

July 22, 1930.

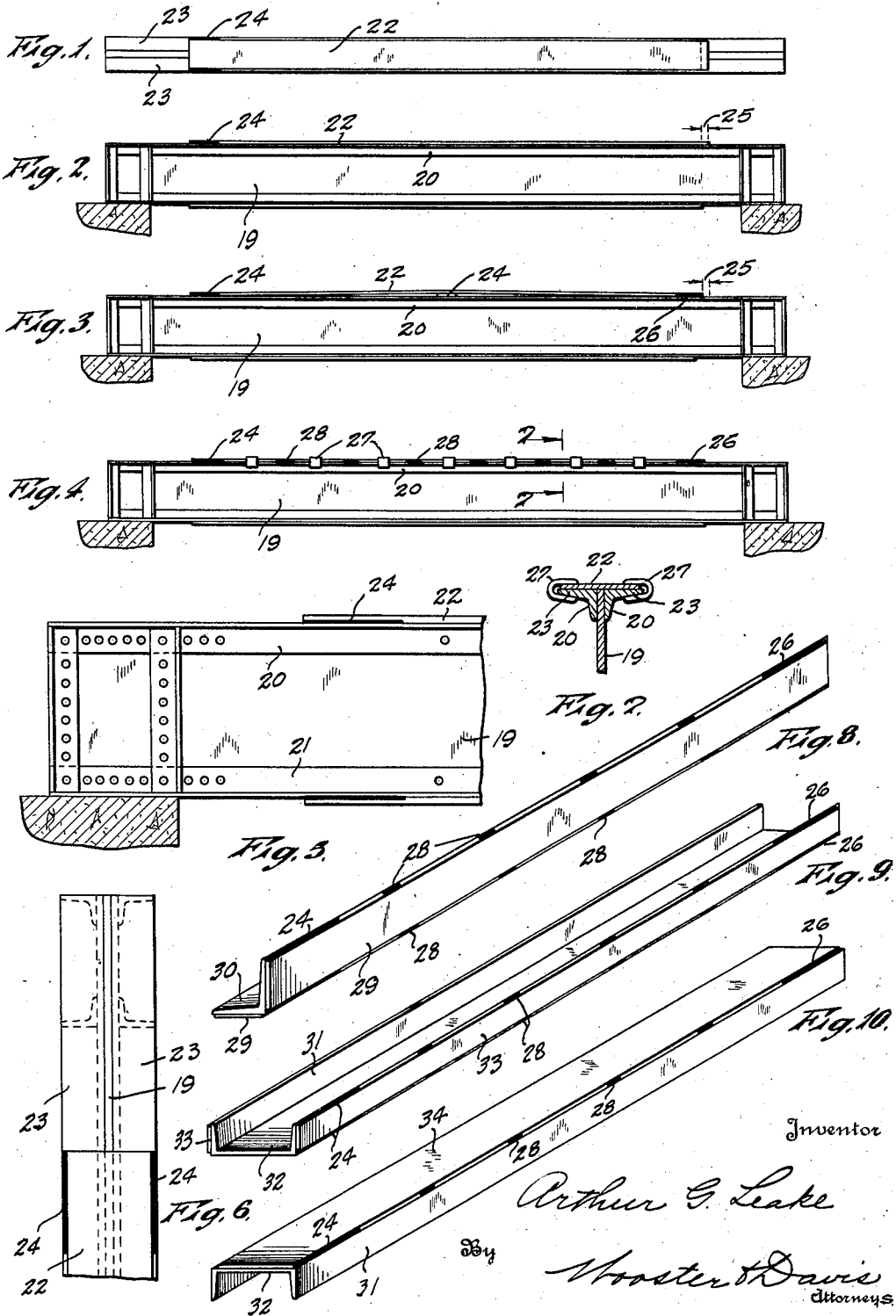
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METHOD OF STRENGTHENING STRUCTURAL MEMBERS UNDER LOAD

Filed May 17, 1929

2 Sheets-Sheet 1



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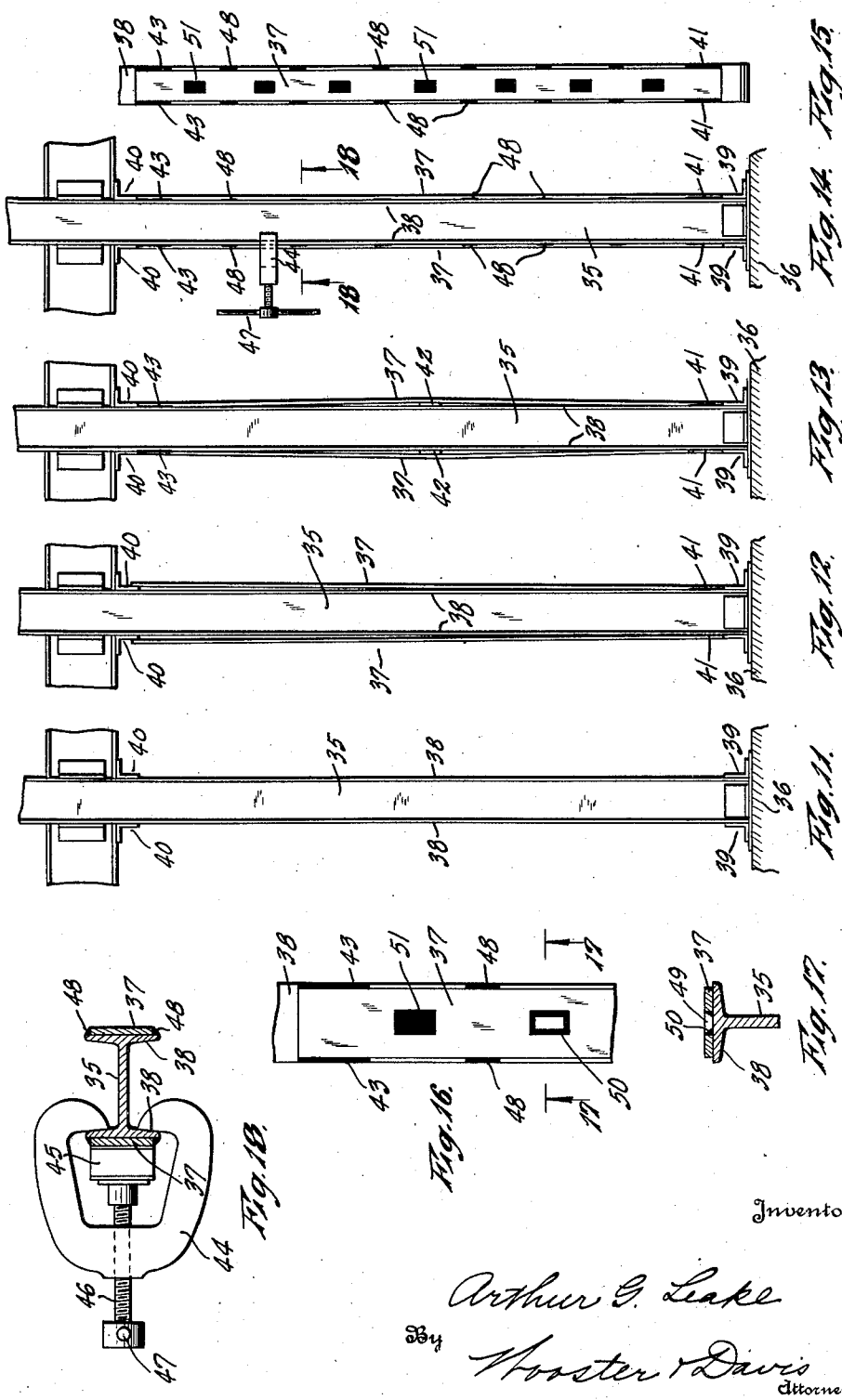
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METHOD OF STRENGTHENING STRUCTURAL MEMBERS UNDER LOAD

Application filed May 17, 1929. Serial No. 363,867.

This invention relates to a method of strengthening structural members such as beams, girders, columns and the like while they are under load, and has for an object to provide a method of strengthening such members which will not require tearing down the structures, so that the work may be accomplished in much shorter time and at much less expense and with a minimum interference with traffic or use of the structure. This application relates more particularly to the method described in my copending application Serial No. 363,866, filed May 17, 1929, as more particularly adapted for reinforcing or strengthening members under compression.

Different uses of this method are illustrated in the accompanying drawings in which

Fig. 1 is a top plan view of a girder built up of plate and angle bar construction with a strengthening bar in place for the first operation.

Fig. 2 is a side elevation thereof.

Fig. 3 is a side elevation showing subsequent steps of the operation.

Fig. 4 is a similar view showing still further steps.

Fig. 5 is a side elevation on an enlarged scale of one end of the girder.

Fig. 6 is a top plan view thereof.

Fig. 7 is a detail section substantially on line 7—7 of Fig. 4.

Fig. 8 is a perspective view of an angle bar showing how my improved method of strengthening may be used in connection therewith.

Figs. 9 and 10 are perspective views showing how it may be employed in connection with channel bars.

Fig. 11 is a side elevation of an upright column with which my improved method may be employed.

Fig. 12 is a similar view showing the first step in the method of strengthening this column.

Fig. 13 is a similar view showing the next step.

Fig. 14 is a similar view showing the final step.

Fig. 15 is a view looking from the right of Fig. 14.

Fig. 16 is an enlarged view of the upper portion of Fig. 15.

Fig. 17 is a partial section substantially on line 17—17 of Fig. 16, and

Fig. 18 is a section on an enlarged scale taken substantially on line 18—18 of Fig. 14.

As indicated above the drawings and description of this application are directed more particularly to strengthening beams and columns which are under compression when under load, and to the method of strengthening these members while they are under load.

Referring first to Figs. 1 to 7 inclusive the girder is composed of the plate 19 with the angle bars 20 and 21 riveted to the upper and lower edges thereof respectively. It will be understood that the bars 20 are under compression. The strengthening member is shown as a rolled steel plate 22 of desired length, width and thickness. The first operation is to weld one end to the flanges 23 of the bar 20 as indicated at 24. As the bar is to be under compression it is contracted or shortened to place it under initial stress. This may be done by cooling it direct with any suitable agent such as liquid carbon dioxide (CO_2) or other suitable cooling agent. It is preferred however, to first buckle out the central portion of the plate away from the flanges 23 forcing it out by suitable means such as wedges or jacks, a wedge being shown at 24. This shortens the effective length of the plate. Gauge marks may be provided to indicate how much the plate is to be shortened to secure the required initial stress as will be determined by computation. These are shown at 25, Figs. 2 and 3. As shown in Fig. 3, the wedge 24 has decreased the effective length of the plate 22 as indicated at 25. The free end of this plate or that is the end opposite to the weld 24 is now welded to the flanges 23 as indicated at 26. The wedge or the forcing means 24 are now removed and the plate is chilled by any suitable means such as carbon dioxide until the plate contracts so as to lie against the flanges 23 throughout its entire length. The plate is then clamped to the flanges by any suitable means such as the removable clamps 27. These clamps retain the plate tightly against the flanges and

retain it in this position while the plate returns to normal temperature or that is substantially the temperature of the flanges 23. It will be obvious that as the plate returns to normal temperature it is placed under initial compressive stress depending on the amount to which the plate was contracted. After the plate has gained its original temperature it is welded to the flanges at points between the two end welds, preferably by tack welds 28, which are welds of about one-half to two inches long. The clamps 27 may then be removed and the operation is complete. As the strengthening member is under initial stress it immediately assumes its part of the load, and by this method the initial stress is placed in the reenforcing member without the necessity of jacking up the structure with the consequent high cost.

In Fig. 8 is shown how this method can be employed for strengthening an angle bar. The strengthening plates 29 are applied to the flanges or the bar 30 in the same manner as described above.

Figs. 9 and 10 illustrate how the method may be employed for strengthening either the flanges 31 or the web 32 of channel bars. With this type of bar the strengthening plates 33 and 34 are applied to the flanges or to the web respectively in the same manner as described above.

In Figs. 11 to 18 I have shown how the method may be employed for strengthening or reenforcing upright columns. These columns may be of various cross-sections but are illustrated as being I-beam columns 35 supported on suitable foundations 36. In reenforcing these columns while under load two reenforcing plates are used, one for the face of each of the flanges 38 of the column, and it is desired that the plate be of proper length to extend from the holding members 39 at the base to the under side of the beam connection 40. This plate is made of the proper length plus the necessary contraction. The first operation in applying the plates is to weld one end thereof to each flange as shown at 41, then the plate may be chilled to contract it to the proper length or it may be buckled outwardly by wedges 42 to bring it to its proper effective length. It is then welded to its flange at its opposite end. If it is chilled before welding it is welded at this end while chilled. If chilled after it is buckled outwardly it is welded at one end before buckling and then chilled so as to lie in contact with the flange of the column throughout the entire length of the plate. Whether chilled before or after welding the portion of the plate between the welds is clamped to the flanges by suitable clamps such as those shown in Figs. 1 to 7 or the clamps shown in Figs. 14 and 18, which may comprise a yoke 44 to engage under the flanges of the column and has a clamping

head 45 on a screw 46 threaded in the yoke which may be turned by any suitable tool in head 47. This clamp will press tightly against the plate or column to hold it during the welding operation. The plate is then welded to the column at points between the end welds as shown at 48.

If the strengthening plates 37 are of considerable width they may buckle in the center under the compressive forces. It is, therefore, preferred to cut or punch rectangular openings 49 in the plates and weld the plates to the column around the peripheries of these openings as shown at 50. After this welding is completed the entire opening may be filled up with the weld metal making a so-called plug weld, and thus the centers of the plates as well as the edges are welded to the columns. With this method the columns of the entire building may be reenforced as desired.

Having thus set forth the nature of my invention, what I claim is:

1. A method of strengthening a structural member while it is under load which comprises welding one end of a strengthening member to the structural member, forcing the central portion of the strengthening member away from the structural member to reduce its effective length, welding the opposite end of the strengthening member to the other member, chilling the strengthening member to cause it to contract so as to lie against the structural member, and welding the two members together at points between the end welds.

2. The method of strengthening a structural member having a flange under compression which comprises welding a metal plate at one end to said flange, forcing outwardly the central portion of the plate away from the flange to decrease the effective length of the plate, welding the other end of the plate to the flange, chilling the plate to cause it to contract and move back against the flange, and welding the plate to the flange at points between the end welds.

3. A method of strengthening a structural member while it is under load which comprises welding one end of a strengthening member to the structural member, forcing the central portion of the strengthening member away from the structural member to reduce its effective length, welding the opposite end of the strengthening member to the other member, chilling the strengthening member to cause it to contract so as to lie against the structural member, clamping the two members together, permitting the strengthening member to return to substantially the temperature of the structural member, and then welding the two members together at points between the end welds.

4. The method of strengthening a structural member having a flange under compression

sion which comprises welding a metal plate at one end to said flange, forcing outwardly the central portion of the plate away from the flange to decrease the effective length of the plate, welding the other end of the plate to the flange, chilling the plate to cause it to contact and move back against the flange, clamping the plate to the flange, permitting the strengthening member to return to substantially the temperature of the flange, and then welding the plate to the flange at points between the end welds.

its opposite ends to the structural member, at least one of said ends being welded while the strengthening member is shortened to an effective length less than its normal length, and welding the two members together between the end welds.

10. A method of strengthening a structural member while it is under compression which comprises rigidly securing a strengthening member at its opposite ends to the structural member, at least one of said ends being so connected while the strengthening member is shortened to an effective length less than its normal length, and securing the two members together between the first two connections.

11. A method of strengthening a structural member while it is under load which comprises rigidly securing one end of a strengthening member to the structural member, forcing the central portion of the strengthening member away from the structural member to reduce its effective length, rigidly securing the opposite end of the strengthening member to the other member, chilling the strengthening member to cause it to contract so as to lie against the structural member, and securing the members together between the end connections.

12. The method of strengthening a structural member having a flange under compression which comprises rigidly securing a metal plate at one end to said flange, forcing outwardly the central portion of the plate away from the flange to decrease the effective length of the plate, rigidly securing the other end of the plate to the flange, chilling the plate to cause it to contract and move back against the flange, and securing the plate to the flange between the end connections.

In testimony whereof I affix my signature.

ARTHUR G. LEAKE.

5. A method of strengthening a girder or column while under load which comprises welding a metal strengthening member at one end to the member to be strengthened, buckling outward the strengthening member to reduce its effective length to correspond with the stress desired for said member, welding the other end of said member to the member to be strengthened, cooling the strengthening member to cause it to contract to said length, clamping the latter member to the girder or column, permitting its temperature to return to normal, and then tack welding the two members together between the end welds.

6. A method of strengthening a girder or column having a flange under longitudinal compression which comprises welding a longitudinally extending metal plate at one end to said flange, buckling outwardly the central portion of the plate to reduce its effective length to correspond with the stress desired for said plate, welding the other end of the plate to said flange, cooling the plate to cause it to contract to said length, clamping the plate to the flange, permitting the temperature of the plate to return to substantially that of the flange, and then welding the plate to the flange at points between the end welds.

7. A method of strengthening a structural member while it is under compression comprising welding one end of a strengthening member to the structural member, cooling the strengthening member below the temperature of the other member to shorten its length, welding the other end of the strengthening member to the structural member, and welding the two members together at points between the end welds.

8. A method of strengthening a column or girder having a flange under compressive load comprising welding one end of a longitudinally extending metal plate to said flange, cooling said plate below the temperature of the flange to shorten its length to correspond with the stress desired for said plate, welding the other end of the plate to the flange, permitting the plate to return to substantially the temperature of the flange, and welding the plate to the flange at points between the end welds.

9. A method of strengthening a structural member while it is under compression comprising welding a strengthening member at

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