Oct. 16, 1945. M. D. STONE ET AL 2,387,190

HYDRAULIC PRESS

Filed April 3, 1943 2 Sheets-Sheet 1

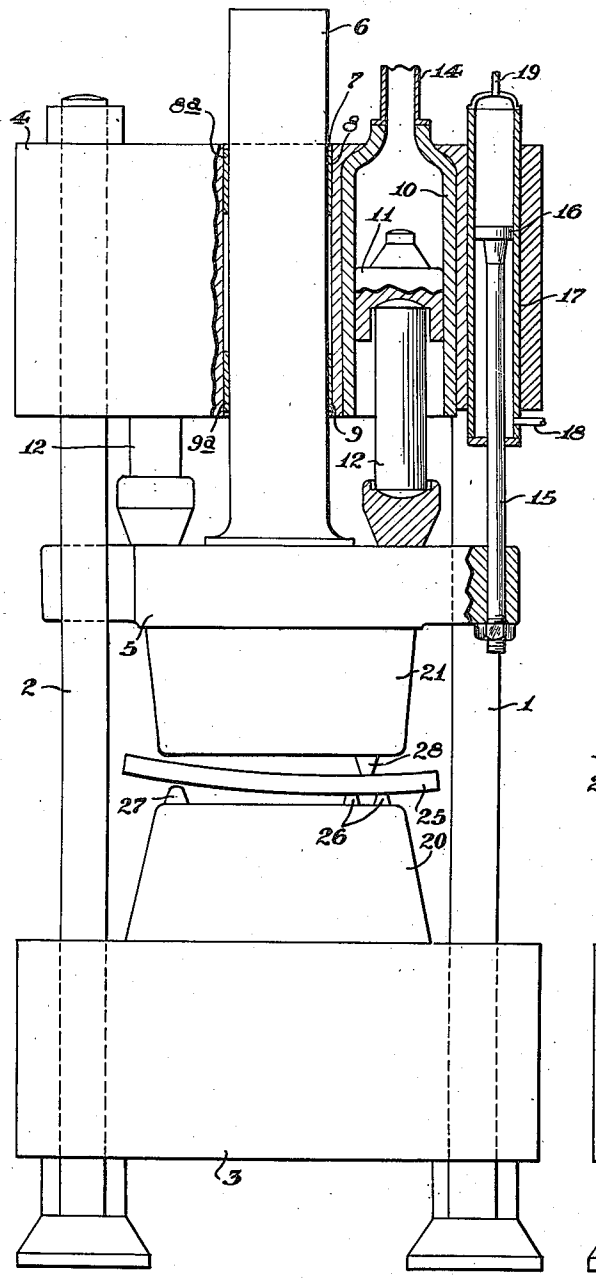


Fig. 1.

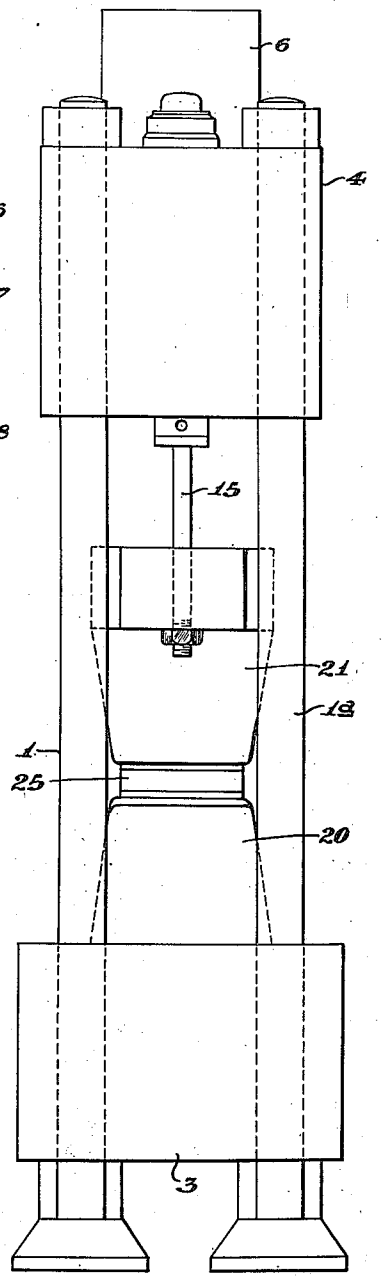


Fig. 2.

WITNESSES.
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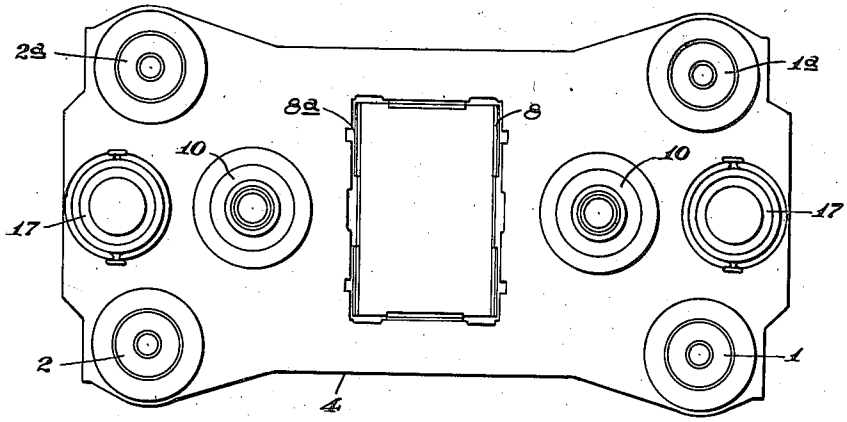


Fig. 3.

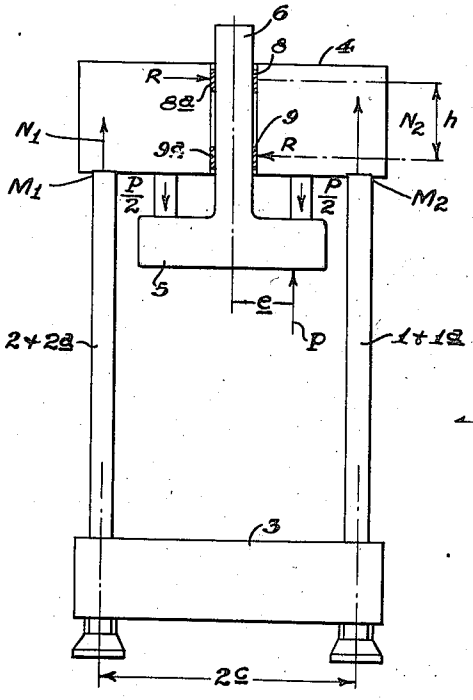


Fig. 4.

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UNITED STATES PATENT OFFICE

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HYDRAULIC PRESS

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Application April 3, 1943, Serial No. 481,764

5 Claims. (Cl. 100—71)

This invention relates to hydraulic presses of the heavy duty type used for forging, bending and other working and shaping of metals and other materials, and has to do particularly with presses of this type which are eccentrically loaded in either their normal or abnormal operation.

Presses of the type here contemplated comprise spaced columns whose ends are engaged by upper and lower entablatures that are supported by the columns, and a crosshead borne by the upper entablature for vertical reciprocatory strokes. Conventional forms of such presses have been so constructed that when their crossheads are loaded eccentrically, that is to say when the load is so applied that the downward resultant of the pressure applied by cylinders does not coincide with the upward reaction from the work piece, the resulting lateral reaction of the crosshead is taken up by some or all of the columns in variable positions in relation to the entablature. In such presses heavy eccentric loads produce high bending stresses in the columns which have resulted in breaking them, and they also cause the upper end of presses to sway laterally several inches with the result that the pipes for supplying hydraulic pressure fluid to the presses have broken. The critical stresses that cause such breakages and sway are those arising from the bending moments on the columns in the general planes of their juncture with the lower side of the upper entablature.

The object of this invention is to provide a heavy duty press of the type explained which is so constructed that when an eccentric load is applied to its crosshead the load is balanced substantially wholly by normal tension forces in the columns, instead of resulting in the application of lateral pressure to them, the columns being substantially free from such bending moments and lateral forces as would cause lateral sway of the press and breakage of the columns as well as of pipes connected to the top of the press.

"Normal tension forces" as used above and throughout the specification and claims means forces that produce uniform tension stresses throughout a body by direct pull on it, as distinguished from tension stresses that are produced by bending.

Heavy duty presses have four columns which may be considered as being arranged in pairs, as they usually are, one pair being to the right and the other to the left end of the work-feeding and manipulating side of the press. However, one pair of columns may be considered as the two front and the other pair as the two rear columns. It is in the space between the columns that loads are applied eccentrically to the crosshead of a press. The press provided according to our invention has spaced pairs of columns, and an entablature which engages and is supported by their upper ends. The entablature is provided centrally with a vertical opening in which the guide stock of a vertically reciprocable crosshead is mounted, the crosshead being integrally formed with or otherwise rigidly connected to the guide stock. The crosshead is positioned between the columns and is incapable of applying lateral pressure directly to them when it is eccentrically loaded.

The guide stock of the crosshead and the wall of the vertical central opening of the entablature are so formed at vertically-spaced opposite portions thereof that when the crosshead is eccentrically loaded the eccentric load couple so formed is taken substantially wholly by laterally directed forces which form an internal couple within the entablature. To this end the wall of the opening is preferably provided with vertically-spaced localized bearings which engage opposite sides of the guide stock. When the crosshead is eccentrically loaded as explained the eccentric load couple so formed is, except for negligible sliding friction forces, taken entirely by laterally directed forces which form an internal couple within the entablature. By providing, as is preferably done, an upper entablature of such massiveness and rigidity that the load strains to which it is subjected are negligible, an eccentric load applied to the crosshead as explained is balanced substantially wholly by normal tension forces in the columns. As a result of this the columns are substantially free from such bending moments and lateral forces as have resulted in their breakage, and in lateral sway of presses.

The invention will be further explained with reference to the accompanying drawings, which diagrammatically illustrate an embodiment of it in the form of an armor plate bending press which has been built and placed in operation, and in the use of which the correctness of the fundamental principles of our invention have been demonstrated.

In the drawings, Fig. 1 is a front elevation of a press, the upper right-hand portion being shown in vertical central section; Fig. 2 a right-hand elevation and Fig. 3 a plan view of the press shown in Fig. 1; and Fig. 4 a small scale stress elevation of the press.

The press comprises two pairs of columns 1, 1*a* and 2, 2*a*, the lower ends of which are provided

with a lower entablature 3 and the upper ends with an upper entablature 4. Positioned between the columns there is a crosshead 5 which is elongate in the direction of the spacing of the pairs thereof, and is provided integrally with a guide stock 6 that is mounted for vertical reciprocation in a vertical central opening 7 formed in entablature 4. Near the upper and lower ends of opening 7 its wall is provided with inwardly projecting bearings 8, 8a and 9, 9a which are preferably formed of bearing material such as bronze plates. Thus when the crosshead is eccentrically loaded to the right (as seen in Fig. 1) of its vertical axis in the direction of the spacing of the columns 1, 1a, the eccentric load couple so formed is taken up by laterally directed forces in entablature 4 acting from left to right on bearing 8a and from right to left on bearing 8, these bearings being vertically spaced and on opposite sides of guide stock 6. In other words, the eccentric load couple is taken up by laterally directed forces which form an internal couple within the entablature.

For applying power to crosshead 5, the upper entablature is preferably provided with hydraulic cylinders 10 positioned one on each side of the guide stock and each equipped with a piston 11, the upper end of each cylinder being formed for attachment to a pipe 14 extending to a source of supply of hydraulic pressure. Between the lower side of each piston and the top of crosshead 5 there is a thrust rod 12 having spherical ends, the upper of which bears against a spherical socket formed on the bottom of the piston and the lower of which bears against a like socket formed on the top of the crosshead. The opposite ends of each thrust rod thus have hinged engagement with a piston and the crosshead.

To counterbalance the crosshead and to move it upwardly at the end of each working stroke, each of its ends is connected to the lower end of a piston rod 15 whose upper end is attached to a piston 16 positioned in a pressure fluid cylinder 17 whose lower end is connected to a pipe 18 leading to a source of pressure fluid supply. The upper end of each cylinder 17 is provided with an opening 19 so that air may be admitted to and discharged from the cylinder upon the reciprocation of piston 16.

The press shown in the drawings is equipped to bend heavy armor plates to their desired curved forms, there being a platen 20 supported by the lower entablature 3 and a platen 21 attached to the lower face of crosshead 5. To bend properly a heavy armor plate it is necessary to apply bending forces to it incrementally from one end to the other end. As shown in Fig. 1 a heavy armor plate 25 is supported near its right end by a pair of spaced blocks 26 which rest on platen 20, and at its left end by a third block 27. Attached to platen 21 and positioned midway between blocks 26 there is a block 28 which bends the portion of plate 25 between blocks 26 when crosshead 21 is moved downwardly. Between strokes of the crosshead the several blocks are repositioned to the end that the plate may be bent step-by-step to the desired curvature from one to the other of its ends, and in doing so the crosshead is at times heavily loaded eccentrically on one side of its vertical axis in the direction of one of the pairs of spaced columns 1, 1a or 2, 2a.

As stated above, the press shown herein has been built and placed in operation, its chief use being the bending of armor plate in the manner just explained. The enormous forces required to do this are indicated by the fact that the press has a capacity of 14,000 tons of pressure. While our invention is not limited to any particular capacity or size of press, it is noted that, properly to carry the high stresses to which the press disclosed herein is subjected, each column is thirty-four inches in diameter, the pairs of columns 1, 1a and 2, 2a being spaced twenty-three feet center to center and the columns 1a and 2a being spaced rearwardly of columns 1 and 2 eleven and one-half feet center to center. The upper entablature 4 is sixteen feet in depth from the top to bottom, and is massive in structure throughout except for its central guide stock opening 7 and the openings in it for receiving hydraulic cylinders 10. The main body of the crosshead is about twenty feet in length between the spaced columns 1, 1a and 2, 2a, about eight feet in width and about five feet in depth. From the base of their footings to their upper ends, the columns are approximately seventy feet in height.

When the crosshead of a press embodying our invention is eccentrically loaded, as for example, for bending armor plate in the manner shown in Fig. 1, the forces acting upon the upper structure of the press are, for all vertical positions of the crosshead 5, as indicated in Fig. 4 in which P represents a load applied eccentrically to the crosshead a distance e from the vertical axis of the crosshead in the direction of the spacing of the columns 1, 1a and 2, 2a, whose center to center spacing is indicated as $2c$. Neglecting relatively insignificant friction between guide stock 6 and bearings 8, 9 and 8a, 9a as the crosshead is moved downwardly, the eccentric moment M equals Rh, in which h is the vertical distance between the centers of pressure on guide stock 6 on bearings 9 and 8a which are on vertically-spaced opposite sides of the guide stock. In the operation of the press the same hydraulic pressure is applied to the upper end of each of pistons 11 so that the forces applied to the upper faces of the crosshead by thrust rods 12 are alike, each being

$$\frac{P}{2}$$

As stated above, the critical stresses on presses such as here contemplated are those arising from the bending moments on the columns in the general plane of their juncture with the lower side of the upper entablature. In the stress diagram of Fig. 4 these moments are indicated at these places as M_1 for the left-hand columns 2 and 2a and M_2 for the right-hand columns 1 and 1a. When the crosshead of a conventional press is loaded eccentrically, it is these bending moment stresses added to the normal stresses upon the column that result in column breakage and press sway. When the crosshead of our improved press is eccentrically loaded as shown, the load is balanced substantially wholly by normal tension forces in the column, the critical stress moments M_1 and M_2 then being very small as compared to those that prevail when the lateral reaction resulting from an eccentrically loaded crosshead is taken up by columns on which the crosshead bears. The correctness of this appears from a consideration of the following formulae that we have evolved by a theoretical mechanics analysis of the press as an indeterminate structure, in which formulae, A is the cross sectional area of each column, I the moment of inertia of each column, and N_1 and N_2 the normal tension forces

in columns 2, 2a and 1, 1a, respectively, as a consequence of the eccentricity of the load:

(1) $$M=Rh=Pe$$

(2) $$M_1=M_2=\frac{M}{4}\left[\frac{1}{1+\frac{Ac^2}{I}}\right]$$

(3) $$N_1=\frac{P}{4}\left(1-\frac{e}{c}\right)$$

(4) $$N_2=\frac{P}{4}\left(1+\frac{e}{c}\right)$$

In presses of the type herein contemplated

$$\frac{I}{Ac^2}$$

is very small, being about

$$\frac{1}{150}$$

Substituting this value in the above formula (2) it will be seen that the bending moments M_1 and M_2 at the tops of the columns are only about

$$\frac{1}{600}$$

of M, or in other words about 0.17 per cent of the eccentric moment Pe.

As appears from formulae (3) and (4), the normal tension force in the columns increases from

$$\frac{P}{4}$$

for a load applied centrally to the crosshead to

$$\frac{P}{4}\left(1+\frac{e}{c}\right)$$

for an eccentric load. For an eccentric loading in which

$$\frac{e}{c}=1/2$$

which is very large in practice, the normal tension stresses added to columns 1 and 1a by the eccentricity of the load are only fifty per cent above the stresses for central loading.

As has been explained, conventional forms of presses have been so constructed that when their crossheads are loaded eccentrically the resulting reaction of the crossheads is taken up by the columns. By theoretical mechanics analysis of such conventional presses as indeterminate structures, the analysis being the same as that used in deriving the above formulae, we have found that bending moments M_1 and M_2 vary from about ⅛ to ¼ of M, instead of being

$$\frac{1}{600}$$

of M. In other words, in presses embodying our invention the bending moments M_1 and M_2 are about

$$\frac{1}{75} \text{ to } \frac{1}{150}$$

of those in conventional forms of presses.

The correctness of the foregoing formulae that we have evolved has been qualitatively demonstrated by a model, and also by observing through the telescope of a surveyor's transit the lateral sway of the top of the press herein disclosed when heavily loaded eccentrically, which sway was found to be only a small fraction of an inch as compared to a sway of several inches which attends a like loading of conventional presses. They can be quantitatively corroborated by strain measurements of the press.

According to the provisions of the patent statutes, we have explained the principle and mode of operation of our invention, and have described and diagrammatically illustrated what we now consider to be its best embodiment. However, we desire to have it understood that, within the scope of the appended claims, our invention may be practiced by forms of presses other than that herein disclosed.

We claim as our invention:

1. An hydraulic press, comprising spaced pairs of columns, an entablature engaging and supported by the upper ends of the columns and provided centrally with a vertical guide-stock opening, and a vertically reciprocable crosshead positioned between the columns and incapable of applying lateral pressure directly to them when it is eccentrically loaded, the crosshead having a guide stock rigidly connected to it extending upwardly through said entablature opening for vertical reciprocatory movements therein, said guide stock and the wall of said opening being so formed at vertically-spaced opposite side portions thereof that when the crosshead is eccentrically loaded the eccentric load couple so formed is taken substantially wholly by laterally directed forces which form an internal couple within the entablature, whereby a load so applied to the crosshead is balanced substantially wholly by normal tension forces in the columns which as a result thereof are substantially free from such bending moments and lateral forces as would cause lateral sway of the press.

2. An hydraulic press, comprising spaced pairs of columns, a massive substantially rigid entablature engaging and supported by the upper ends of the columns and provided centrally with a vertical guide-stock opening, and a vertically reciprocable crosshead positioned between the columns and incapable of applying lateral pressure directly to them when it is eccentrically loaded, the crosshead having a guide stock rigidly connected to it extending upwardly through said entablature opening for vertical reciprocatory movements therein, the wall of said opening being provided on its opposite sides with vertically-spaced bearings engaging opposite sides of said guide stock whereby when the crosshead is eccentrically loaded the eccentric load couple so formed is taken substantially wholly by laterally directed forces which form an internal couple within the entablature, whereby a load so applied to the crosshead is balanced substantially wholly by normal tension forces in the columns which as a result thereof are substantially free from such bending moments and lateral forces as would cause lateral sway of the press.

3. An hydraulic press, comprising spaced pairs of columns, an entablature engaging and supported by the upper ends of the columns and provided centrally with a vertical guide-stock opening, a vertically reciprocable cross-head positioned between the columns and incapable of applying lateral pressure directly to them when it is eccentrically loaded, the crosshead having a guide stock rigidly connected to it extending upwardly through said entablature opening for vertical reciprocatory movements therein, an hydraulic cylinder borne by said entablature at each side of said guide stock, a piston within each cylinder, and a thrust rod between and having hinged engagement at its ends with each piston

and said crosshead, said guide stock and the wall of said opening being so formed at vertically-spaced opposite side portions thereof that when the crosshead is eccentrically loaded the eccentric load couple so formed is taken substantially wholly by laterally directed forces which form an internal couple within the entablature, whereby a load so applied to the crosshead is balanced substantially wholly by normal tension forces in the columns which as a result thereof are substantially free from such bending moments and lateral forces as would cause lateral sway of the press.

4. An hydraulic press, comprising spaced pairs of columns, an entablature engaging and supported by the upper ends of the columns and provided centrally with a vertical guide-stock opening, a vertically reciprocable crosshead positioned between the columns and incapable of applying lateral pressure directly to them when it is eccentrically loaded, the crosshead having a guide stock rigidly connected to it extending upwardly through said entablature opening for vertical reciprocatory movements therein, an hydraulic cylinder borne by said entablature at each side of said guide stock, a piston within each cylinder, and a thrust rod between and having hinged engagement at its ends with each piston and said crosshead, the wall of said opening being provided on its opposite sides with vertically-spaced bearings engaging opposite sides of said guide stock whereby when the crosshead is eccentrically loaded, the eccentric load couple so formed is taken substantially wholly by laterally directed forces which form an internal couple within the entablature, whereby a load so applied to the crosshead is balanced substantially wholly by normal tension forces in the columns which as a result thereof are substantially free from such bending moments and lateral forces as would cause lateral sway of the press.

5. An hydraulic press, comprising spaced columns, an entablature engaging and supported by the upper ends of the columns and provided centrally with a vertical guide-stock opening, and a vertically reciprocable crosshead positioned between the columns and incapable of applying lateral pressure directly to them when it is eccentrically loaded, the crosshead having a guide stock rigidly connected to it extending upwardly through said entablature opening for vertical reciprocatory movements therein, said guide stock and the wall of said opening being so formed at vertically-spaced opposite side portions thereof that when the crosshead is eccentrically loaded the eccentric load couple so formed is taken substantially wholly by laterally directed forces which form an internal couple within the entablature, whereby a load so applied to the crosshead is balanced substantially wholly by normal tension forces in the columns which as a result thereof are substantially free from such bending moments and lateral forces as would cause lateral sway of the press.

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