STEAM-COMPRESSION OF COTTON. The object of compressing cotton-bales is to obtain the largest possible weight in stowage in a ship's hold, inasmuch as, within a certain limit, the quantity in pounds that can thus be stowed governs the price of cotton in the market through the price of freight, the latter being regulated by the amount that a ship can stow per ton register. Consequently, the result sought in compressing is the greatest possible density of material.

Bales as received from the planters vary considerably in size. Their horizontal section ranges between 8 sq. ft. (4 ft. long by 2 ft. wide) and 17 sq. ft. (6 ft. long by 34 in. wide). There would be many advantages in securing a uniform size, and the National Cotton Exchange has recommended that plantation press-boxes be equalized to give an area of cross-section of 9 sq. ft., or 54 by 24 in. The average bale may be considered as weighing 470 lbs., and it measures in volume 50 cub. ft.

The amount of compression to which this can be subjected depends upon the press used, and upon the means of securing the bale while in the press in order to prevent its undue expansion after the pressure is removed. The following figures showing degree of compression in the press and subsequent expansion were obtained by Capt. S. H. Gilman of New Orleans, by the measurement of about 1,000 bales during the cotton season of 1875-'76: Thickness of bale in press, in inches, 11.15; density per cubic foot, in pounds, 39.46; density when turned out of press, 20.90—when delivered to ship, 18.14—when stowed in ship's hold by jack-screws and mechanical means, 21.47; thickness of bales delivered on wharf, in inches, 25.35—when stowed in ship's hold, 21.42; area of horizontal section of bale, in square feet, 12.

At a trial of an India press in Liverpool, Orleans cotton was compressed to 65 lbs. per cubic foot, and tied so as to remain at 46 lbs. without injury to the staple, which opened in 30 minutes without any appearance of having been baled. All India cotton is baled to a density of 45 lbs. per cubic foot measurement on landing in England. The Champion Compress, hereafter described, in New Orleans, it is stated, has compressed a bale of good ordinary cotton to a density of 80 lbs. per cubic foot. The bale was then tied to expand to 38 lbs., and samples in a short time showed no evidence of having been pressed at all.

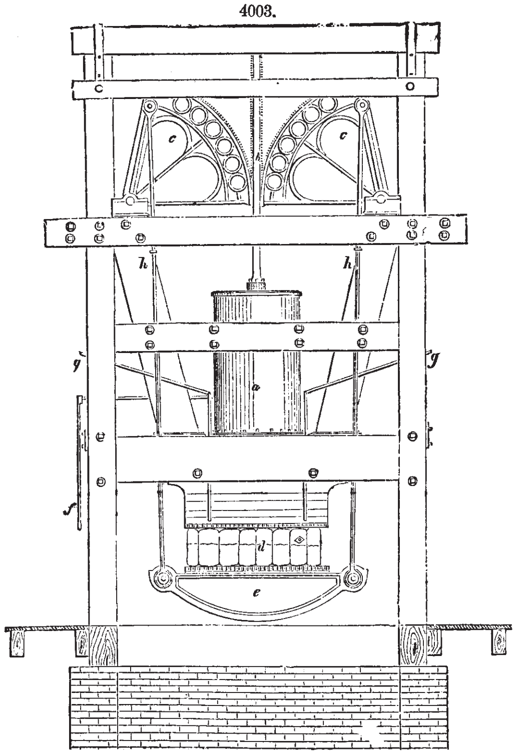
As regards the strength of band-iron in general use on cotton-bales, the elastic strength, according to the authority above quoted, is 2,342 lbs.; the breaking strength is 2,700 lbs.; and the stretch per lineal foot between the elastic strength and the breaking strength is about one inch.

The elastic or lifting strength of a bale of cotton compressed to 6 in. in thickness is, after having expanded 50 per cent. of its volume, 57,222 lbs. It appears from this that such a bale cannot be held with the usual six iron bands, whose total elastic strength is but 14,052 lbs., at a size approxiting nearer than 6 in. to that which it had in the press, except in cases of very large single or double bales. This deduction coincides with the results of compressing cotton in India, where the staple comes from the planter in loose bags or sacks. It is weighed in quantities of 390 lbs. at a time into a cast-iron box 18 by 48 in. in horizontal area, and is there compressed to a thickness of 12 in. and to a density of 65 lbs. per cubic foot. To hold it, 18 iron bands $1\frac{1}{4}$ in. wide (equal to 24 American bands) are applied and riveted together. The bale when removed from the press expands to about 18 in. in thickness, and to a density of about 45 lbs. per cubic foot, as already stated. Cotton compressed in this manner can be stowed in ships at the rate of 2,800 lbs. per registered ton. Twelve ships loaded in New Orleans in the spring of 1876 carried 1,424 lbs. per registered ton. A large gain in stowage is obtained by compressing two bales into one package. Details of this operation are given in connection with the description of the Champion Compress, from which it appears that a stowage of 2,545 lbs. per ton was obtained, which could have been increased to 2,870 lbs.

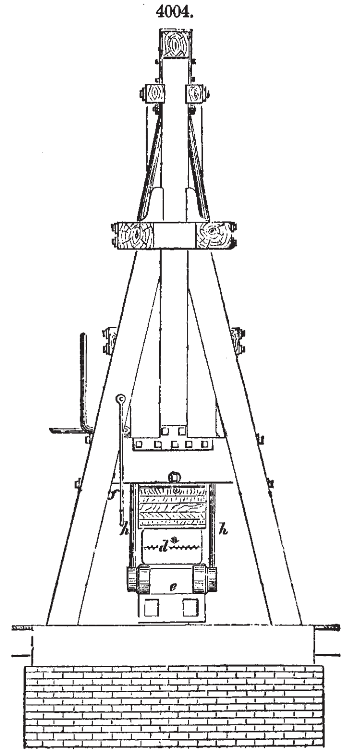
The apparatus used for compressing bales may be divided into two classes: *hydrostatic presses*, the power of which is constant throughout the stroke; and *progressive-lever steam-presses*, the power of which is irregularly progressive and cumulative to the end of the stroke, where the greatest pressure is exerted. The Taylor hydrostatic press, which is the principal form used in this country, is described under PRESSES, HYDRAULIC.

The form of steam-press upon which modern apparatus of the kind is based was devised by Mr. Philos B. Tyler in 1845. Its construction, as originally made, is shown in Figs. 4003 and 4004. Interposed between the piston-rod and follower of the press are levers, so arranged that at the commencement of the operation, when the resistance presented by the bale is at its minimum, the arms in connection with the follower shall be at their greatest length, while those connected with the piston shall be at their shortest. As the resistance increases, the relation of the lever-arms is changed gradually, and in proportion to the resistance of the cotton, so that at the end of the stroke just the reverse condition obtains. In Figs. 4003 and 4004, the bed b is inverted and attached to the under side of a beam of the frame. To the upper side of this beam is secured the steam-cylinder a. The piston-rod is provided with racks which engage with the toothed sectors *c*. The sectors are connected with the follower *e* by four rods *h*. When steam is admitted to the cylinder, the piston is forced up. This causes the sectors to swing on their fulcra, and in so doing to lift up the follower over a small distance. The bale is thus forcibly compressed between the follower and the bed, and so is held until the bands are passed around it and secured.

4003.



4004.



Grader's Standard Compress, constructed similarly to the foregoing, has a second steam-cylinder placed inverted and vertically above the cylinder which rests on the bed of the machine. The upper cylinder has a shorter stroke but larger piston area than the lower one. The operation is as follows: When steam is admitted to the lower cylinder, the piston ascends, and the rack on the piston-rods vibrates the segments as already described. This motion is continued until very near the end of the stroke, when the upper extremity of the piston-rod enters a clutch, by which it becomes connected with the lower end of the piston-rod of the upper inverted cylinder. Steam is then admitted into the latter, and the pressure is by it completed, the large piston surface and short stroke affording a means of applying the very great degree of compression necessary at the end of the operation. In a machine of this description erected in New York, the lower cylinder was 48 in. in diameter, and the upper one 60 in., the strokes measuring respectively 9 and 4 ft. The floor space occupied was 14 by 18 ft., and the weight of the machine was about 100 tons. (See *Scientific American*, xxix., 287.)

The Champion Compress, represented in Fig. 4005, is the invention of Capt. S. H. Gilman of New Orleans, and has achieved very remarkable results in the compression of cotton. The dimensions of a machine built in 1876, and at the present time (1879) in active use, are as follows: Area of bed-plate, 20 by 12 ft.; depth of same, 18 in.; total height to top of reversing cylinder, 36 ft. 6 in.; diameter of main cylinder, 75 in., stroke 10 ft.; diameter of reversing cylinders, 34 in., stroke 18 in.; length of lifting-rods between centres, 32 ft. 7 in.; diameter of same, 12 in.; diameter of lifting-rod shafts (ingot steel), 13 in.; diameter of sector-centre shafts (ingot steel), 18 in.; radius of sectors, 70 in.; face of arched teeth, 20 in.; pitch of same, 8 in.; stroke of lower platen, 55 in.; stroke of wedge, 12 in.; smallest space for bale, 5 in.; largest space for bale, 6 ft.; size of each of four rubber bumpers, 6 by 24 by 15 in.; length of sector-bearings, 9 in.; length of their vibration in their boxes, in degrees of their circumference, 97°; diameter of bearings, 18 in.; length of bearings of the lifting-rods at each end, 13 in.; diameter of same, 13 in.; vibration of same on circumference of upper shafts, 97°; vibration of lower ends of lifting-rods on their shafts, 4° 27′; diameter of upper tie-rods, 8 in.; of lower tie-rods, 6 in. The shafts of the lifting-rods and sector-centre shafts are all of ingot steel, turned one-eighth smaller than their boxes, which are made of brass composition 6 to 1, and those in the ends of the rods are solid rings, 1 in. thick, forced hard into the rods. The average working load on each of these bearings is 800,000 lbs. net. They are lubricated with castor-oil, and, after compressing 24,000 bales of cotton, and making not less than 40,000 compressions, are reported to show no appearance of abrasion or wear. The load on each of these bearings has frequently been carried up to 900,000 lbs., and occasionally to 1,000,000 lbs. It must be observed, however, that this great pressure is on only about one-fourth of the time, and that it is in motion only about 5 in 60 seconds. The result indicates that the pressure of shaft-bearing can safely be carried up to 8,000 lbs. per square inch, with very slow movement, when the parts are made of such materials as are here used. The press represented in Fig. 4005 was constructed to carry a net load of 4,500,000 lbs. The factors for safety are stated not in any part to exceed 10,000 lbs. tensile for wrought iron and steel; 200 lbs. transverse and 5,000 lbs. compression for cast iron.

The valve-gear consists of one double steam-valve 7 in. in diameter, and two exhaust-valves of same make and size, all raised by cams on a rock-shaft worked by the pressman. The first exhaust-valve opens to a distributing steam-chest, with three outlets, all closed by check-valves, and leading respectively to the reversing cylinders, to the steam-jacket, and to the heater. When these are all filled with steam, at about equal pressure with the cylinder, the check-valves all drop and the other exhaust-valve opens to the atmosphere, letting the press down; and when the reversing cylinders have made their stroke forward, an escape-pipe opens behind their pistons to the atmosphere; they are pushed back again by the sectors when the press goes up. The pressure obtained in this way by the exhaust-steam into the reversing cylinders, cylinder-jacket, and water-heater, is nearly half that of the main cylinder, as is shown by the instrument. The boiler-heater constructed for this application is reported to heat the feed-water to a mean of 260°. The heater being between the pump and boilers, the pump throws cold water through the coils in the heater to the boilers. The main cylinder has a cast steam-jacket, with an annular space between it and the cylinder of 1½ in., in which a pressure of 50 lbs. is kept up by the escape-steam as described. The boilers used for this press are three, each 35 ft. long, 48 in. in diameter, with two 16-inch flues, all made of three-eighths iron; outer shells double-riveted in all horizontal seams. They are entirely inclosed in the gaseous products of the combustion, which pass from the furnace under the shells, return to the front through the flues, and back again on the top of the shells to the chimney. The consumption of fuel when constantly running is 13 lbs. of coal per bale of cotton compressed.

The most novel features in the dynamics of this press are, its reversing cylinders, its wedge, and its upper platen; and in its statics, the novel features are its iron frame and the way in which the whole structure is tied together as one piece. The reversing cylinders stand perpendicular to the main cylinder, above and outside of it, and immediately behind the sectors when they are up, and throw their power against the sectors to force them inward and downward when the press is to be opened. These cylinders receive the exhaust-steam from the main cylinders as before described; the mean pressure as indicated by the gauge is 40 lbs. per square inch, which gives a pressure against sectors of 72,560 lbs., equal to 16 lbs. per square inch against the main piston; this starts the press down without delay. The wedge supports the upper platen by flanges which project horizontally from its lower edges, on which run small wheels, whose axles are attached by connections to the platen; the end thrust is held by connecting-rods to the frame, so that when the wedge moves the platen has a vertical movement corresponding to the slope of the wedge. The cylinder has a heavy jacket 2¼ in. thick, which fits to the cylinder at both ends and at two central points. The jacket is heavily ribbed, and is attached to the side frames by two vertical flanges on each side. The cylinder, its jacket, and the two side frames, all being thus bolted together and to the beam, form one solid mass, further stiffened by the tie-rods at the foot of the sectors. The upper tie-rods take the thrust of the reversing cylinders, and also stop the upward movement of the sectors, on rubber bumpers at the top of the top frame and between the tie-rods.

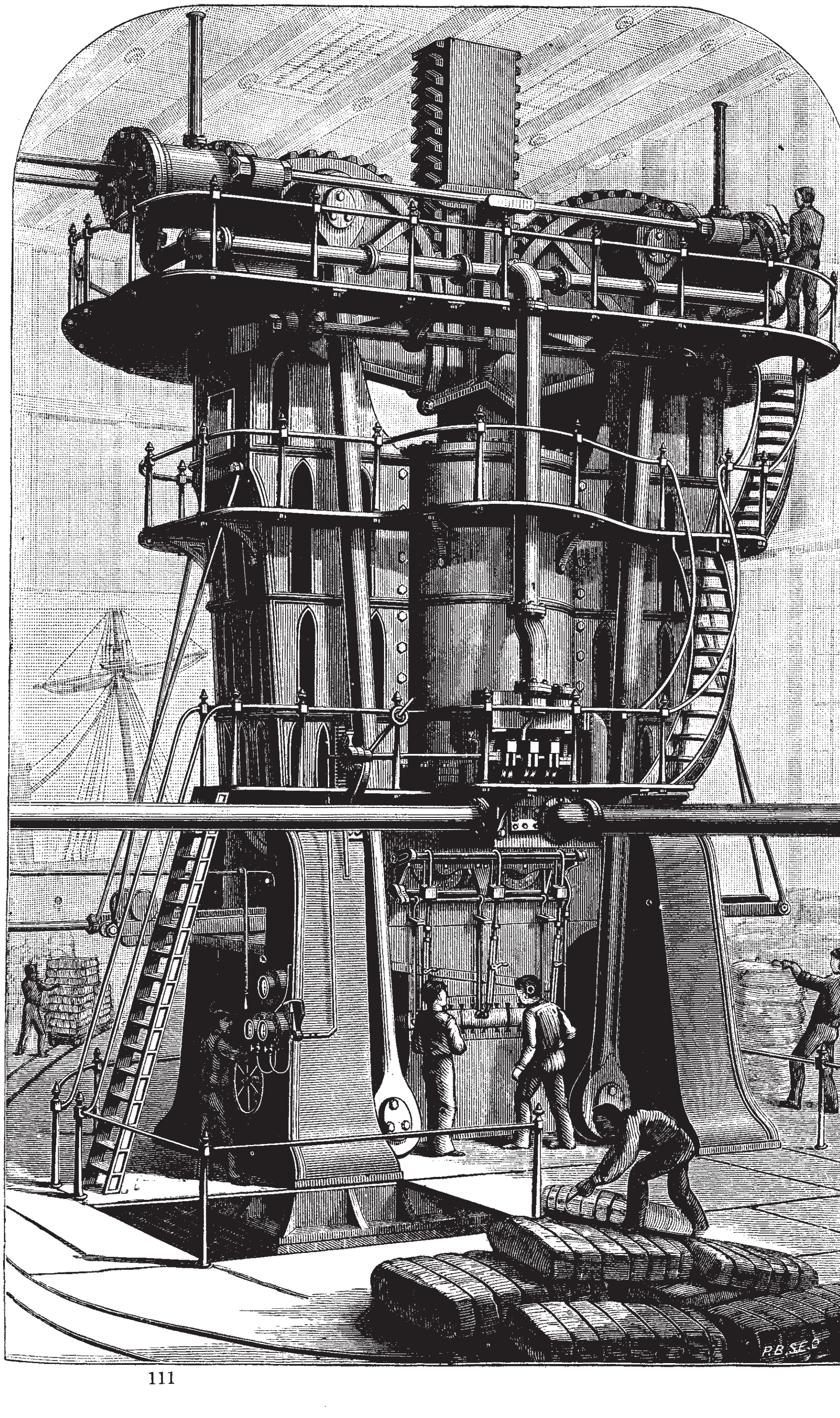
In India the bales, being made of a uniform size and weight, are reduced to a uniform density. In the United States bales vary from 300 to 600 lbs. in weight, and from 8 to 17 ft. in area of horizontal section. It will at once be seen that the pressure required to reduce American bales to the greatest density varies very largely. This will be more fully illustrated by the following table. The cylinder-pressure on the Champion press has, it is stated, in exceptional cases been carried as high as 140 lbs. per square inch, applying a net pressure upon the bale of 4,663,642 lbs.

Table showing Data obtained from the Average Daily Work of the Champion Compress in New Orleans, June, 1877, by S. H. Gilman.

Depth of the Bale in the Press.	Weight per Cubic Foot.	Pressure per Square Foot.	Total net Pressure on Bale.	Pressure of Steam per Sq. Inch in Cylinder.	Angles of the Lifting-Rods and Sectors.		Cumulations of Leverage.	Dead Weight and Friction deducted from Initial Power of Press.
Inches.	Pounds.	Pounds.	Pounds.	Pounds.	Rods.	Sectors.		Pounds.
15.65	28.11	18,993	227,917	40	1.16°	54°	2.73	225,434
12.70	34.64	36,440	437,280	50	1.50°	61°	3	254.270
10.91	40.33	61,201	734,418	60	2.33°	68°	3.84	283,258
9.45	46.56	87,007	1,044,090	70	3.06°	73°	4.46	334.897
8.62	51.04	132,392	1,667,141	80	3.39°	78°	5.62	372.353
6.58	66.86	266,493	3,197,927	96	4.27°	85°	8.76	520,592

Tying Cotton-Bales.—Second in importance only to the reduction of the bale in the compress to the greatest possible density, is the question of checking the expansion of the bale when removed from the press. This expansion varies very greatly, being greatest in wide bales of light weight, and least in narrow bales of heavy weight. In order to maintain the bales as nearly as possible at the density to which they are reduced by the compress, it is necessary that each band should be drawn tightly around the bale and be secured by a tie that does not impair the tensile strength of the band. The following are the essential requisites of a band-tightener and tie, the absence of any one of which would be fatal to the result sought to be obtained: The band-tightener must be entirely flexible in order to adapt itself to the varying width of the bales, which causes them at times to project beyond

4005.

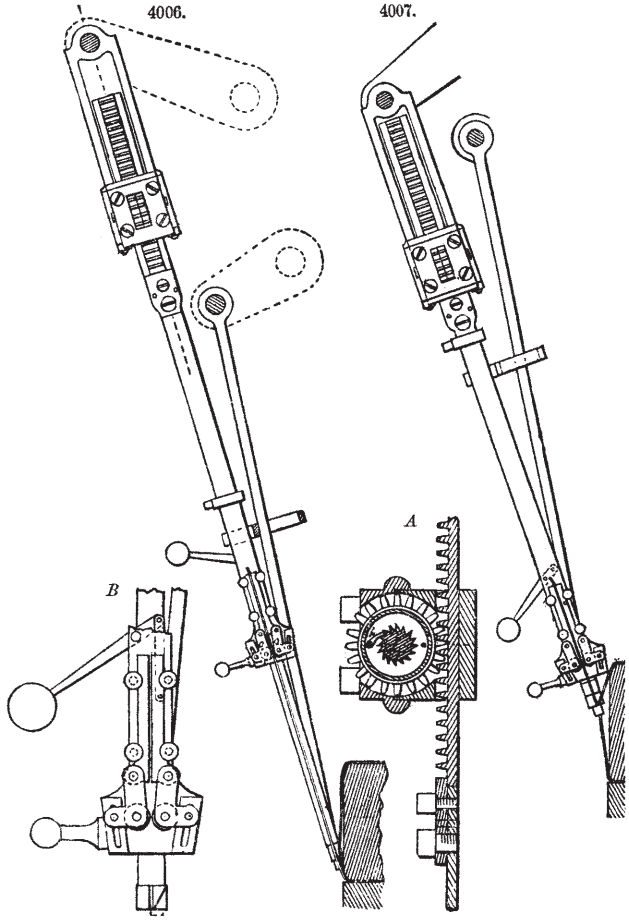


and at others to be several inches within the outer edge of the platens; it must apply the same and consequently an independent strain to each and every band; it must be so simple in its action as to enable any ordinary laborer to use it; and it must be capable of attaining a speed of at least 60 bales per hour. The tie must be self-locking, instantaneous in its action, securing the bands at their ultimate point of tension, and must not impair their tensile strength.

By universal custom six bands are used upon each bale, and six men are employed at a compress, say three on each side. To attain the greatest possible speed, it is therefore necessary that three bands be tied on each side. It will be readily understood that where so enormous a pressure is applied it is necessary that the bale should be placed exactly in the centre of the platens; for if placed flush with one edge of the platens the press would be subjected to an abnormal strain, that would fix the period of its breaking down at a short distance.

Figs. 4006 and 4007 represent a "steam bale-band tightener," invented by Capt. Gilman. Three of these are applied to each side of a press, and each has two perpendicular arms attached to two horizontal bars, upon which they move freely in any direction. These bars are vibrated by two steam-cylinders, by which means one bar is caused to pull up the band while the other forces down the tie. Fig. 4007 represents the puller in position, with the band inserted. Steam is applied first to the lifting or pulling-up cylinder, and then to the depressing cylinder, which pushes down the tie. Fig. 4006 represents the puller in its position after the bands have been tightened. Steam is then exhausted from both cylinders simultaneously, when the pullers let go of the bands and the operation is completed. In order to apply an equal strain to each band, the puller is furnished with a friction-cam and rack (as shown at *A*), which can be adjusted to any strain. It has been found in practice that 1,200 lbs. is the ultimate strain that can be thus applied without causing the bands to break when they sustain the expansive force of the bales upon being released from the press. This arrangement is indispensable, as it is proved by practice that the bands, when passed around the bales by hand and inserted in the pulleys, vary in length as much as 10 in. upon the same bale. *B*, Fig. 4006, represents the mechanism for holding the loose end of the band. It is gripped tightly between rollers moving upon an inclined plane of $7\frac{1}{2}°$, as at that angle the wedge will neither slip nor stick. By this arrangement the bands do not slip as long as any strain is applied, and release themselves as soon as the strain is removed.

4006. 4007.



4008.

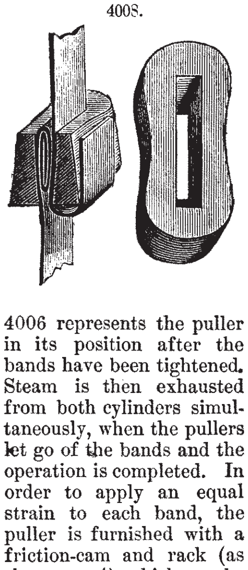


Fig. 4008 represents the "grip-tie," also the invention of Capt. Gilman. One end of the band is doubled over to form a bulb. The band when passed through the tie moves freely in one direction; but when pressed down so as to force the bulb into the tie, it forces the loose end of the band into the curved line of the tie, holding it securely without impairing its strength.

Experience has proved that by the use of an efficient bale-band tightener and self-locking tie the carrying capacity of a cotton-laden vessel is increased fully 20 per cent. The following example will illustrate this fact. In 1878 the British steamship Whickham, of 1,124 tons net register, was loaded at New Orleans with cotton from various presses, all using a hand band-tightener. Her cargo consisted of 5,127 bales of cotton and 136 tons of oil-cake (equal in stowage room to 500 bales of cotton), making the equivalent of 5,627 bales of cotton, or 5 bales to the ton. About the same time the British steamship Enmore, of 1,122 tons net register, was loaded from the same presses, but without the use of a band-tightener. Her cargo consisted of 4,527 bales of cotton and 30 tons of oil-cake (equal to 110 bales of cotton), making a cargo equivalent to 4,637 bales of cotton, or 4.13 bales per ton.

Doubling Bales.—The natural tendency of all bodies when subjected to an expansive force is to assume a round form. This tendency is only checked by the degree of resistance offered by the material of which the body is composed. It is therefore evident that the broader the bale is in proportion to its thickness, the greater will be the expansion when it is freed from the pressure of the compress. A bale 32 in. in width and weighing about 350 lbs. is readily brought down to 5 in. in the Champion Compress. While in the press its longitudinal cross-section is a parallelogram 5 × 32 in. To raise the long side (32 in.) of this parallelogram into a parabolic curve 6 in. in height, it is only necessary to draw each of the ends of the short (5-inch) side 1 in. into the bale, or in other words to diminish the distance between them by 2 in. When therefore the pressure of the compress is removed, the figure of the cross-section of the bale soon becomes a paraboloid 30 in. in length and 16 in. in depth. When two such bales are returned to the press and tied together, the two parabolic curves that come in contact are reduced to a straight line through the centre of the package. The cross-section of the doubled bales forms a paraboloid of 17 × 31½ in. A bale 26 in. wide and weighing about 480 lbs. is brought down to 7 in. in the press, and expands to 14 in. Two such bales when laid together in the press expand to 21 in. Of 20 bales doubled into 10 by the Champion Compress, the average weight per bale was 506½ lbs.; average cubic contents per bale, 12 ft. 1¼ in.; average weight per cubic foot, 42.22 lbs. The British steamship Kensington was loaded at New Orleans in 1878 partly with doubled bales, and carried the largest cargo per registered ton ever taken from an American port. Her net registered tonnage was 908 tons, and her cargo consisted of 4,976 bales, equal to 5.48 bales and 2,545 lbs. per ton register. Of this cargo, 2,990 bales were doubled, 1,662 were compressed by the Champion, using the tie and band-tightener above described, and 324 bales were from other presses. Tight compressing insures the delivery of cotton at the port of destination in better order, and reduces the cost of stowage. The Kensington's cargo was stowed for 40 cents per bale, the customary charge being at the time 60 cents.

The average width of bales received at the Gulf ports is about 32 in., while at the Atlantic ports it is about 25 in. It will thus be seen that, with presses of the same power and the use of the steam bale-band tightener and self-locking tie, vessels from the Atlantic ports should carry about 20 per cent. more pounds per registered ton than from the Gulf ports. This important fact may eventually induce planters to adopt a uniform size for boxes of plantation presses, as recommended by the National Cotton Exchange.*

* The foregoing details concerning the Champion Compress, band-tightener, and tie have been contributed by John B. Lafitte, Esq., President of the Louisiana Cotton Tie Company, of New Orleans.