may be sufficient for proper tension, whereas after a few days three wraps will be necessary, and sometimes four; three wraps being those generally used. Considered in an average, the transverse lay or layers of slubbing or roving is three times that of the longitudinal lay or layers on the bobbin, by which we mean, that there are three times as many layers of roving met with per inch, counting from centre of bobbin outward, as there are layers when counting lengthwise on the bobbin.

The taper of bobbins must be such to keep the ends of the bobbins from raveling when handled from one machine to another, the usual amount of taper being produced by giving every successive layer of slubbing or roving one coil less than the preceding layer, and thus produce the characteristic cone shaped end to the bobbin.

A Constant Number.—It is not always necessary for every change required to make complete calculations, for if a machine is satisfactorily running on one class of work, a change of which is required, then the change of gears necessary to produce this result is frequently ascertained by the use of constants and sometimes by means of proportion. A "constant number" is a known "dividend" which at any time can be divided by some required quantity or condition, the quotient obtained being the gear, draft, twist, etc., necessary to be used to give the required condition; again the converse of this rule may be used. For this reason, a constant number for change pinion is a number which if divided by any required draft will give the necessary change pinion, or vice versa, if divided by any change pinion will give the draft. A constant number for twist is a number, which if divided by any desired turns per inch will give the requisite twist gear, again if divided by any particular twist gear, will give turns per inch put in the slubbing or roving. It will be readily seen, that where a number of fly frames are running in a mill, with certain gears that are seldom changed, while at the same time the hanks are frequently varied, that in this case "constant numbers" are very useful, it giving us a kind of shorthand arithmetic, similar to the slide rule.

With reference to calculations now to be given, it must be stated, that they do not refer to any special make of fly frame, each example to be considered by itself, in turn forming a formula to go by in connection with similar examples to be solved. Since however the various makes of fly frames are identical with reference to their principle of construction and operation, a study of explanations and examples given will guide the reader to solve any calculation for any make of fly frame.

Draft.—The drawing or attenuation of the sliver, slubbing or roving, as respectively fed to the various processes of fly frames, is performed by the drawing rolls, it being accomplished by the different velocities of the three pairs of rolls, i. e., the three fluted bottom rolls and the three leather covered top rolls.

The speed of each pair of rolls differs from the other, the rolls at the front having the greatest speed, and the middle pair a speed slightly in excess of the back pair, just sufficient extra speed being allowed to give the tension necessary to keep the fibres of cotton straight. If the delivery is one fifth as heavy as the feeding to the rolls, then the drawing rolls under consideration are geared for a five draft; again if the delivery is only one third as heavy as the feeding, then the drawing rolls are geared for a three draft, etc., etc.; fractions of the unit being also taken into consideration, for example a draft of 4.2, etc.

To get the draft of a slubbing or roving frame: Divide the product of the diameter of the front roll and teeth in driving gears (from front to back roll) by the product of the number of teeth in the driven gears and the diameter of the back roll. For example, Front roll $1\frac{1}{4}''$ dia., crown gear 100 teeth, gear on back roll shaft 56, gear on front roll shaft 40, change gear 35, diameter of back roll $1''$.

$$1\tfrac{1}{4} \times 100 \times 56 = 7000$$
$$40 \times 35 \times 1 = 1400 \text{ and}$$
$$7000 \div 1400 = 5 \text{ draft. Ans.}$$

To find the constant number for draft: Multiply and divide as before, only omitting change gear (35 in this example). This calculation is readily explained for any make of fly frame, in connection with gearing given in diagram of drawing roll drive Fig. 206 thus:

$$\frac{1\frac{1}{4} \times 100 \times 56}{40 \times * \times 1} = 175.$$

The calculation gives us 175 for draft constant, and which if divided by the draft wanted will give the proper draft gear (*) to use. For example, Find draft gear needed for a draft of 5?

$175 \div 5 = 35$ draft gear wanted, being the same gear as previously obtained when using gearing calculation in full in order to find draft, showing also the advantage of a constant number for calculations.

In place of taking the diameter of both the front and the back roll in consideration for draft calculations, we may use their circumference, without changing the answer.

Proof: $3.927 \times 100 \times 56 = 21991.2$
$40 \times 3.1416 = 125.664$ and
$21991.2 \div 125.664 = 175$ constant number.

If required to change the hank of slubbing or roving on a fly frame to another hank, the draft gear can also be found by inverse proportion thus: The hank to be made is to the gear in use, the same as the hank made is to the gear to be used. For example, Suppose we are making a 2 hank roving with a 33 draft gear and have to change to 2.5 hank roving, what draft gear is required?

$2.5 : 2 :: 33 : x$ and $2 \times 33 = 66 \div 2.5 = 26$ gear required. Ans.

This inverse proportion may also be expressed, for the sake of a convenient rule, thus: Multiply draft gear in use by the hank made and divide that product by the hank roving to be made.

If dealing with slubbing or roving having its weight expressed in grains, and we have to change from one weight to another and want to know draft gear to use, we may ascertain the latter either by proportion, or, what will give the same result: Multiply gear in use by weight of slubbing or roving you have to change to, and divide product by weight being made. For example, Suppose you are making a roving of 50 grains per (for example) 12 yards, using a 33 draft gear, and you have to change to 40 grains per 12 yards (must be the same length of roving as before); ascertain change of gear required?

$33 \times 40 \div 50 = 26$ is the change gear required. Ans.

If dealing with a sliver expressed in grains fed to the drawing rolls, and a given hank of slubbing delivered by the front roll, and we have to find the draft, the grains must first be changed to its equivalent count in hanks and when the example then is readily solved by proper rule previously given. For example, Ascertain draft required to produce a 0.6 hank slubbing from a 50 grain sliver fed?

50 grains = $8\frac{1}{3} \div 50 = 0.166$ hank, and
$0.6 \div 0.166 = 3.61$ draft required. Ans.

To find the speed of front roll for any hank slubbing or roving, the speed of spindle being given: Divide speed of spindle by the circumference of front roll expressed in inches, and divide the quotient by twist per inch for the hank roving desired. For example, Speed of spindle 650; dia. of front roll $1\frac{1}{4}''$; twist per inch 1.2.

$1\frac{1}{4}''$ dia. = $3.927''$ circumference of front roll.
$650 \div 3.927 = 165.52$ and
$165.52 \div 1.2 = 137.91 = 138$ revolutions. Ans.

On a slubber each strand (sliver, as coming from the drawing frame) as fed to the machine is operated upon separately, while on the other fly frames, as a rule, two strands (slubbing or roving) are fed together, the number of strands thus fed in together to the back roll being called the number of "doublings."

If there is doubling, the hank received multiplied by the draft and divided by the doublings gives hank delivered. For example, Two ends of 1.2 hank roving are doubled into one on an intermediate frame having a draft of 5. The hank delivered then will be $1.2 \times 5 = 6$ and $\div 2 = 3$. Ans.

Another way to express the rule is thus: Size of roving at the front or delivery end of the frame equals size fed, divided by number fed, times the draft. Proof: $1.2 \div 2 = 0.6 \times 5 = 3$. Ans.

To ascertain size of slubbing or roving fed at back of machine, hank delivered and draft being given: Multiply hank delivered with number of ends fed and divide product obtained by draft. For example, Hank produced 6, draft 5, number of ends fed 2.

$6 \times 2 = 12 \div 5 = 2.4$ size of hanks at back. Ans.

Another example: Hank produced 6, draft 5, number of ends fed 1.

$6 \div 5 = 1.2$ size of hank at back. Ans.

For draft required to produce a certain hank, divide the latter by the hank fed divided by the number of ends thus fed together. For example, Find draft required to produce a 8 hank roving from two strands of 4 hank roving?

$4 \div 2 = 2$ and $8 \div 2 = 4$ is the draft required. Ans.

As explained under the chapter on "Draft," twist has to be introduced into the slubbing and roving in order to be able to handle it on the next process. This means that the strand contracts in length, said contraction varying according to the amount of twist introduced, between 1 and 4%; $2\frac{1}{2}$% being a fair average. For this reason, if "actual size" of slubbing or roving is referred to, add this allowance for contraction to the "figured size" as given in all our examples.

Draft gear needed always calls for the draft constant to be divided by the actual draft required, and in order to explain subject we will quote an example, showing draft gear calculated by both drafts, the difference being about one tooth, and which in most examples met with, will be the difference between considering calculated vice versa figured draft.

Example: Ascertain draft gear needed to produce 2 hank roving, two ends of 0.8 hank being fed; the draft constant being 175 and the contraction by twist 2.5%.

$0.8 \div 2 = 0.4$ = hank fed; $2 \div 0.4 = 5$ = figured draft.
$175 \div 5 = 35$ draft gear (figured draft).

$97.5 : 100 :: 5 : x = 5.126$ = calculated draft.
$175 \div 5.126 = 34.13 = 34$ draft gear to use, considering the calculated draft.

The draft change gear regulates the size of the roving, consequently its change at the same time requires, as a rule, a change in the twist gear, since twist required varies with every change of hank. In slight changes of the hank, the tension gear or lay gear is not changed, however if the slubber is changed 0.5 hank or more, the intermediate 0.75 hank or more, the roving frame one hank or more, the tension and lay gears are then changed; however it must be remembered that changing the tension and lay gears is more or less a matter of practical experience, since the calculated gear frequently gives wrong results, the cause of which has been previously referred to.

Twist in Roving.—By this is understood the number of turns or twists put by the spindle into each inch of roving as delivered by the front roll. Mechanically speaking, it means the number of turns made by the spindle while front roll revolves its circumference one inch. Suppose that 100 inches of roving are delivered by the front roll, while the spindle makes 350 revolutions. Since for every revolution of the spindle one turn of the twist is introduced into the roving, the 350 turns of twist are introduced into the 100 inches of roving delivered, and when consequently the number of turns in each inch are $350 \div 100 = 3.5$ turns.

As previously stated, there is some contraction caused to the slubbing or roving as delivered during twisting, for which reason there is actually more twist per inch in the slubbing or roving than the figured twist will show. The percentage of this additional twist in the slubbing or roving however is so insignificant that no notice has to be taken of it in calculating, although we take the affair into consideration in connection with calculating for the draft gear.

To find the twist per inch to put into slubbing or roving, the customary procedure is: Multiply the square root of the number of slubbing or roving by 1.2. For example, Find standard twist for 4 hank roving?

$\sqrt{4} = 2$ and $2 \times 1.2 = 2.4$ twist per inch. Ans.

To find the twist per inch from the gearing of a fly frame: Set the train of gears (see Fig. 200) beginning with the gear attached to that part carrying the flyer, and run back to the front roll; or in other words—Multiply spindle driving gear *r*, gear *p* on main shaft, gear *P* on top cone shaft, and front roll gear *Y* together for a dividend; then multiply spindle gear *s*, shaft gear *q*, twist change gear *N*, head gear *X*, and circumference of front roll together for a divisor; the quotient equals the number of turns or twists put into each inch of slubbing or roving delivered.

Example: Ascertain twist per inch put in a roving on a fly frame having the following gearing: r = 55 teeth, p = 52 teeth, P = 37 teeth, Y = 164 teeth, s = 27 teeth, q = 45 teeth, N = 30 teeth, X = 97 teeth, circumference of front roll ($1\frac{1}{4} \times 3.1416$) 3.927 inches.

$55 \times 52 \times 37 \times 164 = 17354480$
$27 \times 45 \times 30 \times 97 \times 3.927 = 13884497$ and
$17354480 \div 13884497 = 1.25$ twist per inch put in roving.

To find the constant number for twist on any fly frame: Proceed as before, only omitting the twist change gear.

$$\frac{r \times p \times P \times Y}{s \times q \times * \times X \times 3.927}$$ and substituting gearing, as quoted before, in its place, we find

$$\frac{55 \times 52 \times 37 \times 164}{27 \times 45 \times * \times 97 \times 3.927} = 37.497 \text{ constant number.}$$

To find twist change gear, twist constant and twist being given: Divide constant by twist. For example, Constant 37.497, twist 1.25.

$37.497 \div 1.25 = 29.99 = 30$ twist gear.

To find twist, constant and twist change gear being given: Divide constant by twist change gear. For example, Constant 37.497, twist change gear 30.

$37.497 \div 30 = 1.25$ twist per inch.

If required to change to a different twist gear in connection with a running frame, the same can also be found by means of inverse proportion, thus: Twist required is to twist made, the same as gear in use is to gear wanted. For example: Suppose we are making a roving with 2.8 twist in connection with a 25 twist gear, and we have to change to a roving calling for 2.4 twist. Ascertain by inverse proportion twist gear required?

$2.4 : 2.8 :: 25 : x = 29.16 = 29$ twist gear required.

This method of calculating twist gear for sake of a simple rule may be also expressed thus: Multiply twist made by twist gear in use, and divide product by twist required; the quotient being the twist gear wanted.

$2.8 \times 25 = 70 \div 2.4 = 29.16$ practically 29, being the same answer as previously obtained.

The twist or turns per inch can be also found thus: Divide r.p.m. of spindles by the length of slubbing or roving delivered by the front roll p.m. For example, Speed of spindles 718.5 r.p.m. Length of slubbing delivered p.m. 70 ft. = 840 inches.

$718.5 \div 840 = 0.85$ turns per inch. Ans.

To find speed of spindles: Referring for this purpose again to diagram Fig. 200, Multiply r.p.m. of main shaft *B* by gear *p* on said shaft and in turn by spindle driving gear *r*, for a dividend; then multiply gear *q* on end of spindle shaft by gear *s* on spindle, for a divisor; the quotient being the speed of spindle. For example, B = 376 r.p.m., p = 63 teeth, r = 46 teeth, q = 45 teeth, s = 22 teeth. Find r.p.m. of spindles?

$376 \times 63 \times 46 = 60536$
$45 \times 22 = 990$ and
$60536 \div 990 = 1100.65$ or practically 1100 r.p.m. Ans.

To find speed of front roller: Referring again for this purpose to diagram Fig. 200, Multiply speed of main shaft *B* by twist change gear *N*, and by gear *X* on end of top cone shaft, for a dividend; then multiply gear *P* near top cone, by gear *Y* on end of front roll shaft together for a divisor. The quotient will be the speed of front roller.

For example, B = 376 r.p.m., N = 30 teeth, X = 110 teeth, P = 45 teeth, Y = 150 teeth. Find r.p.m. of front roller?

$376 \times 30 \times 110 = 1240800$
$45 \times 150 = 6750$ and
$1240800 \div 6750 = 183.82$ or practically 184 r.p.m. Ans.

Cone Gear.—The same is the centre for distributing motion from the cones to both the differential motion and the carriage. It is a change gear, although we seldom make use of it after a suitable gear once secured, relying on the other change gears of the fly frame for average changes in slubbing or roving, and actually only change cone gear when changing machine onto a different size of bobbin barrel, or when a larger surface of cones has to be used, both being incidents not frequently met with. Since it is rather unreliable to calculate the speed of the cone gear on account of not being able to designate exactly the effective point of the belt on the cones, as well as that there is always some little slippage of the belt, it will be found advisable to count speed by means of an indicator.

When required to change, i. e., calculate for a new cone gear, for one or the other reason stated before, an expression of the speed of the bottom cone is obtained by first calculating for the necessary excess speed of the bobbin, and which depends upon the diameter of the empty bobbin barrel. Then get the correct spindle speed (see twist calculations for it) and add it to the excess speed of the bobbin. Now consider that the bobbin drives the remaining gears of the frame, and in turn find the speed of the last and then of the first gear in the differential. Since there are different differential motions used we must adapt the latter two calculations to the particular differential used in the fly frame under consideration. For this reason we refer the reader to a close study of the chapter on "Differential Motions," also to its calculations. By considering then the first gear as driving back to the bottom cone, and tracing through the train of gearing, an expression for the speed of the bottom cone can be obtained.

To find speed of top cone: (for reference see Fig. 200) Multiply the speed of the main shaft *B*, with the teeth in the twist gear *N*, and divide product by gear *P* on top cone shaft. For example, B = 376, N = 30, P = 45.

$$376 \times 30 \div 45 = 250.66 \text{ r.p.m. of top cone.}$$

To find fastest speed of bottom cone: Multiply r.p.m. of top cone (*R*) by its largest dia., and divide product by smallest dia. of bottom cone (*R'*). For example, R = 250.66 r.p.m. and 7″ large dia., R′ small dia. = $3\frac{1}{2}$″.

$$250.66 \times 7 \div 3.5 = 501.32 \text{ r.p.m.}$$

To get slowest speed of bottom cone: Reverse diameters of cones in previously given rule. For example, R = 250.66 r.p.m. and $3\frac{1}{2}$″ dia., R′ = 7″ dia.

$$250.66 \times 3.5 \div 7 = 125.33 \text{ r.p.m. of bottom cone.}$$

From examples given, the change in speed of bottom cone per inch of length traversed by cone belt is found thus: Subtract slowest speed from fastest speed and divide by length of cones.

$501.32 - 125.33 = 375.99 \div 30 = 12.53$ r.p.m., change in speed per inch in length of cone.

The Lay Gear.—The same is shown in its position in the fly frame by gear indicated by letter of reference *f*, in connection with Fig. 200. It is a change gear, to permit a change in speed of the carriage when so required, i. e., when changing size of roving, since if handling a finer hank on the frame, the carriage must travel up and down at a slower speed than when dealing with a coarser hank slubbing or roving. The lay gear is a driving gear, hence the speed of the carriage varies with the changing of this gear, and the faster the carriage goes up and down, the fewer will be the coils of slubbing or roving laid per inch on the bobbin. Consequently said coils vary inversely to the size of lay gear used, the size of the lay gear in turn varying inversely to the square root of the hank of slubbing or roving made.

Calculations for the lay gear consist in ascertaining size of gear needed to give the carriage the speed required for laying a certain number of coils of slubbing or roving lengthways per inch on the bobbin. The number of layers or coils that will thus lie side by side in an inch varies with the hank and twist. For detail on this subject the reader is referred to the chapter "Builder Motion."

If a different twist has to be put into the slubbing or roving, as previously mentioned, the layers per inch must be varied, i. e., a different lay gear used. The rule for this is: Multiply twist you are using by lay gear in use, and divide product by twist desired, the quotient being lay gear required. For example, Twist made 2.4, gear in use 20, twist wanted 2. Ascertain lay gear required?

$$2.4 \times 20 = 48 \div 2 = 24 \text{ lay gear is wanted.}$$

To Find the Lay Constant: Multiply the square root of the number of roving you are making by the number of teeth in your lay gear. For example, What is my lay constant if I am using a 44 lay gear in making 0.2 hank slubbing?

$\sqrt{0.2} \times 44 = 19.6768$ = constant number, and which if divided by the square root of the hank slubbing required to be made, will give us proper change gear to use.

Provided we have a change gear which is established as the right one to wind or lay a certain number of hank roving, Multiply the square root of the number of hank being made by the gear in use, and divide the product by the square root of the number of hank you wish to make; the result being the gear required. For example, 0.36 hank slubbing is made with a 32 lay gear, find lay gear required if changing to 0.64 hank?

Square root of $0.36 = 0.6$
" " " $0.64 = 0.8$ and
$0.6 \times 32 = 19.2 \div 0.8 = 24$ lay gear required.

The Tension Gear, so called on account of the work it does in regulating the tension of the roving through the action of the cones and the differential motion, lends itself not as readily to calculations as the other gears on the fly frame thus far explained, for the fact that temperature, humidity, twist, open or close wind of the traverse motion and the number of coils around the presser finger make the problem somewhat complicated. However if all these conditions are known, the proper gear needed for any size of roving can be readily calculated for. It is a change gear and has been already previously referred to under the chapter "Builder Motion," see also Fig. 215 for it. It regulates the exact movement of the cone belt fork as each successive layer of roving is wound upon the bobbin, hence the number of teeth required by the gear depends upon the number of layers required to fill the bobbin. It thus controls the amount by which the excess speed of the bobbin over the flyer is gradually decreased during the building up of the bobbin. Its work begins after the first layer of slubbing or roving has been wound upon the bobbin barrel, and we have to calculate for a different gear every time the hank is changed. The Providence Machine Co. give the following rule for the number of layers in the build of bobbin: Square root of the hank roving × 40 times the diameter of full bobbin — dia. of bobbin barrel ÷ 2, the product being the number of layers to use. For example, Find layers for 1.5 hank roving?

$\sqrt{1.5}$ (hank) = 1.2247 × 40 = 48.988
$3\frac{9}{16}''$ dia. full bobbin, less $1\frac{3}{8}''$ dia. empty bobbin ÷ 2 = $1\frac{3}{32}$ and
48.988 × $1\frac{3}{32}$ = 53 = layers. Ans.

53 layers equals 52 moves of the cone belt, as belt is already on the diameter for the first layer.

This movement is over a cone surface of $32\frac{1}{8}''$ long and equals 32.125 ÷ 52 or 0.6177″ to each move.

Cone rack is 8 pitch or 0.392 circular pitch, and
0.6177 ÷ 0.392 = 1.58 teeth movement of cone rack and of the 29 gear on the upright rack shaft.

$$\frac{1.58}{29} \text{ of } 40 \text{ of } \frac{50}{10} \text{ of } \frac{38}{9} = 46 \text{ tension change gear.}$$

52 movements × 46 = 2392 constant number, which if divided by the layers required on bobbin of any hank roving, as per rule given before, will give the correct tension gear.

If it is found that after putting on the calculated gears that the slubbing or roving is slack between the roll and the flyer, a larger tension gear must be put on, and vice versa.

If with a certain hank of slubbing or roving a known gear is giving good results, the gear needed for any other hank can be found by the use of an inverse proportion, "Square root of hank being made : square root of the hank to be made :: gear wanted : gear in use;" or find first your contact constant by multiplying the square root of the hank you are making by gear in use. Dividing the contact constant thus obtained by the square root of hank to be made will give us tension gear wanted. For example, 0.36 hank slubbing is made satisfactorily with a 48 tension gear, what tension gear is required for a 0.64 hank slubbing?

$\sqrt{0.36}$ = 0.6 × 48 = 28.8 constant number and
28.8 ÷ ($\sqrt{0.64}$) 0.8 = 36 tension gear is required.

If a certain hank slubbing or roving, using with satisfaction a given twist and tension gear, and we have to change the turns of the twist, the proper tension gear is found thus: Multiply twist in use with gear on for a dividend, otherwise known as a constant, and divide the latter by twist required to be inserted. For example, Twist in use 2.8, gear in use 24, twist to be inserted 2.4; ascertain tension gear necessary?

2.8 × 24 = 67.2 constant, and
67.2 ÷ 2.4 = 28 tension gear wanted.

Note: The reader is also referred to the Calculations given previously in connection with the fly frames as built by the American Machine Co., Platt Bros. & Co., the various differentials, gearing calculations given in connection with diagrams Figs. 200 and 206, etc., etc.

PRODUCTION.

The same may be calculated for in different ways, viz: (1) using the speed of the fly frame for its basis, (2) timing one set produced, (3) calculating from the hank clock, (4) using a constant number for it, or (5) using a short process, i. e., by proportion. We will now refer to the different methods in detail, in connection with examples wherever necessary.

Calculating Production from Speed of Machine.— The "calculated" production of a fly frame in this instance is simply a matter of ascertaining speed of the front roll. Either calculate this speed of front roll from that of the main shaft, or get its actual speed with an indicator. After thus obtaining the r.p.m. of the front roll multiply it with its circumference, the minutes in an hour, the hours in a day, and the number of spindles in a frame; dividing the product thus obtained by 840 multiplied by 36 and the number of roving. For example: Suppose a roving frame has 120 spindles on 3.75 hank roving. What is the production per day of 10 hours, if the front roller ($1\frac{1}{8}''$ dia.) makes 145 revolutions?

$$\frac{145 \times 3.53 \times 60 \times 10 \times 120}{840 \times 36 \times 3.75} = 324.9 = 325 \text{ pounds. Ans.}$$

Pounds per day multiplied by hank = hanks per day.

Another way to find the calculated production is thus:

$$\frac{\text{Speed of spindles per min.} \times 60 \text{ min.} \times \text{No. of hours taken}}{\text{Turns of twist per inch} \times 36'' \times 840 \text{ yards}} = \text{Hanks delivered,}$$

or:

$$\frac{\text{Inches delivered by front roll per min.} \times 60 \text{ min.} \times \text{No. of hours taken}}{36'' \times 840 \text{ yards.}}$$

= Hanks delivered,

$$\text{and } \frac{\text{Hanks per No. of hours taken}}{\text{Hank of sliver}} = \text{Pounds delivered.}$$

As mentioned, rules and calculations given, refer to calculated production only, that is, considering a continuous running of the machine for the number of hours taken. To obtain a near estimate of the actual production of the machine, certain allowances have to be made for loss in piecing, doffing, etc., and which vary according to speed of spindles, hank produced, efficiency of the operative, number of spindles in frame, etc., the following percentages being a fair average: Slubbing 30 to 15%, Intermediate 22 to 12%, and Roving 12 to 7%, the proper per cent. depending on the hank of slubbing or roving under operation, it being greater in connection with a coarse hank than with a fine hank, since the former needs doffing oftener than the latter. 15 minutes is a fair allowance, per set, for doffing and other stops of the machine. A slubber on 0.5 hank work will run a set in about an hour, and when the stoppage of the frame for doffing in that case would be about 25%, whereas a roving frame on 6.5 hank work will run a set in about 5 hours, and when a stoppage of 15 minutes of the frame for doffing will figure about 5% only. The number of spindles under the care of one operative will also greatly influence this item of percentage to be allowed for stoppage of machine. The maximum speed at which the front roll can be run, as shown by calculations given, is a most important item with reference to production. If a machine is over-speeded, the ends will break down more frequently, and consequently more production will be lost by stoppage of the frame for piecing up broken ends than is gained by the greater delivery of the front roll at the fast speed.

Another way of calculating production is based on time required to turn off one or more sets, and which may be ascertained either by calculating for it, or timing the machine.

With reference to calculating for it, the following rules and examples, as given by the American Machine Co., will prove interesting.

$$\text{Minutes required to build bobbin: } \frac{\text{Total twists on bobbin}}{\text{r.p.m. of spindle}}$$

Twists on bobbin: Length in inches on bobbin × twists per inch.

Length in inches on bobbins: Weight of bobbin in lbs. × hank roving × 840 × 36

$$\text{Minutes per set: } \frac{\text{Hank} \times \text{twist per inch} \times \text{wt. of bobbin in lbs.} \times 840 \times 36}{\text{r.p.m. of spindles.}}$$

To find number of sets in 10 hours, allowing 15 min. per set for doffing, etc.: 600 (minutes in 10 hours) ÷ Minutes per set + 15 min. for doffing.

To find production per spindle in lbs. per day of 10 hours: Number of sets in 10 hrs. × weight of bobbin in lbs.

To find hanks per spindle per day of 10 hours: Lbs. per spindle per day of 10 hours × hank roving.

Example: Hank roving 4, twists per inch 2.4, weight of bobbin 10 oz., r.p.m. of spindles 1100. Find hanks per spindle per day of 10 hours?

$$\frac{4 \times 2.4 \times 10 \times 840 \times 36}{1100 \times 16} = 164.9 \text{ minutes per set.}$$

$$\frac{600}{164.9 + 15} = 3.33 \text{ sets in 10 hours.}$$

$$\frac{3.33 \times 10}{16} = 2.08 \text{ lbs. per spindle in 10 hours, and}$$

$$2.08 \times 4 = 8.32 \text{ hanks per spindle in 10 hrs.}$$

To Calculate Production by Timing One Set Produced.—First ascertain the length of time that it takes to make one set of bobbins by timing the fly frame on which the set is being made, and to which time then add 15 minutes for time lost in doffing, the sum of which is then divided into the number of working hours in a week, the quotient giving us the number of sets of full bobbins that can be taken off the machine in a week.

A number of bobbins are then weighed, and the average weight taken, and from which then deduct the weight of the bobbin barrel. This average weight of slubbing or roving on one bobbin, expressed in ounces, is then multiplied by the number of spindles on the machine, the product being the number of ounces produced at each set, and which if divided by 16, then expresses the number of pounds in a set. The number of pounds thus obtained, multiplied by the number of sets produced in a week, in turn gives us the number of pounds produced on the machine in one week.

For example: Suppose that we are making a 0.5 hank slubbing, and that it takes 80 minutes, including the allowance of time for doffing, to complete a set. Question: What will be the production of a 60 spindle slubber for a week of 60 hours, if average weight of slubbing on bobbin is 33 ounces?

$60 \times 60 = 3600 \div 80 = 45$ sets per week of 60 working hours, and

$33 \times 60 \times 45 = 89100 \div 16 = 5568\frac{3}{4}$ lbs. is the actual production per week (60 working hours) for the slubber in question.

From the production, no matter which way calculated for, a certain allowance must be made on account of clean waste (less than 2%).

To Calculate Production by the Hank Clock.—All fly frames are provided with these clocks and which register the number of hanks run off by the machine in a given time. To calculate the pounds from the hank clock, multiply the hanks indicated by the hands of the clock with the number of spindles, and divide product by the count of the hank being made. For example, the clock registers 20 hanks of 4 hank roving delivered in a given time, 120 spindles on frame. Then: $20 \times 120 \div 4 = 600$ pounds. Ans.

Another example: Suppose you have an intermediate frame of 120 spindles, making 2.1 hank roving, and should run to 46 hanks per week, then $120 \times 46 \div 2.1 = 2628\frac{1}{2}$ lbs. production per week.

To get the lbs. per spindle per day, from the hank clock, divide the hanks indicated by the clock, by the count of the hank made. For this reason 8 hanks of 2 hank roving delivered per day $= 8 \div 2 = 4$ lbs. production per spindle per day.

To find production per spindle: Multiply surface speed of front roll by 60 and divide product by 36; the quotient being the number of yards of slubbing or roving produced per hour; multiply this with the working hours of the machine per day and divide product by 840, the quotient being the number of hanks per day per spindle. Divide this by the hank roving being made, and the quotient is the pounds per day per spindle.

Calculating production by the hank clock is more reliable than the methods previously explained, for the fact that the hank clock shows at any time the amount of slubbing or roving turned off, and since the clock is positively driven from the front roll, the measurement is accurate; whereas if production is calculated by sets, it may have been the case that when the set upon which calculation is based, was timed when the machine was running unusually smooth and that said set consequently was run up at less than the average time; again the reverse may have been the case. Calculating doffing at 15 minutes, as usually done, may also influence the correctness of answer with reference to production in the long run.

Calculating Production from a Constant Number.—The Providence Machine Co. in connection with their fly frames quote the following constants to figure production by: 12×6 frame = 404, $11 \times 5\frac{1}{2}$ frame = 293.57, 10×5 frame = 222.16, $9 \times 4\frac{1}{2}$ frame = 165.14, 8×4 frame = 142.56, $8 \times 3\frac{1}{2}$ frame = 122.2, $7 \times 3\frac{1}{2}$ frame = 101.83, 7×3 frame = 85.68, 6×3 frame = 71.28, $6 \times 2\frac{1}{2}$ frame = 56, $5 \times 2\frac{1}{2}$ frame = 40.73, $4\frac{1}{2} \times 2\frac{1}{4}$ frame = 30.55.

Constant $\times$ yards to the ounce of the hank roving $\div$ by the r.p.m. of front roll = minutes per set.

Adding 15 minutes to the above = total minutes for one doffing.

Example: Ascertain production of a $7 \times 3\frac{1}{2}$ roving frame on 3 hank roving, revolution of front roll 157; constant = 101.83?

3 hank roving $= 3 \times 840 = 2520$ yds. per lb. and
$2520 \div 16 = 157.5$ yards per ounce; or

52.5 yds. per ounce for 1 hank roving may be considered as standard, and which $\times$ with hank in question = always yards per ounce for hank in question; thus in our example $52.5 \times 3 = 157.5$, and

$$\frac{101.83 \times 157.5}{157} = 102.15 \text{ min. per set (calculated).}$$

$$+ \ 15. \quad \text{“} \quad \text{allowance for doffing.}$$

$$117.15 = \text{min. per set (actual).}$$

600 ÷ 117.15 = 5.12 sets per day.
5.12 × 10 (oz. of roving on bobbin) = 51.2 oz. per day per spindle.
51.2 ÷ 16 (oz. per lb.) = 3.2 pounds per day per spindle.
3.2 × 3 (hank roving) = 9.6 hanks per day per spindle.

A Short Method for Calculating Productions as practiced by some carders is thus: Break down one end of slubbing or roving as it is delivered by the front roll and let the strand run for half a minute, in your hand, or on a piece of card-board, or on a tray removed from a pair of scales, so as to have the delivery in a handy shape for removal. As soon as the half minute is up, break the end and remove the delivery of slubbing or roving, as the case may be, from the machine, and weigh it on a pair of fine scales—down to fractions of a grain. The custom observed then is to consider that this weight of the strand of cotton produced in half a minute, weighed in grains, equals the number of pounds produced by the fly frame per spindle in one week = 60 hours, and which weight multiplied by the number of spindles on the fly frame equals the production of the whole machine, expressed in pounds, per week. That grains for $\frac{1}{2}$ minute equal pounds per week of 60 working hours, is based upon the fact that 60 hrs. × 60 minutes per one hour = 3600 minutes, or (×2) 7200 half minutes, and that 1 lb. = 7000 grains, or which is within 100 minutes of the working minutes in one week.

The production thus obtained is what we might consider as calculated production, plus 3% (7000 : 200 :: 100 : x) towards the usual 15% allowance of calculated production to be changed to actual production. If collecting the delivery of slubbing or roving for only 25 seconds in place of half a minute, its weight in grains will then express in pounds the actual production of the fly frame in question per week of 60 working hours.

Provided the mill runs more than 60 hours per week, ascertain production for these working hours from the short method, either by common calculation or by proportion. For example: For 72 working hours, simply add $\frac{1}{5}$ more to the production as obtained by the short method in connection with 60 hours.

Changing the Twist on a fly frame will alter production, since the gears which put in the twist are a train of gears connecting front roll and spindle; and, to change twist put into slubbing or roving requires us to change the ratio between front roll and spindle. The speed of the latter is never changed, therefore the speed of the front roll must be changed; and since the latter is the point from which production is either figured, or gets its foundation from, it will be at once seen that any change in speed of that roll increases or decreases the production of the machine, according which way the change was made. In other words, less twist put in will increase production, whereas more twist will decrease it.

Regulating Production.—On account of changing the count of yarn spun, or to regulate production between the various processes, it sometimes may be found necessary to increase production on the roving frame, the intermediate, or perhaps on the slubber, by making the roving or slubbing slightly heavier, increasing in turn the draft on the next process. For example: If an intermediate is making 10 pounds of 1 hank roving in a given time, it will deliver 11 pounds of 0.9 hank roving in the same time, an item which if multiplied by the number of spindles in the machine, say for example 120, will equal 120 pounds gain in production in the given time for said intermediate frame, certainly a considerable increase. This change however cannot always be made, for the possible fact that the next process machine frequently has all the draft it can stand, however in some instances a similar change, or less, may be resorted to with little, if any trouble, and thus help over accumulation of work at one of the processes.

Average Hank.—Mills that are constantly more or less changing the hank produced, for the sake of simplifying cost calculation at the office, will have resort to this procedure (to calculate average hank) every week. It would require considerable figuring to calculate the cost of a variety of counts of hanks if so made in the mill, hence the short way of ascertaining the average hank and figuring by it. This at the same time will give the office a chance to always keep in touch with the card room by comparing the weekly reports with the standard figures of the mill kept for this purpose in the office. By means of it a fairly accurate check can be kept on the cost of running the room, since if the average falls below the standard figures in the office, the overseer can be called upon to explain why it should cost more to make a certain average hank at one time.

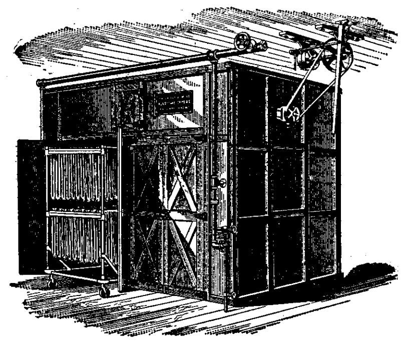
How to figure the average hank is best explained by an example: Suppose a mill is producing the following quantities of different roving in a week—2040 lbs. of 1 hank, 1800 lbs. of 1.2 hank, 1200 lbs. of 2 hank, 1420 lbs. of 4.5 hank and 600 lbs. of 6 hank. Find average hank?

$$\begin{array}{rl} 2040 \times 1 & = 2040 \\ 1800 \times 1.2 & = 2160 \\ 1200 \times 2 & = 2400 \\ 1420 \times 4.5 & = 6390 \\ 600 \times 6 & = 3600 \\ \hline 7060 & \quad 16590 \text{ and} \end{array}$$

$$16590 \div 7060 = 2.3498 \text{ average hank. Ans.}$$

This will give us rule: Multiply the pounds produced of each hank roving by the number of the hank and divide the total of the products thus obtained by the total of the pounds produced.

[END OF VOL. 2.]



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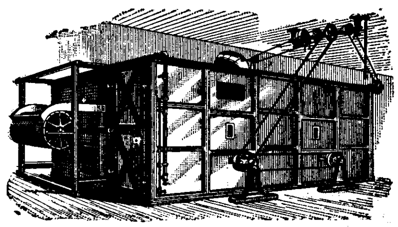

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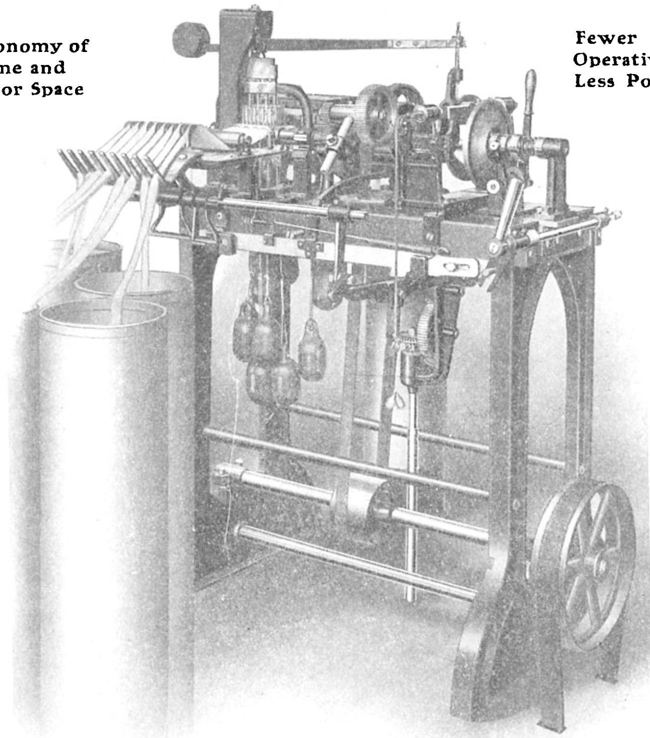

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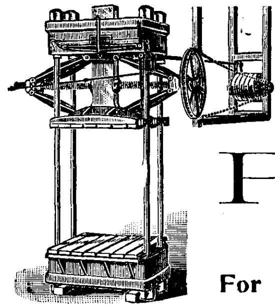

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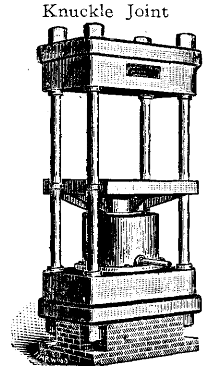

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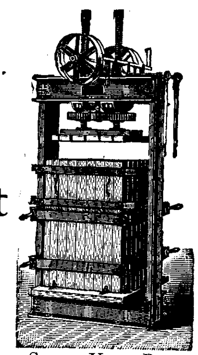

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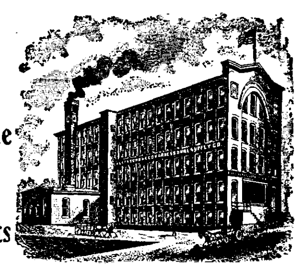

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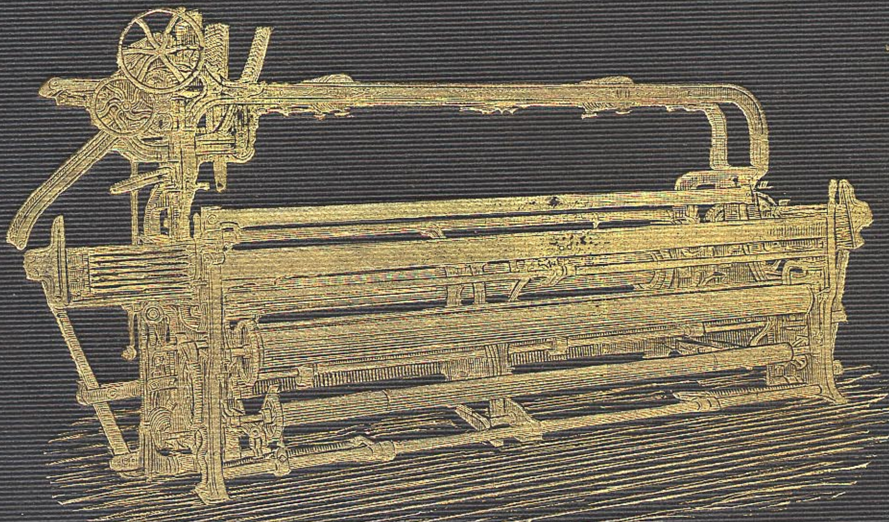
WORKS: WORCESTER, PROVIDENCE, PHILADELPIHA.



BUILDERS OF EVERY VARIETY OF

WEAVING MACHINERY

SEE INSIDE PAGE 2