# United States Patent [19]

**Shoe**

[11] **3,770,360**

[45] **Nov. 6, 1973**


[54] **APPARATUS FOR STRIPPING SLAB CASTING FORMS**


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[52] **U.S. Cl.** ..... **425/440**, 249/66

[51] **Int. Cl.** ..... **B28b 13/04**

[58] **Field of Search** ..... 249/50, 66; 425/440



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 3,061,904 | 11/1962 | Wise | 425/440 |
| 3,023,477 | 3/1962 | Smith et al. | 249/50 |
| 2,614,309 | 10/1952 | Price | 425/450 |
| 3,142,106 | 7/1964 | Wise et al. | 425/440 |
| 3,523,997 | 8/1970 | Hennig | 425/440 X |



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*Attorney*—Lawrence B. Biebel et al.



[57] **ABSTRACT**

A method and apparatus for stripping slab casting forms from cured concrete slabs by flexing the forms to allow grout keyway forming protrusions projecting inwardly from the form side walls to clear the associated grout keyways formed in the slab. By applying stripping forces to the form in a particular manner a more satisfactory grout keyway, from a structural view point, can be formed in the slab while still permitting the form to be stripped from the slab by flexing without exceeding the elastic limit of the material, such as steel, of which the bottom pan of the form is constructed.


**7 Claims, 6 Drawing Figures**

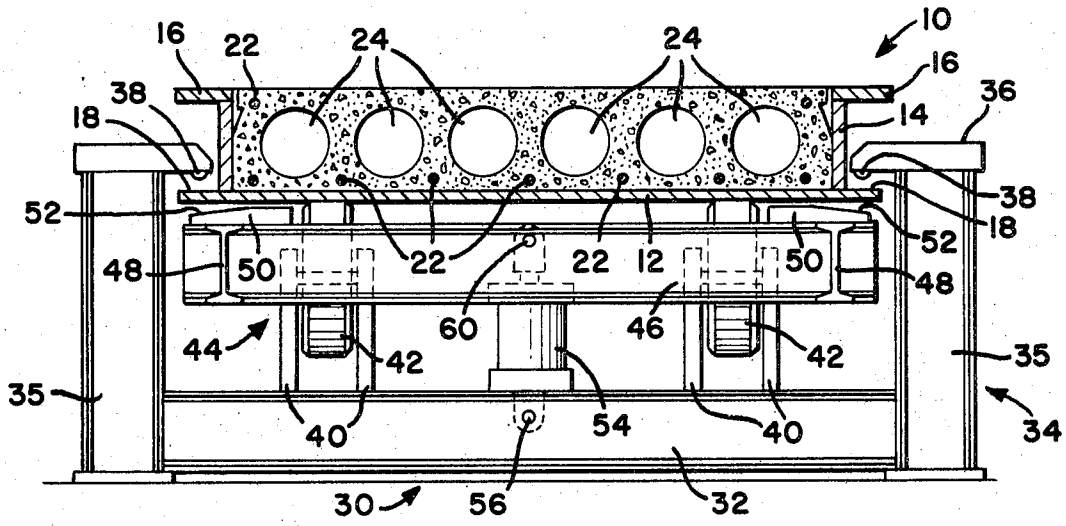


FIG-1

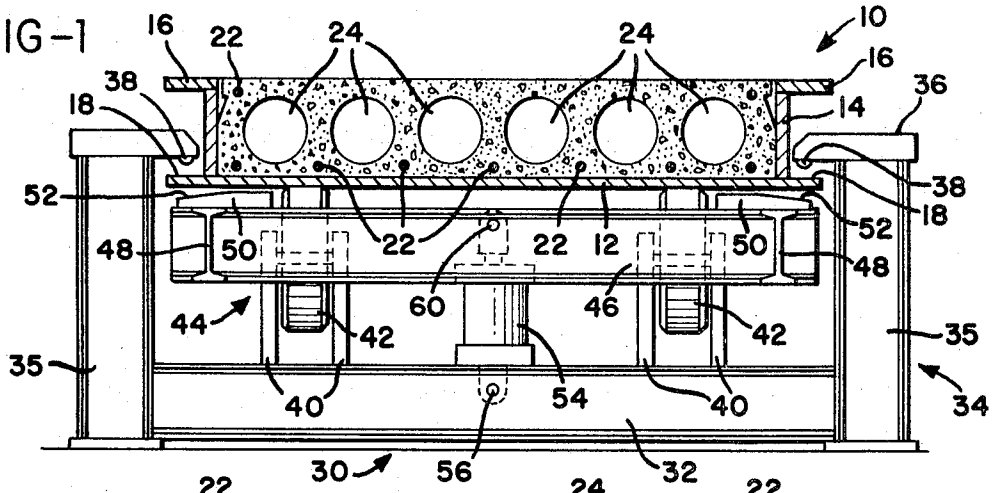



FIG-2

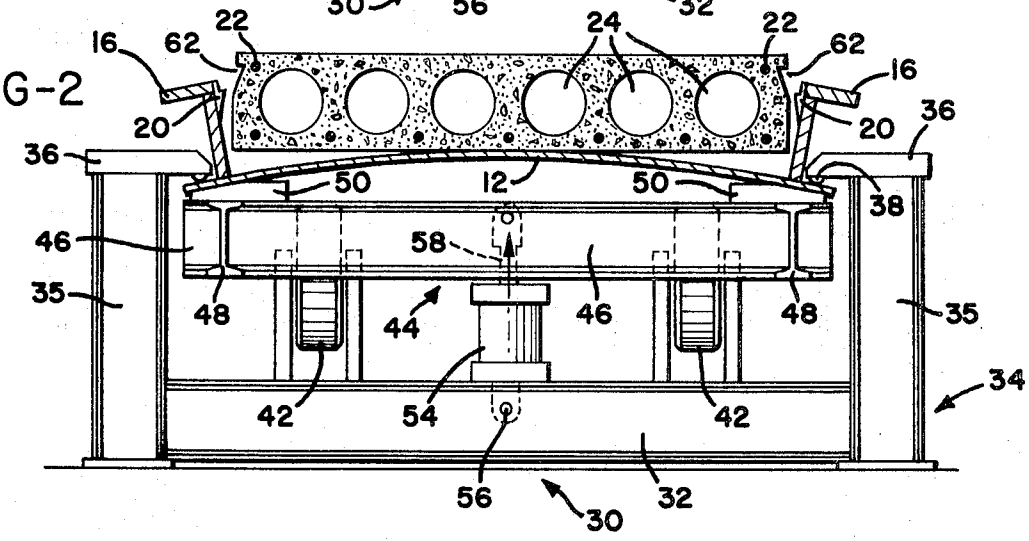



FIG-3

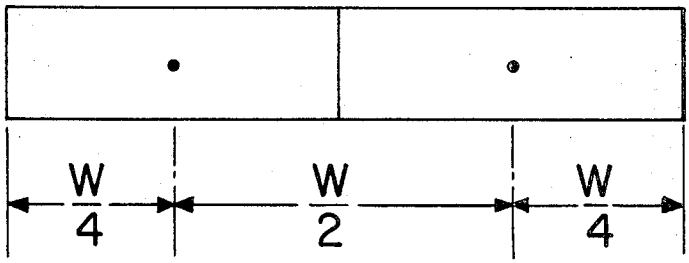


FIG-4

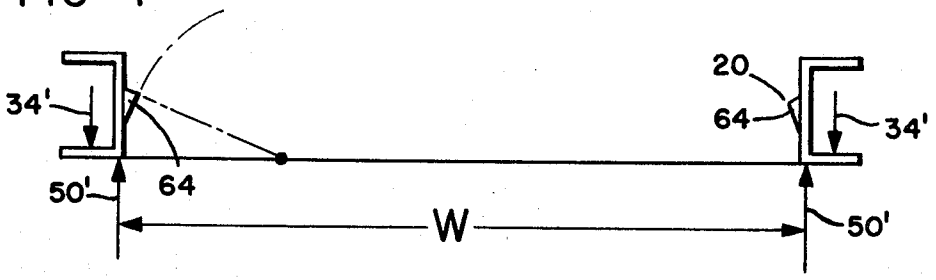



FIG-5

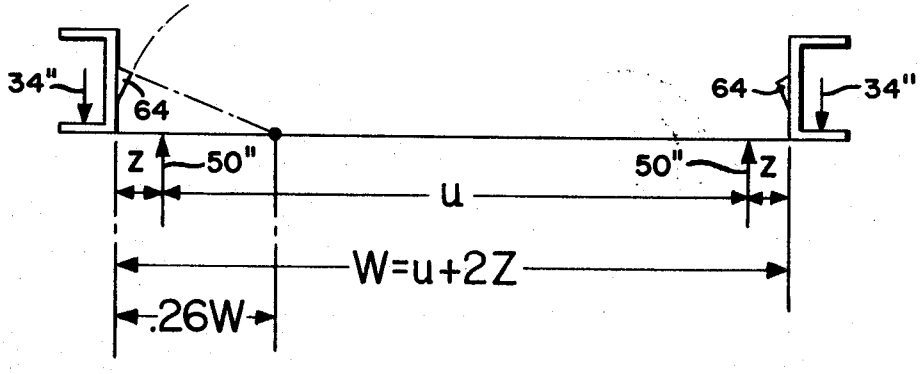
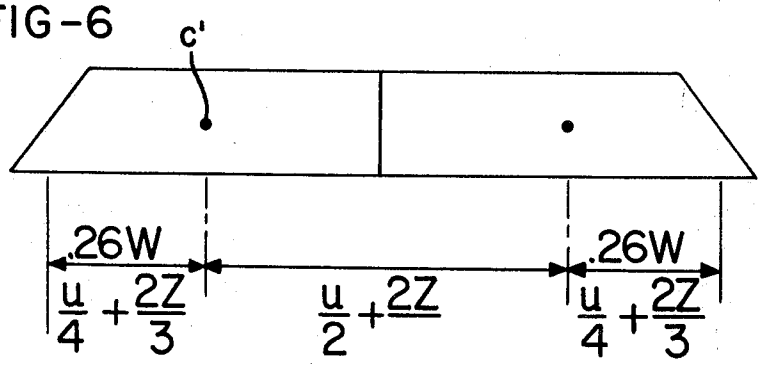



FIG-6



# APPARATUS FOR STRIPPING SLAB CASTING FORMS

## BACKGROUND OF THE INVENTION

The use of precast, prestressed, concrete slabs offers advantages in several areas over in situ casting operations. Such slabs are, accordingly, used in a variety of building structures. In using precast slabs, grout keyways or cavities are formed in the side edges of the slabs to transfer load so that the total slab assembly acts as a monolithic structure. These cavities, when the slabs are placed side by side, cooperate to define a void which is thereafter filled with grout and allowed to harden to key the slabs to each other.

From the standpoint of the structural integrity of the structure formed by the precast slabs, the keyways or cavities should penetrate at least some predetermined amount into the side of the slabs. That is, the offset of the keyway into the sides of the slab must be sufficiently defined so that when the slabs are keyed to each other by grouting, loads may be transferred from one slab to another so that the assembled, grouted slabs act as a monolithic deck.

In casting prestressed slabs, however, it is desirable to utilize what is generally referred to as a "one-piece form." This is somewhat of a misnomer, since such forms are generally constructed from several pieces joined together by welding or the like to form a composite structure. Actually, the term "one-piece form" indicates that the components of the form are permanently interconnected, as by welding, to act as a unit, rather than being constructed of readily separable pieces.

U.S. Pat. No. 3,023,477 describes a one-piece casting form of this type and discusses certain problems inherent in their use. For example, it will be apparent that the cured slab cannot simply be lifted from the form since the grout keyways or cavities formed in the slab will be interlocked with the protrusions on the form side walls which form these cavities during the casting process.

As discussed in the above noted patent, this problem is overcome by shaping the cavity producing protrusions with outwardly and downwardly sloped lower portions. The contour of these lower portions is carefully controlled so that the protrusions will clear the cavities when the bottom pan of the form is flexed about a series of contour ribs having a predetermined radius of curvature.

Thus, as explained in some detail in the above noted patent and also mentioned in U.S. Pat. Nos. 3,061,904 and 3,142,106, "instant centers" are determined for the form and a series of arcs struck using the instant centers as the centers of the arcs and all parts of the lower portions of each of the key forming protrusions must lay outside this arc. The instant centers may be determined by analyzing the bending moments applied transversely of the form during the contour stripping process.

For example, in contour stripping, the bottom pan contacts the contour ribs first at its center, inducing a moment at that time which decreases from a maximum at the center of the pan outwardly toward the longitudinal side edges thereof. As the stripping process proceeds, the character of the bending moment induced in the pan varies from that described above to a substantially uniform moment across the width of the pan when the bottom pan has been fully flexed around the contour of the ribs.



At the outset of the flexing process the instant center for each half of the form is located at a point along the bottom pan coicident with the lateral position of the centroid of the bending moment diagram for that side of the pan. For the initial stripping condition, therefore, the instant centers are spaced inwardly from the longitudinal edges of the bottom pan a distance equal to one-third the width of the pan. Therefore, the slope of the bottom portion of the grout keyway is determined by arcs swung from this instant center as the center of rotation.

While the centroid of the uniform moment which obtains when the bottom pan is fully flexed around the contour ribs results in the instant centers being positioned closer to the side walls of the form, and hence would provide an arc of shorter radius, it will be apparent that the worst condition, that is, the condition at the outset of stripping, must control, since there must be clearance between the grout cavity forming protrusions and the slab at all times during the stripping process, including the initial flexing of the pan.

A stripping system in accordance with the teachings of U.S. Pat No. 3,023,477 has proved very successful and received widespread commercial acceptance in the manufacture of slabs of approximately 2 feet in width, a common size. The present trend in the industry, however, would appear to be toward wider slabs, say four feet or more in width. On the other hand, as a practical matter, it has been found that stripping by the use of contour ribs is restricted to slabs whose width to depth ratio does not exceed a certain amount. Thus, if the width of the slab becomes too great the geometry involved in stripping the form will not permit successful stripping since the protrusions on the form side walls will not clear the keyways they form in the slab.

Additionally, it will be apparent that it is desirable that the finished slab, for aesthetic as well as structural considerations, should be substantially flat. The bottom pan of the casting form, therefore, should exhibit very little deflection when the form is loaded. Obviously, for wider pans of the same material, if they are to resist such deflection satisfactorily without additional bracing, they must be substantially thicker than pans used in casting narrower slabs.

In accordance with well known engineering principles, however, if a thicker pan is flexed about the same radius of bend as that used in flexing a thinner pan, a much higher stress concentration will result. As a practical matter it has been found that with the type of steel used in the bottom pans of the forms and the thickness necessary to keep deflection within acceptable limits on the wider forms, if the wider forms are bent to the same radius of curvature presently used in stripping narrower forms using contour ribs, overstressing of the pan material will result, and the elastic limit of the pan material will be exceeded.

## SUMMARY OF THE INVENTION

Method and apparatus for stripping slab casting forms from cured slabs of substantial width in a manner which permits the formation of grout keyways in the slab adequate to transfer load from one slab to another in a composite slab assembly and prevents overstressing of the bottom pan of the form.

In the stripping process the bottom pan is arched inwardly of the form, causing the side walls thereof to move, relative to the pan, outwardly and downwardly, by stripping forces acting on the bottom pan longitudinally thereof at points spaced transversely outwardly from the center of the pan.

By stripping in this manner the configuration of the bottom surfaces of the cavity-forming protrusions on the side walls of the form and their inward extent may be substantially increased over that permissible by prior art stripping methods, such as the above noted contour method, as well as permitting an increase in the distance that the protrusions may be spaced from the top of a finished slab.

This is because the centroids of bending moments induced in the form when stripping in accordance with the present invention are positioned closer to the longitudinally extending side edges of the bottom pan than in prior art stripping processes, thereby spacing the "instant centers" closer to the sides of the form. For example, if both the forces applied to the bottom of the form to flex the bottom pan inwardly and the forces, such as restraining forces, acting in opposition thereto, are applied outwardly of the longitudinally extending side edges of the pan, a uniform bending moment will be induced transversely of the pan.

With this condition, the instant centers would be positioned approximately a quarter of the width of the pan inwardly from the longitudinal side edges thereof, as opposed, for example, to one third the width when using contour stripping. Thus, the radius of an arc swung from the quarter point on the bottom pan through the side wall of the form at any point along its height will be shorter than the radius of an arc intersecting a form at a corresponding point thereon but having its center at the third point of the bottom pan. Obviously, a much sharper arc results, permitting a commensurately steeper slope for the lower portion of the grout cavity forming protrusions.

In an embodiment of the invention disclosed herein the forces applied to the bottom pan are actually applied at points spaced inwardly of the longitudinal edges thereof. This is to avoid the application of force at weakened areas that may exist near the edges of the bottom pan due to notching in the manufacturing process and to also reduce the stripping forces necessary. For example, on a 48 inch wide form the forces may be applied to the bottom pan at points spaced inwardly from the side walls approximately 3 inches on each side.

As will be explained in detail below, although this results in a slight shifting of the instant centers toward the center of the form, for all practical purposes the resulting conditions are almost identical to the conditions which occur when these forces are applied at or outwardly of the edges of the bottom pan. For example, with the dimensions mentioned above, the locations of the instant centers shift from points located about 25 percent of the pan width inwardly from the pan side edges to points located inwardly of the side edges about 26 percent of pan width.

Regardless, the method and apparatus of the present invention permit stripping of slab casting forms without over-stressing of the bottom pans thereof, despite the fact that such forms may have bottom pans of substantially increased thickness with respect to narrower forms, and still produce a slab having grout keying cavities sufficient to provide the desired structural characteristics.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view, partly in cross-section, showing stripping apparatus in accordance with the present invention and a casting form received therein;

FIG. 2 is a view similar to FIG. 1, but showing the casting form in its fully flexed configuration;

FIG. 3 is a bending moment diagram illustrating the theoretical moment induced in a form when the opposing stripping forces are applied at or outside the side edges of the bottom pan of the form;

FIG. 4 is a diagrammatic representation showing how the configuration of grout keying protrusions are checked for stripping;

FIG. 5 is a diagrammatic representation similar to FIG. 4; and

FIG. 6 is a diagram similar to FIG. 3 but showing the bending moment induced in the bottom pan of a form when the stripping forces are applied thereto in the manner indicated in FIG. 2 of the drawings.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference initially to FIGS. 1 and 2 of the drawings, it will be seen that a "one-piece" form **10** suitable for casting prestressed, precast, concrete slabs, may include a bottom pan **12**, upstanding side walls **14**, and outwardly projecting flanges **16** overhanging the portions **18** of the bottom pan that extend outwardly beyond the side walls **14**.

Additionally, the form will include inwardly projecting grout keyway forming protrusions **20** positioned on the inner surfaces of each of the side walls **14**. These protrusions may be formed as continuous members extending the length of the form or they may be discontinuous, as shown, for example, in U.S. Pat. No. 3,168,888, to provide keying in a horizontal as well as a vertical plane.

Regardless of whether or not the grout keyway protrusions are continuous, in the casting process bulkheads are attached to opposite ends of the form and prestressing cables, as at **22**, mounted in the forms extending between the bulkheads under tension and void forming inflatable tubes (not shown) positioned within the form.

Concrete is thereafter placed in the form and vibrated to settle it about the tubes and prestressing cables and the filled forms are thereafter placed in a kiln under controlled humidity and temperature to allow the concrete to cure. The tubes are removed when the concrete has hardened sufficiently, thereby providing the voids indicated at **24** in FIG. 1 of the drawings. The forms, with the bulkheads removed, are then placed in a stripping fixture to allow the cured slab to be removed from the form.

In the process described in the above noted U.S. Pat. No. 3,023,477, a series of curved, transversely extending contour ribs engage the pan of the form and the pan is flexed about the ribs to allow the keyway forming protrusions to clear the cavities which they have formed in the side edges of the cured slab so that the slab may be removed from the form.

The problems encountered when attempting to use this type of stripping system for slabs in which the width to height ratio exceeds some predetermined amount

are discussed above. To avoid these problems the present invention provides stripping apparatus in which the bending moments induced in the bottom pan during the stripping operation are uniform, or nearly so, across the width of the pan.

Thus, as seen in FIGS. 1 and 2, apparatus in accordance with the present invention may include a main or base frame 30, consisting of laterally extending structural members 32 suitably tied together by longitudinally extending structural members. Fixed to each side of the base frame are restraining members 34. Each of the restraining members 34 includes a series of uprights 35 (only one of which is shown at each side of the machine), inwardly projecting flanges 36 and semicylindrical form engaging members 38 on the lower surfaces of the flange members.

The base frame 30 also supports roller brackets 40 which project upwardly from the base frame intermediate the restraining members 34 and rotatably mount rollers 42. While only two rollers are shown in FIGS. 1 and 2, it will be apparent that a series of such rollers extend throughout the stripping fixture. Additionally, it will be apparent that the flanges 36 and form engaging members 38 may be continuous throughout the length of the form or consist of a series of such devices suitably supported by a series of structural uprights 35.

A movable bed or stripping platen 44, consisting of cross-members 46 tied together by longitudinally extending members 48, supports stripping bars 50 along each longitudinal edge of the bed. Each of the stripping bars includes a sloped upper surface 52, the angularity of which is controlled so that this surface is tangent to the bottom surface of the pan when the pan is fully flexed to a curved configuration wherein the keyway forming protrusions clear the cavities formed in the sides of the slab. As in the case of the members 36 and 38, bars 50 may be formed asscontinuous members or as a series of such bars.

A hydraulic or pneumatic cylinder 54 is mounted in the stripping fixture, pivotally attached to the base frame as at 56 and having a piston rod 58 projecting therefrom and pivotally attached, as at 60, to the stripping platen 44. With the above construction it will be seen that forms containing cured slabs may be moved into the stripping fixture on the rollers 42 with the flanges 18 disposed beneath the members 38 for engagement thereby. Of course, while the use of fixed restraining devices simplifies the construction of the stripping fixture, in some installations where, for example, space limitations do not permit endwise insertion of the form into the stripping fixture, it will be desirable to have one or both of the restraining devices 34 movable inwardly and outwardly of the fixture so that the form may be moved laterally into and out of the fixture.

Regardless of how the form is moved into and out of the fixture, however, after it is positioned as shown in FIG. 1 of the drawings, the cylinder 54 is pressurized, causing the platen 44 to move upwardly as seen in FIG. 2 of the drawings. The sloped upper surfaces 52, it will be noted from FIG. 2, serve as a convenient means for limiting relative movement between the restraining members and stripping bars, thereby eliminating the necessity of attempting to monitor and control relative movement or use external stops to limit relative movement.

In this regard it will be apparent that if, for some reason, this function of the stripping bars was not desired, other stripping members, such as round bars or rods, providing only line contact with the bottom pan, could be used.

As the platen is displaced from its rest position, the restraining members and the stripping bars 50 cooperate to flex the form into the arched configuration shown in FIG. 2 of the drawings. In this configuration the bottom pan is flexed inwardly of the form in a curve and the side walls 14 are moved outwardly with respect to the form a distance sufficient to clear the protrusions 20 from keyways 62 in the slab. With the pan so curved it will be seen from FIG. 2 that the sloped upper surfaces 52 are now disposed tangentially with respect to the bottom pan.

If both the stripping bars and the restraining members engage the form outwardly of the point where the pan meets the side walls, as indicated by the arrows 50' and 34' in FIG. 4 of the drawings, the bending moment induced in the bottom pan will be substantially uniform, as seen in FIG. 3 of the drawings. In this case the centroids C of the bending moments applied to each side of the bottom pan will be located approximately one-fourth of the width of the pan, W/4, inwardly from each of the side walls of the form.

As a result, the instant centers from which arcs are swung to determine the configuration of the keyway forming protrusions, as indicated in FIG. 4 of the drawings, are located at the quarter points of the bottom pan, providing shorter radius arms for the arcs. This in turn results in more sharply curved arcs, permitting a steeper slope for the bottom surface 64 of each of the protrusions 20.

While positioning the stripping bars and restraining forces outwardly of the side walls of the form will produce the optimum conditon for stripping, in practice it will usually be desirable to position the stripping bars inwardly somewhat from the point of intersection between the bottom pan and the side walls. This will usually be a small amount, on the order of approximately 3 inches on a 48 inches wide form, and will not appreciably affect the position of the instant centers.

For example, as illustrated graphically in FIGS. 5 and 6 of the drawings, if the stripping forces are applied at a distance inwardly from the side walls equal to Z, as indicated by arrows 50 inches, while the restraining forces are applied as illustrated by the arrows 34 inches, the bending moments induced in the bottom pan will be approximately as shown in FIG. 6 of the drawings.

Thus, the moment induced in the bottom pan is substantially uniform across all but a minor portion of the bottom pan, with the bending moments decreasing in magnitude from the maximum at a point located inwardly from the side edges thereof a distance equal to Z. With the stripping forces spaced from each other a distance equal to U, the centroids C' of the bending moments induced in each side of the pan are as indicated in FIG. 6 of the drawings, thereby positioning the instant centers inwardly from the side edges distance equal to approximately $U/4 + 2Z/3$, as indicated in FIGS. 5 and 6 of the drawings.

This results in a slight outward shifting of the instant centers from points spaced inwardly of the sides of the forms a distance equal to 0.25W to a distance equal to 0.26W. While this does lengthen the radius of any arc swung through the side wall from the instant center, it

will be apparent that as a practical matter this variation may be considered neglibile.

In either case, therefore, with the stripping method and apparatus of the present invention a deeper grout keyway having a much more sharply sloped bottom surface can be formed at a lower point in the slabs than in prior art stripping methods, despite the fact that the radius of curvature of the flexed pan is large enough to prevent overstressing of the material of which the bottom pan is formed.

While the methods and forms of apparatus herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise methods and forms of apparatus, and that changes may be made therein without departing from the scope of the invention.

What is claimed is:

**1.** Apparatus for stripping from a cured slab a casting form having a bottom pan, upstanding side walls and grout keying protrusions projecting inwardly of said form from each of said side walls comprising:

a. first means for engaging said form outwardly of longitudinal side edges of said bottom pan,

b. second means for engaging said form at spaced locations extending longitudinally thereof inwardly of and in opposition to said first means and outwardly of the center of said pan, and

c. means for moving said first and second form engaging means relative to each other in opposing directions with said form engaged therebetween a distance sufficient to cause said side walls to move outwardly of said form, said bottom pan to flex upwardly in a curve and said grout keying protrusions to clear cavities formed thereby in a slab cast in said form.

**2.** The apparatus of claim **1** wherein:

a. said second form engaging means include longitudinally extending bars.

**3.** The apparatus of claim **2** wherein:

a. each of said bars has a sloped upper surface extending downwardly and outwardly of said apparatus, and

b. said sloped upper surfaces of said bars are substantially tangent to the curve formed by said pan.

**4.** The apparatus of claim **1** wherein:

a. said second form engaging means are spaced inwardly of said first form engaging means in a position for engaging said bottom pan inwardly of longitudinally extending side edges thereof.

**5.** The apparatus of claim **1** wherein:

a. said second form engaging means are spaced inwardly from opposite longitudinally extending side edges of said pan a distance equal to Z,

b. said second form engaging means are spaced from each other a distance equal to U, and

c. U is substantially greater than 2Z.

**6.** Apparatus for stripping from a cured slab a casting form having a bottom pan, upstanding side walls and grout keying protrusions projecting inwardly of said form from each of said side walls comprising:

a. first means for engaging said form outwardly of longitudinal side edges of said bottom pan,

b. second means for engaging said form at locations extending longitudinally thereof outwardly of the center of said pan, inwardly of said side edges a distance equal to Z, spaced from each other a distance equal to U, and in opposition to said first form engaging means,

c. means for moving said first and second form engaging means relative to each other in opposing directions with said form engaged therebetween a distance sufficient to cause said side walls to move outwardly of said form, said bottom pan to flex upwardly in a curve and said grout keying protrusions to clear cavities formed thereby in a slab cast in said form, and

d. said first and second form engaging means being positioned relative to each other and to said form such that centroids of the bending moments applied to each side of said pan during flexing thereof are located inwardly of the longitudinal edge of that side of said pan a distance equal to approximately $U/4 + 2Z/3$.

**7.** Apparatus for stripping from a cured slab a casting form which includes an elongated bottom pan having a width equal to U + 2Z, upstanding side walls, flanges projecting outwardly from said form and grout keying protrusions projecting inwardly of said form from each of said side walls comprising:

a. hold down means for engaging said outwardly projecting flanges,

b. a pair of longitudinally extending bars adapted to engage the bottom pan of said form at points spaced inwardly of longitudinally extending side edges of said form a distance equal to Z and a transverse distance from each other equal to U,

c. each of said bars having a substantially flat upper surface and a sloped upper surface sloping downwardly and outwardly from said flat upper surface,

d. the angularity of said sloping surface being such that said sloping surfaces are substantially tangent to the curved pan of said form when flexed an amount sufficient to move said side walls outwardly to a point where said protrusions thereon will clear grout cavities defined in a slab cast by said form, and

e. means for moving said bars in opposition to said hold down means a distance sufficient to flex said bottom pan to a curved configuration curved to the extent that said sloping surfaces are tangent thereto.

* * * * *

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# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 3,770,360 Dated November 6, 1973

Inventor(s) Theodore W. Shoe

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, lines 46, 47 and 48, "50 inches and 34 inches" should be --- 50'' and 34'' ---.

Signed and sealed this 17th day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents