A STUDY OF THE BEATER

The Theory of Beating Has to be Considered From Many Angles. The U. S. Bureau of Standards Recently Discovered That Too Much Hydration Detracted From the Permanency of Certain Papers.

PART II.

Comparison Between Small and Large Beater

The remark is often made that small beaters produce better stuff than large ones, and many papermakers dislike large beaters in consequence. Small beaters will undoubtedly produce better stuff in a given time, but it is quite untrue to say that a small beater will do the work either better or more economically. The cause of the difference can best be explained by examples.

Fig. 4 shows two beaters drawn to different scales—one with a trough 12 ft. x 6 ft.; the other with a trough 18 ft. x 9 ft. to a smaller scale. The outlines of both are similar. The difference is in the scale only. Both beaters are in perfect proportion. The details are quite in accordance with current practice and are as follows:—

	Small Beater	Large Beater
Trough	12 ft. x 6 ft.	18 ft. x 9 ft.
Roll	3 ft. x 3 ft.	$4\frac{1}{2}$ ft. x $4\frac{1}{2}$ ft.
Bars	60	90
Speed	240 revolutions	160 revolutions
Bedplate	22 bars	22 bars
Capacity	360 lbs.	1080 lbs.

The simplest way to compare two such beaters is to work out the cutting power thus:

Small Beater—

$60 \times 22 \times 36 \times 240 = 11{,}404{,}800$ inch cuts $= 1$.

Large Beater—

$90 \times 22 \times 54 \times 160 = 17{,}107{,}200$ inch cuts $= 1\frac{1}{2}$

These results are as 1 is to $1\frac{1}{2}$ and if the figures were worked out it would be seen that no benefit has been obtained by increasing the diameter and the number of bars in the large roll, because we have to reduce the speed to maintain the same surface velocity, and as the number of bedplate bars is the same in both beaters, the two sums will cancel out all except the length of the rolls which is as 1 is to $1\frac{1}{2}$. This shows clearly for an ordinary "Hollander" as usually made, that the length of the roll is the deciding factor.

The trough, however, has been increased in length, in width and in depth, three dimensions, and the capacities, therefore, are approximately as 1 is to 3.

If the cutting power is divided by the capacity, we get a comparison of output:—

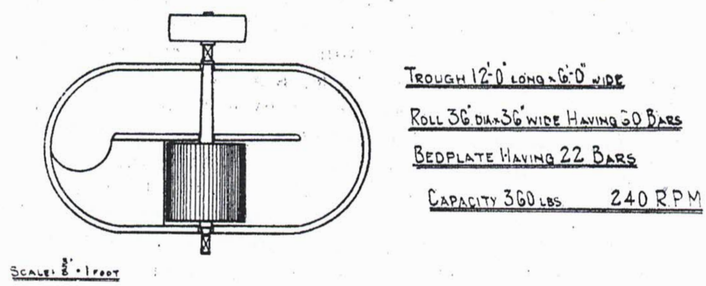
Small Beater—

$$\frac{11{,}404{,}800}{360} = 31{,}680 = 2.$$

Large Beater—

$$\frac{17{,}107{,}200}{1080} = 15{,}840 = 1.$$

The small beater, therefore, puts twice as much work on every pound of paper as the large one does and if the small beater takes 4 hours to a charge of 360 lbs. the large one will take 8 hours to a charge of 1080 lbs.



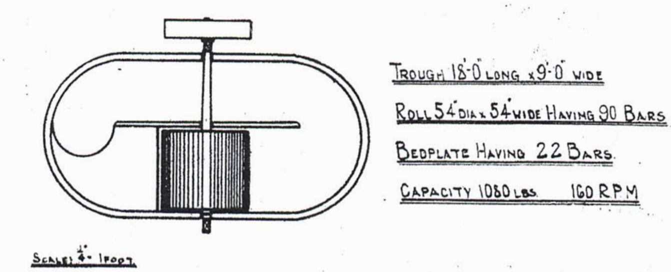


Fig. 4.—Comparison of Large and Small Beater.

The large beater, therefore, requires more time, because the capacity of the trough increases in greater ratio than the beating power, but there is no reason why the stuff should not be of equal quality if the necessary time is given.

Another method of calculating output is as follows:

Assuming the small beater to take 4 hours to a charge of 360 lbs. = 90 lbs. per hour, or $1\frac{1}{2}$ lbs. per minute.

then

$$\frac{11{,}404{,}800}{1.5} = 7{,}603{,}200 \text{ inch cuts per lb.}$$

The output of the large beater would be:—

$$\frac{17{,}107{,}200}{7{,}603{,}200} = 2.25 \text{ lbs. per minute} = 135 \text{ lbs. per hour.}$$

$$\text{or } \frac{1{,}080}{135} = 8 \text{ hours per charge.}$$

The figure for inch cuts per pound gives a fairly accurate indication of the beating and it is easily remembered. The figure will vary from 2 to 15 millions, depending on the quality of the paper being made.

Wet Beating

Although the cutting power of a beater is important, the wet beating power for most papers made from short fibres is of much greater importance.

To understand fully what any beater is capable of doing, it is essential to combine or compare the cutting power with the wet beating power.

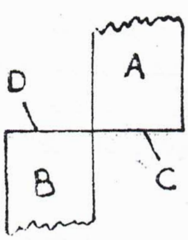
Wet Beating

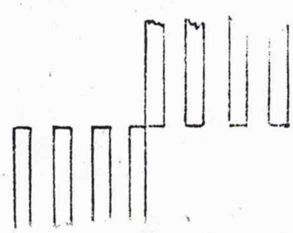
Wet beating is produced by the pressure of the roll bars on the bedplate bars, combined of course with the motion of the roll bars, and is quite distinct from the cutting action. It is easy enough to say that thick bars give more wet beating than thin ones, but it has not been easy to state the difference numerically.

The wet beating function has hitherto been considered somewhat mysterious, simply because it has not been understood, and even experts have found a difficulty in explaining it clearly.

However, we live in a scientific age and do not believe in mysteries, and we have to try to arrive at the science of wet beating and to put it into simple figures and simple language.

Wet beating is produced by the thickness of the bars and has nothing whatever to do with the edges. The edges produce the cutting action and have nothing to do with the thickness, thus—





If we take roll bar "A" meeting bedplate bar "B," the cutting edges have completed their work the moment they touch one another, while the wet beating faces "C" and "D" have not come into action at all.

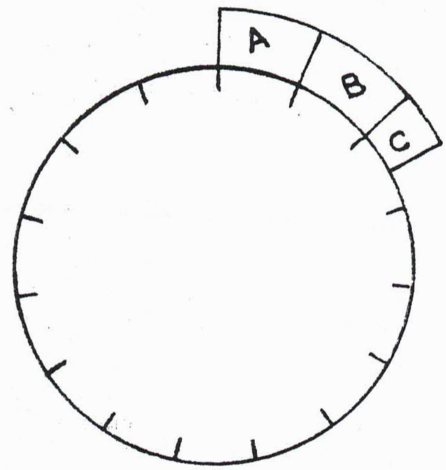
The wet beating power of any beater depends on the total thickness of the bars in the roll and the total thickness of the bars in the bedplate, and has nothing whatever to do with the number of cutting edges.

This is clearly shown by supposing bars "A" and "B" to be each 1" thick, and by substituting for each of them four bars each ¼" thick. By doing so we shall have increased the cutting power from 1 to 16 without in any way altering the wet beating power, as the total thickness is the same.

If we take as an example the smaller beater referred to above and take the edges of the roll bars as being ¼" thick and the edges of the bedplate bars to be ⅛" thick, we have—

Roll bars 60 x ¼ = 15", and
Bedplate bars 22 x ⅛ = 2¾".

If we imagine the edges of the roll bars put into a solid cylinder, it would have a circumference of 15", and if we put all the bedplate bars together, we would have a piece 2¾" wide, which we can divide up into two pieces each 1" wide and one piece ¾" wide —suppose also that the cylinder is 1" thick—thus—



If part "A" is moved one complete revolution, we shall have moved it 15" x 1" = 15"; part "B" would also be 15", while part "C," which is only ¾" long, would have moved 15" x ¾" = 11¼", making a total of 41¼".

Now 15" x 2¾" = 41¼", so that we have to multiply the surfaces together to get the wet beating effect for one revolution of the roll.

As the roll bars are 36" long and the roll runs at 240 revolutions per minute, we get the total wet beating effect thus—

41¼ x 36 x 240 = 356,400 square inches.

It will be seen that the number of bars does not enter into this calculation, as if we had had 120 bars each ⅛" thick in the roll, the total thickness, namely, 15" would have been the same.

Wet beating, therefore, depends on area or surface and is quite independent of the number of bars either in roll or bedplate.

With the area, however, worked out as above, we can obtain a very close idea of what any beater can do.

The cutting effect of this beater is 11,404,800 inch cuts, while the wet beating effect is 356,400 square inches. These put in the form of a fraction thus—

$$\frac{11{,}404{,}800}{356{,}400} = 32 \text{ to } 1$$

gives full information regarding any beater. It could be quite correctly termed the numerical factor of this beater while 1/32 is the wet beating factor.

It has been shown above that the number of bars does not affect the wet beating area, but it remains now to show a method of calculating this area from the cutting capacity and thickness of bars, thus—

For inch cut we have beating = ¼ x ⅛ = 1/32, so that we get—

$$\frac{11{,}404{,}800}{32} = 356{,}400 \text{ as before.}$$

There is a point in connection with wet beating which is not easily grasped, and the question could quite reasonably be asked as to "what effect the slipping of the fibre has on the wet beating." The answer is "None"—and this may be clearly shown by imagining a bundle of fibres firmly attached to block "A" and rotated round "D," and again imagining fibres to be wound entirely round "D", and "A" to move round it. The effect is the same and would be the same if the fibre slipped in any proportion on either of the rubbing faces.

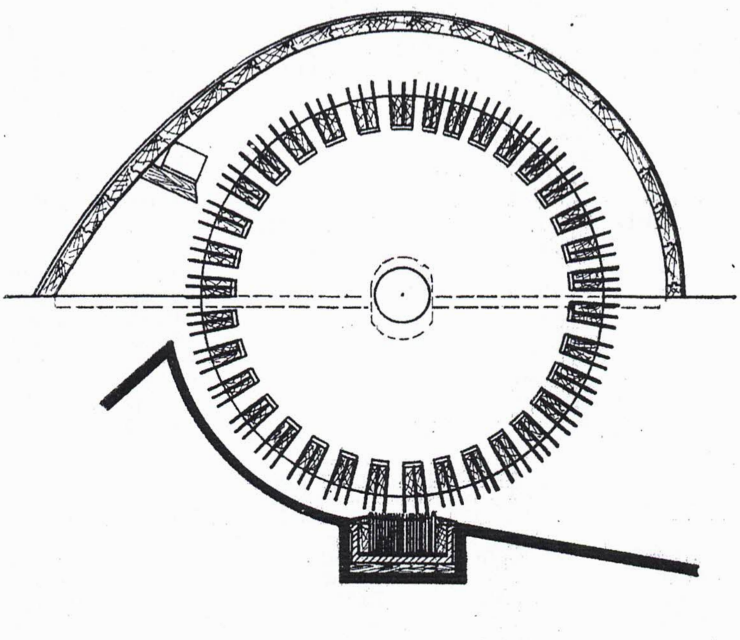
It will be realised, however, without any further explanation, that a beater, as we have shown, having a factor of 1/32 cannot make wet pulp; and beaterman asked to make wet pulp from such a beater cannot do it, because he finds it impossible to lower the roll to get the wet beating effect without cutting the fibres, and even a thick furnish and a long time will not produce the result desired.

Such a beater will, however, be credited with small power consumption, but the efficiency will be lower the smaller the power. It will, however, make "fine" pulp which will show wetness in any tester and on the machine wire, but it will only be "apparent" wetness after all.

It is owing to the difficulty of producing wet pulp from such a beater that bedplates are run down to be solid. This, of course, reduces the cutting effect and increases the wet beating effect to a certain extent, but such a bedplate ceases to function properly, as the bars scrape the pulp before them and the fibrage disappears a short distance from front of plate, and it is certain the bars would go metal to metal and beating would entirely cease.

To increase wet beating power, we require to increase the solid surfaces, and in this case the roll bars have a solid surface of 15″, while the bedplate has a solid surface of 2¾″. Doubling either of these surfaces would double the wet beating effect and, obviously, doubling the smaller figure, namely, the bedplate, is simplest and cheapest.

If the bars in the bedplate are made ¼″ thick, the same as in the roll we should have—



SECTION AT BACKFALL OF HOLLANDER ENGINE

Fig. 5.
Ordinary Back Fall.

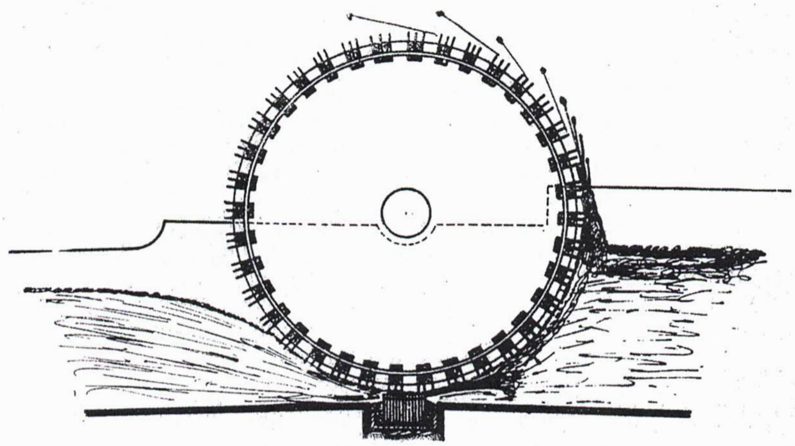


Fig. 6.
Section with Back Fall Cut Away.

$$\frac{1}{4} \times \frac{1}{4} = 1/16 = \frac{11{,}404{,}800}{712{,}800}$$

To increase cutting power, we must increase the number of bars and as the roll usually has all the bars it can carry, obviously, again, the bedplate is the only way open.

A wider bedplate requires to cover a larger arc of the roll and the number of bars that can be put in any beater depends on the diameter of the roll and the arc of the circumference covered by the bedplate, and as these are limited we have carefully studied this matter in connection with the very important function of circulation.

Circulation

The circulation of pulp in a beater is of great importance and the ordinary "Hollander" is very deficient in this respect.

Good circulation ensures good mixing and uniformity, besides ensuring sufficient fibrage on the bars to prevent metal touching metal.

The circulation is a good guide to the size of fibrage, but if the pulp is carried over the roll there may be ample fibrage but poor circulation.

We never had any doubt as to the capability of the roll to circulate the pulp, even with bars worn well down, and we were convinced that the difficulty lay not with the roll, but with the backfall.

The explanation of the difficulty will be made clear by Fig. 5 which shows the ordinary type of blackfall usually found in "Hollander" beaters. The drawing may be taken a typical of most beaters.

The bedplate usually projects some distance above the backfall, and the space between the roll and the backfall gradually increases towards the top. There is, therefore, a layer of pulp between the roll bars and the back fall, into which the pulp from the roll is thrown the moment the roll bars pass the last bar in the bedplate. The pulp leaves the roll in the form of slugs, quite separated from each other by the pitch of the bars. Each slug, although it has ample velocity, has little weight and its momentum is easily absorbed by the layer of pulp it is thrown into. The flow is, therefore, stopped and there is only a short distance past the last bar of the bedplate where the cells in the roll can be considered to be empty of pulp. Above this point there is the whole depth of the backfall, which is cometimes greater than the depth of pulp in front of the roll.

We know that the pulp at the front forces itself into the cells and we must expect the same thing to happen at the back, and this is really what does happen and the pulp is carried over the roll.

This was proved very conclusively by cutting the backfall completely out of a small beater, as in Fig. 6.

When the roll was running it was easily proved that the bars discharged their pulp at the bottom, immediately behind the bedplate; and, at a very short distance above the bottom it flowed into the bars again and went right over the top. With a suitable density of pulp there was a larger head at the back than at the front and the whole quantity was carried over the roll, so that there was no circulation at all.

There is no possible way of overcoming this defect in an ordinary "Hollander," or in any beater having a pocket in which pulp can lie after passing the bedplate. This defect exists in "Hollander" beaters even when new, but gradually gets worse as the roll bars are worn and the bedplate raised.

Doctors in the cover are of little value, as the pulp is within the cells.

The above test completely confirmed our idea which is that the pulp must be allowed to get clear away without obstruction from the last bar of the bedplate.

(To be continued)

April Newsprint Statistics

Production in Canada during April 1929 amounted to 221,784 tons and shipments to 220,270 tons according to the Newsprint Service Bureau. Production in the United States was 118,679 tons and shipments 121,548 tons, making a total United States and Canadian newsprint production of 340,463 tons and shipments of 341,818 tons. During April, 20,950 tons of newsprint were made in Newfoundland and 1,424 tons in Mexico, so that the total North American production for the month amounted to 362,837 tons.

The Canadian mills produced 75,776 tons more in the first four months of 1929 than in the first four months of 1928, which was an **increase of 10 per cent.** The United States output was 10,331 tons or 2 per cent less than for the first four months of 1928. Production in Newfoundland was 8,224 tons, or 11 per cent more in the first four months of 1929 than in 1928 and in Mexico 1,358 tons more, making a total increase of 75,027 tons, or 6 per cent over the same period in 1928.

During April the Canadian mills operated at 85.5 per cent of rated capacity, United States mills at 81.4 per cent and Newfoundlond mills at 102.3 per cent. Stock of newsprint paper at Canadian mills totalled 25,741 tons at the end of April and at United States mills 27,102 tons, making a combined total of 52,843 tons, which was equivalent to 3.4 days' average production.

CANADIAN MILLS

	Production			Shipments		
	Rating Tons Per Day	Actual Tons Per Month	Actual Tons Per Operating Day	Per Cent Rating (Totals Per Month)	Tons Per Month	MILL STOCKS
1929—April	10,018	221,784	9,026	85.1	220,270	25,741
Four Months	10,018	840,677	8,994	82.3	833,778	25,741
1928— " "	8,921	764,901	8,196	84.1	756,211	46,641
1927— " "		654,264			643,003	26,389
1926— " "		581,183			579,875	12,415
1925— " "		492,945			489,365	25,163
1924— " "		452,322			445,738	20,978
1923— " "		400,993			395,632	12,357
1922— " "		328,434			333,545	8,726
UNITED STATES MILLS						
1929 —April	5,611	118,679	4,655	81.4	121,548	27,102
Four Months	5,670	460,731	4,642	79.8	469,357	27,102
1928— " "	5,645	471,062	4,758	81.0	457,832	33,734
1927— " "		518,447			506,202	24,105
1926— " "		560,846			554,861	19,478
1925— " "		504,643			498,693	29,446
1924— " "		500,464			491,708	31,868
1923— " "		488,076			488,286	18,876
1922— " "		432,962			432,022	24,874
UNITED STATES AND CANADIAN MILLS						
1929—April	15,629	340,463	13,681	83.8	341,818	52,843
Four Months	15,625	1,301,408	13,636	81.4	1,303,135	52,843
1928— " "	14,566	1,235,963	12,954	84.9	1,214,043	80,375
1927— " "		1,172,711			1,149,205	50,494
1926— " "		1,142,029			1,134,036	31,893
1925— " "		997,588			988,058	54,609
1924— " "		952,786			937,446	52,846
1923— " "		889,069			884,018	31,233
1922— " "		761,396			765,567	33,600

NORTH AMERICAN PRODUCTION

	Canada	United States	Newfoundland	Mexico	Total
1929—April	221,784	118,679	20,950	1,424	362,837
Four Months	840,677	460,731	80,557	6,382	1,388,347
1928— " "	764,901	471,062	72,333	5,024	1,313,320
1927— " "	654,264	518,447	66,218	4,744	1,243,673
1926— " "	581,183	560,846	55,233	4,081	1,201,243
1925— " "	492,945	504,643	20,942	4,167	1,022,697
1924— " "	452,322	500,464	21,576	3,832	978,194
1923— " "	400,993	488,076	20,886	4,000	913,955

Representing Erkensators

Regarding the article in "Pulp and Paper Magazine of Canada" of May 2, 1929, entitled "Erkensator is new kind of screen," we are informed that the sole representatives in the United States and Canada for J. W. Erkens, Niederrau, Germany, manufacturing the "Erkensator" is

Erkens Corporation,
122 East, 42nd Street, New York City.
Chanin Building,
President: Sven C. Lindberg., Chem. Eng.

Mr. and Mrs. A. C. Price and Mr. Dick Price sailed from Quebec last week on the Megantic, for a short stay in England.

A STUDY OF THE BEATER

This is the Last instalment of article by Mr. Samuel Milne, describing the beater developed on scientific lines after much careful research and experimentation

Circulation continued

As this is one of the important features of our new beater, Fig. 7 shows how completely we have overcome the difficulties inherent in the "Hollander."

The bedplate commences about a line drawn vertically from the centre of the roll. It ends at an angle of about 15° below the horizontal line, thus giving the backfall an angle of 15° and making it very short. The bedplate covers an arc of 75° of the circumference of the roll and this is about as large as it is practically possible to cover.

With this arrangement of bedplate and backfall and with the plate removed from the front of the roll, the circulation was excessive, far exceeding any possible requirements, and consumed too large a proportion of power.

We, therefore, adjusted the front plate until we got a reasonable fibrage on the bars, and found that the opening could be reduced to about 4" wide. Such a narrow opening, however, is apt to be choked with a spadeful of pulp, so that we now make the front as shown, which gives an opening about 12" wide, but does not increase the area of roll in contact with pulp.

Our experimental beater has a capacity of 1,000 lbs. of dry fibre at 7% density without any loading.

The roll is 60" diameter x 53" long and has 88 bars equally pitched and runs at 140 revolutions per minute—2,200 feet per minute.

When freshly charged the pulp makes one complete revolution in about 3 minutes, say 333 lbs. per minute passing under the roll.

The number of bars or cells per minute is—

$$140 \times 88 = 12{,}320$$

Each bar, therefore, lifts—

$$\frac{333}{12{,}320} = .027 \text{ lbs. of dry fibre.}$$

This, at 7% density, makes .386 lbs. pulp and water per bar, which is equal to about 10.67 cubic inches, which divided by the length of the bar 53" = .2 square inches cross section. This may be represented thus—

1" x .2"	or thus:	.45" sq.

As the beating proceeds the circulation increases until the pulp is making one complete revolution in about 1 minute. The section of the pulp in the cells would then be represented by—

.6 square inches	or	.78" square

The smaller section, when the beater is newly filled, seems a small quantity for each cell; but it is quite ample as the circulation is rapid enough at the commencement and increases as the beating proceeds, which is as it should be.

The roll when running at 2,200 feet per minute = 36.6 feet per second, has a velocity capable of lifting water to a height of 20 feet while the backfall is only about 15" above the last bar of the bedplate.

The important point is that the pulp cannot leave the roll till the bedplate is passed and at this point there is kinetic energy enough in each slug to lift it 20 feet high if it were quite free, which is, therefore, ample to overcome the friction of the short backfall.

Fig. 7 shows exactly what occurs. The pulp strikes the cover, follows it and falls down, piling itself up as shown, leaving the top of the backfall well above the

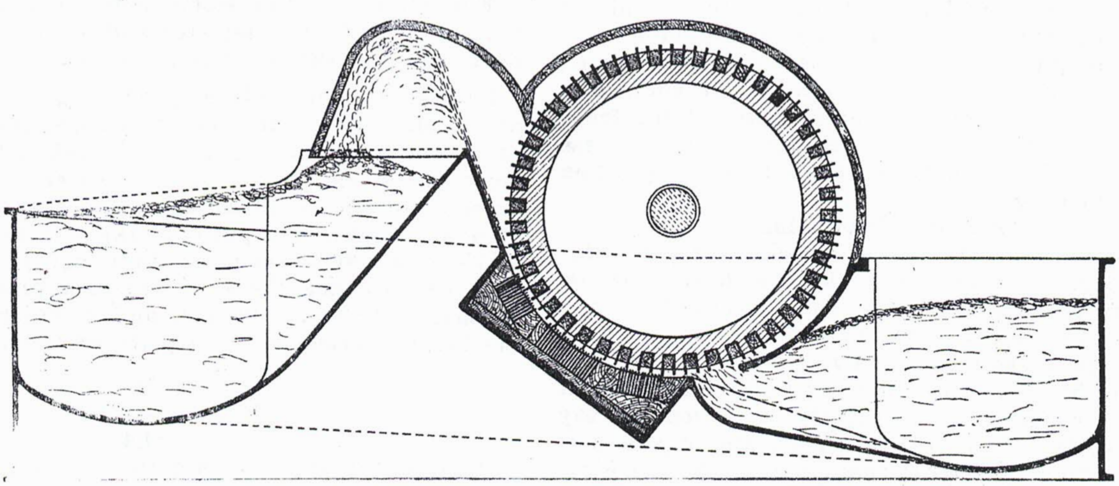


Fig. 7.
Section of Patent Beater.

pulp and the pocket between backfall and roll quite empty, so that no pulp is carried over the roll. Nothing better can be imagined.

It is clear from the above that if a roll discharges all the pulp it gets, it becomes necessary to regulate circulation by restricting the quantity of pulp flowing to the roll.

The question might well be asked as to "what really determines the rate of circulation, seeing the roll takes all it gets and completely discharges it?" The answer is "that the circulation depends on the quantity fed into the roll"—this depends on the head of the pulp in front of the roll and, of course, the area of the opening. The head depends on the rate at which the pulp flows round the trough and this depends on the viscosity or density of the pulp and the angle it flows at. The roll deals with all it gets and has no control over the quantity.

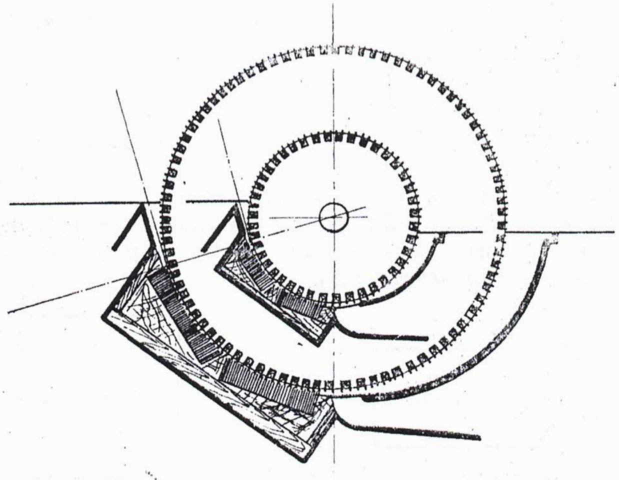


Fig. 8.
Showing Bed Plate Increasing with Diameter of Roll.

If the density is increased, the head of pulp at front of roll is reduced, giving less pressure to force the pulp to the roll, which, of course, reduces the quantity passing in. By increasing the density also, we raise the pulp higher at the back and increase the angle of flow; and if the pulp were made very dense only a small quantity would pass to the roll and circulation would be reduced, while the angle of the surface would be much increased.

When the beater is freshly charged at 7% density, about 333 lbs. pass under the roll per minute and the angle of the surface of the pulp is at a maximum.

When the pulp is beaten it becomes more fluid; flows much more easily; the angle at the surface is reduced, increasing the head or pressure at the front of the roll and forcing 1,000 lbs. per minute to pass into the roll. 7% density is really thick pulp when there is no loading.

Power for Circulation

It is impossible in any beater to bring the power for circulation down to anything like the theoretical figure, simply because it is impossible to circulate pulp without beating it to some extent.

This is easily shown as under:—

Taking 333 lbs. per minute at the commencement of a charge at 7% density, representing say 4757 lbs. of pulp and water, we impart sufficient energy to lift this quantity 20 feet high. This requires:—

$$\frac{4757 \times 20}{33{,}000} = 2.88 \text{ H.P. theoretically.}$$

We cannot, however, calculate on the mere lifting of the pulp; as even with the roll up, a certain amount of work will be done on the pulp while it is passing over the bedplates.

The roll bars strike the pulp 12,320 blows per minute, and these with the acceleration of the pulp from, say 6 inches per minute to 2,200 feet per minute, represents power which cannot be avoided in this or in any other beater.

Beaters having the rolls elevated, are subject to the same laws; as the rolls must and do impart their surface velocity to the pulp and the power necessary to do this is absorbed whether the rolls are allowed to lift the pulp or not. There is no possible way in which this loss of power can be avoided.

Our beater takes a total of 12 H.P. at 2,200 feet per minute, for circulation, with the roll about 3/16″ clear of bedplate. This power includes motor and belt. The roll alone with beater empty takes 3 H.P. so that the actual power required for circulation is about 20 H.P.

The work actually done in elevating the pulp is theoretically 2.88 H.P. and if we allow a similar amount for power used at front, we shall probably not be far wrong. This will leave about 14 H.P. for work done on the pulp while passing over the bedplate with the roll up, and about 6 H.P. for circulation. It does not seem possible to reduce this with a roll 53″ long, and it is not possible to do it for so little power with a pump or propellor.

We can, however, consider whether by any other modification we could improve efficiency. There is one method and one only, viz., by making the bedplate wider so that a given length of roll would do more beating in a given time. The width of bedplate varies in direct proportion to the diameter of roll, so that if we double the diameter of roll we can double the beating power. Fig. 8 shows how this can be done by increasing the diameter of the roll, but as we do not increase the length of the roll we do not alter the power used for circulating the pulp.

It is certain that increasing the diameter and reducing the width of the roll is the only way in which the power for circulation can be reduced. If we double the diameter and halve the width, we shall also halve the power for circulation, while maintaining the same beating power.

For our beater this would mean increasing the roll from 5 ft. to 10 ft. diameter and although this would be an unusual size we may see it before long.

Seeing that the surface speed of 2,200 feet per minute is more than sufficient to ensure vigorous circulation, the question might well be asked "what is the most economical speed to run beater rolls at?" The answer to this involves much more than mere cost of power or waste of power. Take, for instance, speeds of 1500 and 3000 feet per minute, equalling 25 and 50 feet per second, these velocities represent heights of, say, 10 feet and 40 feet, and it will be noted that the height varies, as the square of the velocity, viz.:

$$H = \frac{V^2}{64.4}$$

Taking 333 lbs. per minute, as before, the slow speed would require—

$$\frac{4712 \times 10}{33{,}000} = 1.43 \text{ H.P. theoretically,}$$

and the high speed would require—

$$\frac{4712 \times 40}{33{,}000} = 5.72 \text{ H.P. theoretically.}$$

These powers, it will be observed, are in the ratio of 1 to 4.

The roll speed, however, has only been doubled and it is thus seen that to double the beating power by increased speed, we must lose considerably in power required for circulation, so that there is a distinct loss in the higher speed due to the greater amount of power required for circulation.

It is quite true, therefore, to say that the slower speed is more economical so far as power is concerned, but there is more to consider than power. The question of capital cost comes in along with floor space, etc., and each installation must be considered on its merits.

It might, for instance, be quite easily proved to be economical to run a beater at what might be termed excessive speed to get increased output in a given space, rather than make a complete reconstruction of a beater house, and no law can, therefore, be laid down which will suit every case.

So far as our beater is concerned, there is no limit to speed, except the bursting of the roll. We have run it up to and over 3,000 feet per minute.

From the above it will be seen that it is impossible to obviate the losses incidental to circulation in any beater, but in our beater we have reduced these losses to a minimum by—

1. Having the smallest possible area of roll in contact with the pulp at front, less than in any other beater, but sufficient to ensure ample fibrages.
2. Reducing the total arc of contact of the roll with the pulp to the width of the bedplate plus the inlet portion amounting to about 90 degrees in all, as compared with from 150 to 180 degrees or more in ordinary "Hollander" beaters.
3. Having the bedplate occupying the largest possible arc of the circumference, thus increasing the beating power in the most efficient manner possible and reducing the time required and thereby the total power required for circulation for a charge.

An example will make the latter point clear:—

Take an ordinary "Hollander" beater requiring, say, 40 H.P. for 4 hours to complete a charge, 20 H.P. being required for circulation, we have:—

Circulating	$20 \times 4 = 80$	H.P. hours.
Beating	$20 \times 4 = 80$	" "
Total	160	H.P. hours.

If this beater were altered and its beating power doubled, so that only 2 hours were required per charge, we should have—

Circulating	$20 \times 2 = 40$	H.P. hours
Beating	$40 \times 2 = 80$	" "
Total	120	H.P. hours.

which shows a saving of 40 H.P. hours = 25%.

It is clear, therefore, that if we can reduce the time required to obtain a definite result, we save largely in power necessary for circulation, and the only way in which time can be reduced is by increasing the number of bars in the bedplate in the way we have carried out in our beater.

Fibrages

The quantity of pulp carried by each bar, representing a cross sectional area of .2 to .6 square inches, seems surprisingly small, but it is ample not only to ensure vigorous circulation, but to cover thoroughly the edges of the bars.

It is impossible to ascertain the exact shape the pulp takes when passing over the bedplate, but it seems reasonable to suppose that centrifugal force is continually urging the pulp outwards so that it forms a fibrage on every bar of the bedplate immediately in front of the roll bar. It is only by some such action that every bar can do equal duty.

The fibrages are formed on the roll bars before they touch the first bar of the bedplate, but further fibrages must be formed by centrifugal force, as it is unreasonable to imagine a roll bar to carry a fibrage across, say, 60 bars in a bedplate, without renewal.

Fibrage is an excellent expression and it is quite true to say that without fibrages there can be no beating.

Roll Bars.

When bars are fitted into the roll in clumps, the front bar of each clump carries most of the pulp, and the others are apt to carry too small a quantity. There can be no doubt that equally pitched bars will give better results, but it is somewhat difficult to decide the minimum pitch that would be workable for different classes of material.

We have 88 bars in a roll 60″ diameter, which are approximately 2″ pitch, and the results are excellent in every way. The bars only project from the roll 1″ when new, and to prove that they could be worn well down, we filled in pieces of wood, leaving the bars projecting only ⅜″, and the circulation was very little, if at all, reduced on a wood pulp furnish.

When the cross section for pulp required for circulation, namely, .2 to .6 inches, is considered ⅜″ projection is ample.

It seems reasonable to suppose, however, that a greater projection would be advisable for long fibred material like hemp or flax, but it is quite conclusively proved that a small projection is all that is necessary for short fibred material.

Bedplates.

It has often been stated that no advantage can be gained by increasing the number of bedplate bars beyond a certain limit, and this statement has been made so often that it has come to be accepted as a fact.

Before we built our beater we carefully considered this matter and concluded that as the roll bars would form fibrages on every bedplate bar by centrifugal force, we could use a much greater number of bedplates with perfect safety.

As explained above, we therefore decided to make the bedplate cover an arc of 75° of the circumference of the roll. We arranged the backfall at an angle of 15° to ensure the pulp being thrown forward. This brought the front bar of the bedplate directly under the centre of the roll, leaving ample inlet for the pulp to the roll.

The pitch of the bars in the bedplate is very important and, like the roll bars, they should not be placed too close together.

The actual beating effect can be reduced very seriously by placing the bedplate bars too close together, as the spaces between them would be easily plugged up.

Here, as with the roll, it is difficult to lay down any law, but it would seem that the dividers should be somewhat thicker than the bars for short fibred materials and probably considerably greater for long fibred stuffs.

Angle of Bars.

Much has been written regarding the angle of the bars and it has been stated that the angle should not exceed 43° nor be less than 3°.

We are inclined to a small angle, merely enough to ensure smooth action and the smaller the better.

No increase in cutting or wet beating action can be obtained by angling the bars, and it is quite a mistaken idea to assume that parallel bars do not cut. The reverse is the case.

We had an experience a good many years ago with one of our refiners. We were testing the large angle theory and arranged the bars at a smaller angle than 43°. The result was disastrous, as the machine was utterly useless until the bars were altered to a small angle. It seemed that the large angle allowed the bars to push the pulp away and no work of any kind was done on the fibre. This test was conclusive so far as we were concerned regarding large angled bars.

Weight of Roll.

The statement has often been made that good stuff, particularly for thin tissue papers, cannot be made with heavy rolls, and for some stuffs, wood rolls are advocated on account of their light weight.

No greater mistake was ever made. The real point in beating is not the weight of the roll, but the distance between the roll and the bedplate, which will vary with every condition of the pulp down to the diameter of a fibre or less. This distance, however, should be quite regular and not be subject to variation such as by the jumping of the roll or bedplate.

The weight is not all necessary for pressure on the bedplate, but the inertia is very necessary to ensure smooth action.

A light roll will yield to a lump which will pass through and come round again, whereas if the roll is of ample weight the lump is dealt with at once.

The heavy roll will, so to speak, receive a heavy blow without yielding and will run in a smooth steady manner, which requires to be seen to be really appreciated.

It is this want of weight or inertia which has been fatal to the hydraulic plates. These looked at one time to be very fine things indeed, but they have not come up to expectation, entirely owing to their small mass and want of weight.

The roll, shaft, etc., in our beater weighs about 10 tons and is not an ounce too heavy. It runs in ordinary ring oiling bearings. We do not consider roller or ball bearing would be of any advantage, as the roll only takes 3 H.P. to drive it, and any saving possible through other bearings would not cover the uncertainty involved.

Adjustment of Roll and Beater Pressure

In an ordinary "Hollander" beater in which the roll is adjusted by hand, the beaterman when he lowers the roll reduces the distance between the roll and bedplate bars. This distance remains constant until he alters it again.

Every time the roll is lowered, the pressure on the pulp is increased and this pressure gradually decreases until the roll is lowered again.

If the pressure applied to the pulp was recorded on a chart, it would show a number of steps corresponding with the lowering of the roll. A chart for power would also show these steps.

Our beater was originally fitted with the ordinary hand operated gear, but a trial or two convinced us that it was impossible to expect any beaterman, with a number of beaters under his charge, so to operate them that efficiency could be obtained, particularly at the commencement of a charge.

This was clearly seen when an attempt was made to maintain constant power, as to do so it was necessary to be at the hand wheel all the time. This was no doubt due to the large amount of work put on the pulp, and as no pulp was going over the roll, the difference produced in one revolution, say 3 minutes, was considerable and the roll required to be lowered.

After we fitted the automatic gear (Fig. 9) the improved results were immediately apparent and exceeded all expectations.

This gear consists of a heavy cross shaft and levers connecting the two main levers which carry the roll and compelling them to move in unison.

The front main lever is operated by compound levers and the weight is adjusted by handwheel and screw so that any desired pressure may be applied.

All the levers are fitted with ball or roller bearings so that they are very sensitive.

The effect of this arrangement is to relieve the beaterman of his most difficult duty, while at the same time maintaining the highest efficiency all the time. *(Please continue on page 862)*

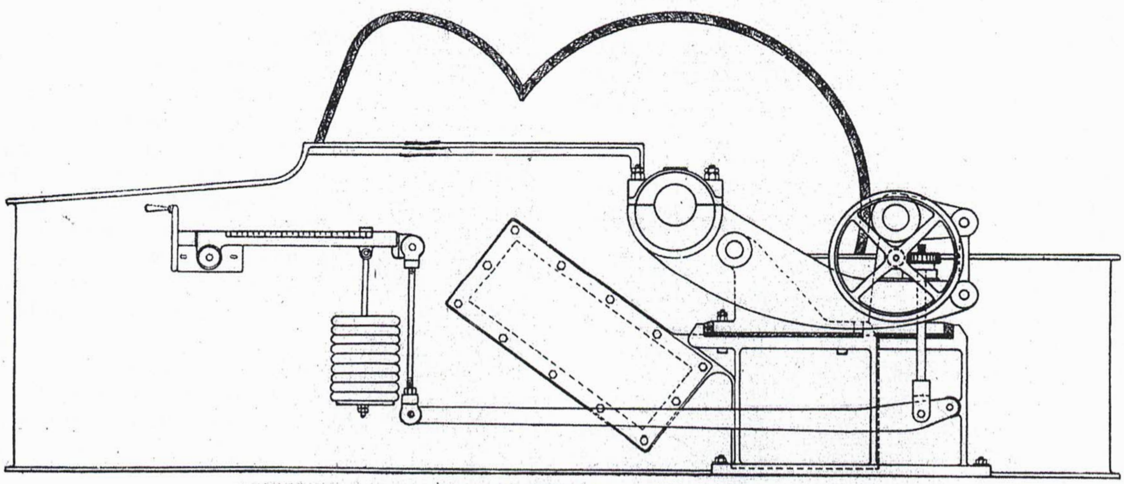


Fig. 9.
Lever Arrangement for Adjusting Pressure of Roll.

A Study of the Beater

(Continued from page 844)

The pressure can be maintained constant from start to finish if need be, but can be easily adjusted to suit requirements.

The actual pressure applied to the pulp could be easily calculated and once this pressure was found for any given material or paper it could be repeated over and over again with certainty.

The distance between roll and bedplate is at a maximum when the beater is freshly charged while the roll is automatically lowered as the beating proceeds.

This means, of course, that the fibrages are largest at the commencement and gradually get smaller notwithstanding the fact that circulation is accelerated. The cells carry more pulp, but the fibrages are smaller.

The layers of pulp on the bars, or the fibrages, while getting thinner, still carry the unbalanced weight of the roll and the treatment becomes more intense.

Carrying this to the extreme, we can imagine the layer of pulp to be one fibre thick and this layer being bruised but not cut. Wet beating would thus be at a maximum.

If the roll were lowered a fraction further, every fibre on the edges of the bars would be cut.

The movement of the roll between these two positions would be exceedingly small and 1/1000 inch would be a comparatively large movement.

It is just here where the beaterman shows his skill in getting the best wet beating effect without cutting the fibres too much.

If the weight is adjusted at the commencement of a charge and left alone, the power required will gradually increase due to the closer contact of the bars and to the increased circulation.

Thick bars give a greater area and enable more pressure to be applied to increase the wet beating effect, and these with the automatic lowering of the roll increase efficiency to the maximum.

Data regarding the actual pressure various pulps will stand is not available meantime. It is, however,

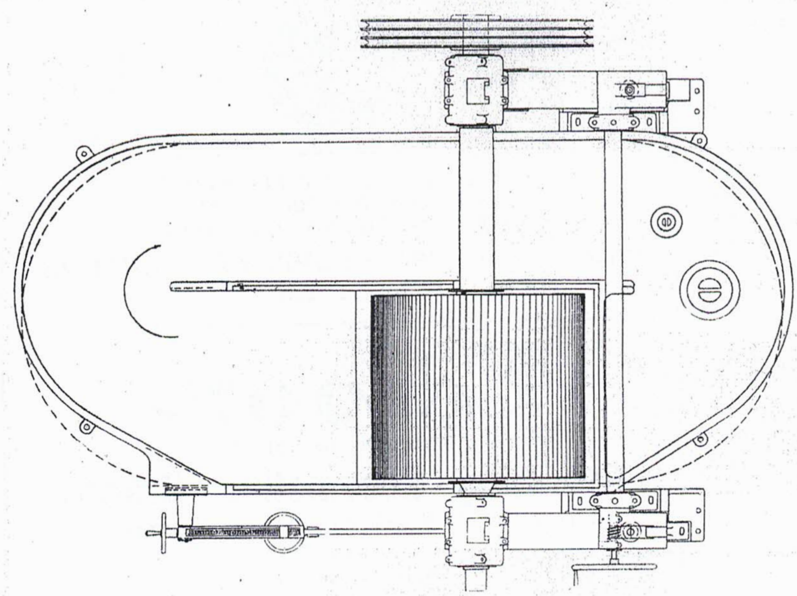


Fig. 10.
Design of Beater Trough to prevent lodgments.

safe to say that it is much higher than generally sup-

imum thickness of bars that can be used and the pressure they will require to attain highest efficiency.

Edges of Bars.

The bars in the roll and bedplates have square edges and will, therefore, maintain their cutting and wet beating properties all the time.

Bevelled bars are continually changing in thickness, and the ratio between cutting and wet beating is, therefore, also varied.

For all ordinary papers and for most special papers, bars with square edges are better in every way.

The actual thickness of the bars must be fixed to suit the average paper being made, and experience is required to determine the most suitable thickness.

Thin or sharp bars will cut the pulp very readily, but it is a mistake to think that thick bars will not cut the fibres, as if the roll is heavy enough and the pressure applied, thick bars can be made to cut just as easily as thin bars; and an important point in beater design is so to arrange the thickness of the bars that the roll can be lowered to use the power to the best advantage.

Many ordinary beaters use more than 50% of the total power to circulate the pulp, and it is quite a common thing to find a beater using 37½ H.P. at full load and 20 H.P. with the roll up, in which case 20 H.P. is absorbed in circulation and 17½ H.P. in the actual beating.

The efficiency of such a beater could be very greatly increased by making the bars thicker, so that the beater would take a total of say 60 H.P., in which case 20 H.P. would be required for circulation and 40 H.P. for the actual beating, and a great saving in power would result, as the greater the difference between the full load power and the circulating power, the higher the efficiency of the beater.

We have to confess that the data regarding thickness of bars which we have been able to obtain from existing beaters, has been of little value in assisting us to fix the best thickness for the bars, and we can arrive at a conclusion very much better when we get a charge of material to put through the experimental beater. We can then arrange the wet beating factor much more accurately.

Temperature

A small rise in temperature of the pulp in a beater is a very fair guide to the efficiency of the beater. The whole of the power put into the beater shows itself in increased temperature of the pulp; and if there were no radiation or loss of heat, the total power could be fairly accurately calculated from the rise in temperature.

The beater which will produce a certain quality of pulp with the smallest rise in temperature, will be the most economical.

When the temperature rises too high the stuff, instead of becoming more wet, will become more free and for very fine stuffs a small rise in temperature assumes very great importance.

Some of the results of our tests are as follows:—

Finest tissue papers from rags—8 hours beating — 51° rise.

Kraft paper 2 hrs. 30 mins, beating 20° rise.

Kraft paper 2 hrs. 10 mins. beating 17° rise.

Sulphite wrapping paper 1 hr. 40 mins. beating 13° rise.

Esparto papers 3 hrs. beating 23° rise.

These are for first trials and there is little doubt that better results can be obtained with a little experience in working the beater.

Mixing and Lodgments

In many of the older books on papermaking it is repeatedly mentioned that the beaterman should keep the stirring stick going. These instruments, no doubt, were necessary long ago, but they should not be necessary to-day.

If the beater is properly constructed with the trough of correct shape, so that pulp cannot find any place to lodge in, the circulation should be so perfect that there should be no need of any assistance from stirring sticks.

The ordinary 'Hollander'' trough has been experimented with in many ways, chiefly in regard to the distance between the midfeather and the ends of the trough, and it has been found that the narrower this space is made the greater the trouble.

The theory of the correct shape of trough is really very simple when clearly understood.

Fig. 10 shows a plan of the trough of our experimental beater, and it will be seen that the roll channel is 53″ wide, while the back channel is only 38″ wide.

The ordinary method of construction is to make the end of the trough a semi-circle and this has been proved to be entirely wrong.

The correct construction is to take the end of the midfeather as a centre and to make the end of the trough a circle up to the point where a tangent from the front or back of the trough will meet it.

With such a trough there are no lodgments and the velocity of the pulp is practically identical at all points.

With the trough made semi-circular at the ends, there will be lodgments at the points shown.

The pulp comes along the back channel in a solid mass without the slightest sign of any cross movement and continues this motion up to the point where the tangent commences. It then flows in straight lines to the roll.

The bottom of the trough is made to the same incline as the surface of the pulp and this angle, of course, requires to be adjusted to suit the density of the pulp. With such a trough there can be no lodgments and a stirring stick is not required.

We can, of course, make troughs with an under channel to suit situations where space is limited.

We also provide a mixing apparatus in the cover which moves the pulp from the midfeather to the outer wall and this is very effective, consumes no power, and is continually changing the position of the pulp from midfeather to outside wall.

The experimental beater in our works has a numerical factor of:

$$\frac{31,342,080}{2,448,600} = 12.8 \text{ to } 1.$$

We are building beaters with the following numerical factors:

$$\text{(A)} \quad \frac{39,177,600}{3,696,000} = 10.6 \text{ to } 1.$$

$$\text{(B)} \quad \frac{31,342,080}{5,913,600} = 5.3 \text{ to } 1.$$

and are prepared to build still larger and more powerful ones.