

March 6, 1962

M. J. WISE
CASTING FORM

3,023,476

Filed April 25, 1961

2 Sheets-Sheet 1

FIG 1

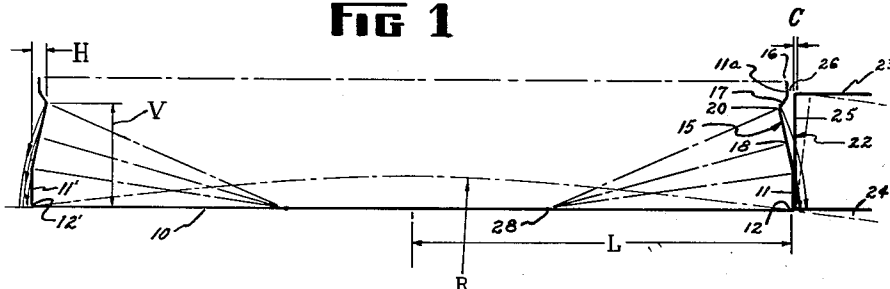


FIG 2

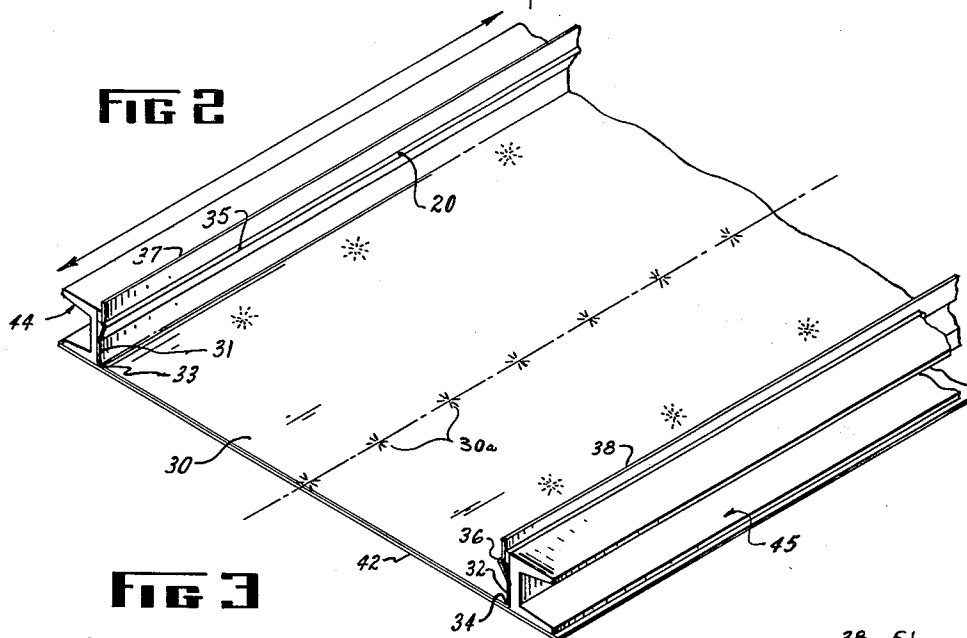
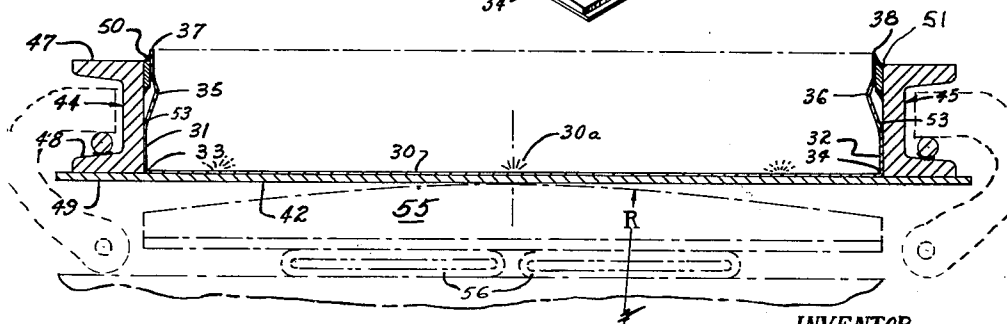


FIG 3



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FIG 4

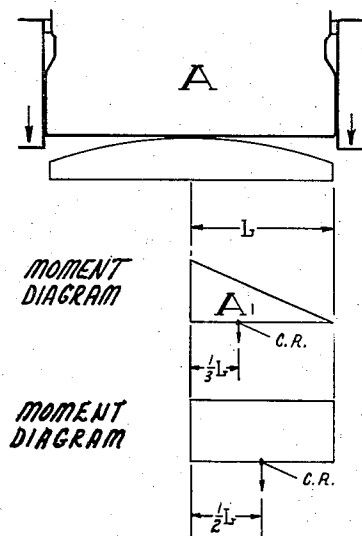


FIG 5

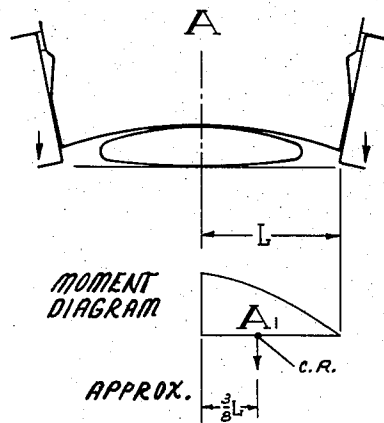


FIG 8

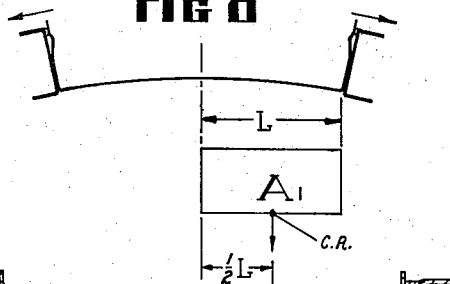


FIG 6

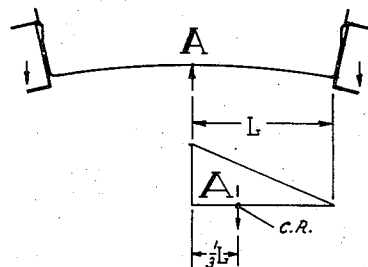


FIG 9

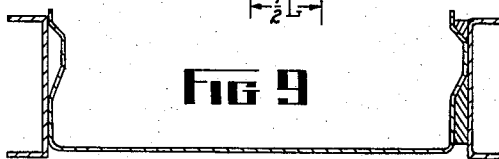


FIG 7

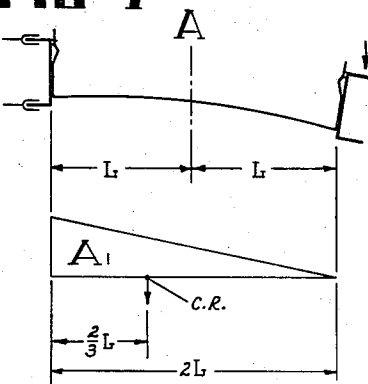
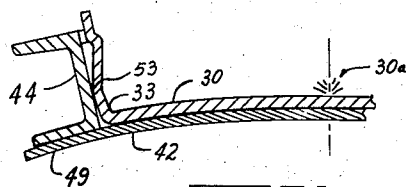


FIG 3A

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3,023,476

CASTING FORM

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Filed Apr. 25, 1961, Ser. No. 105,425
5 Claims. (Cl. 25-121)

This invention relates to a casting form for concrete slabs. Concrete slabs or beams as disclosed in United States Patents 2,299,070; 071; 072; and 111, issued on October 20, 1942, consist of long slabs or beams along the sides of which are grout keys or channels. Such cast slabs when disposed in side by side relation, have complementary grout keys which cooperate to provide a grout canal so shaped as to lock the slabs together when filled with grout or similar material. The canal in section has a generally bottle shape; i.e., a restricted mouth at the top with a maximum width mid-portion. One slab has one grout key at each side, such key being hereafter designated as semi-bottle shaped. Slabs of the type referred to are cast in forms having a generally U-shaped cross-section with bulkheads for defining the slab ends.

To provide grout keys along the slab sides recourse has been had to one of two expedients. One expedient is disclosed in the 2,299,072 patent previously identified. In this patent, the sides of the form are separable from the bottom of the form. This permits the form sides to incorporate, as a permanent part thereof, means for molding the concrete to provide the grout keys.

The use of a casting form separable into two or more parts leaves much to be desired and in addition is responsible for loss or misplacing of separate parts and the requirement for additional time in assembling and dismantling the form.

In an attempt to overcome the above disadvantage, a generally U-shaped springable form, as disclosed and claimed in United States Patent No. 2,614,309, issued October 21, 1952, was devised. This form has highly desirable advantages but suffers from one drawback. This form requires removable liners for creating the grout keys along the slab sides. The necessity for handling such separable liners, keeping the liners straight and maintaining the liners and the parts of the form covered by the liners clean and free from dirt is undesirable.

Attempts have been made to integrate the liners with the form sides with the object of providing what may be termed a one piece form. Such attempts, however, have generally failed. Incorrect designs of the grout key requiring excessive springing of the form has been responsible for the difficulties. For a casting form to be of one piece, we have determined that it is necessary for the grout key to satisfy certain geometrical conditions.

In the following discussion it will be assumed, for convenience, that the casting form is seen in transverse section and has the bottom horizontal and the sides extending up at right angles from the bottom. Beginning from the top of the key, this would correspond to the mouth of a bottle shape, the key outline will extend downwardly and inwardly (toward the interior of the casting form) until what may be designated a peak is reached. The peak is the innermost (laterally) point on the key during stripping and it is the critical point which the casting must clear for release. Below the peak (in the direction of the form bottom) the key outline will extend downwardly and outwardly (as seen from the outside of the form) so that at or near the form bottom the casting region has full width.

One specific geometrical condition to be satisfied is the location of the center for drawing arcs and is dependent upon the manner in which the casting form is stripped; i.e., whether the form sides are both moved or one side

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anchored and the other side moved or whether the bottom is operated upon directly, all of which will be explained in greater detail later. In all instances, the casting form will have a bottom portion which will be subject to flexing during the stripping operation.

With reference to one side of a casting form, take a point on or near the form bottom which is between about $\frac{1}{4}$ and about $\frac{3}{4}$ of the form width distance away. The location of this point is determined by the centroid of the bending moment diagram pertaining to the particular mode of stripping the form. In case a stripping procedure involves one moment diagram at one stage and a different moment diagram at a different stage (as for example, described later in connection with FIGURE 4 of the drawing), then the worst condition should be assumed; i.e., the point determined by the initial moment diagram. From this point, determine the distance to the peak as previously defined and use this distance as a radius. From the point referred to and with the radius as set forth, draw an arc from the peak downward toward the form bottom (or its extension). Every point on the grout key below the peak must lie on or inside of this arc. Furthermore, with the same center, any arc drawn from any point on the grout key outline below the peak must lie on or inside of arcs drawn from points higher up and must lie on or outside of arcs drawn from points lower down on the key outline. Thus, each successive arc drawn from the same center point beginning with a new point on the one form side below the key peak (the radius will of course be determined by the new point) must be on or outside of all parts of the one form side below the new point. From geometrical conditions, it is clear that the portion of the key outline below the peak need only be analyzed in this fashion since any straight vertical form side portion below the key bottom will always meet this condition.

The center point or origin for the radius will lie on the form bottom and will be about from one-fourth to three-fourths of the form width from the side. The range for the location of the center or origin depends upon how the form is manipulated to release the casting as previously stated. By treating the form along its width as a beam (using conventional stress analysis technique), the $\frac{1}{4}$ to $\frac{3}{4}$ factor comes in by virtue of operating on one side of the form or on both sides of the form during the stripping.

In the copending application of Warner B. Smith, Mark J. Wise and Robert E. Smith, Serial No. 844,012, filed October 2, 1959 and assigned to the same assignee, there is disclosed a one-piece casting form wherein the bottom of the casting form assumes all of the stress incident to stripping. In the one piece casting form disclosed in said copending application, the sides of the casting form are reinforced with members which form structural elements and cooperate to open the form sides. The present invention modifies this one piece construction and provides a composite form which has all the characteristics of a one piece form insofar as use is concerned but is free of some of the limitations of the one piece casting form described and claimed in the application previously referred to.

The design of a casting form which can be sprung without exceeding the elastic limits of the steel involves a number of considerations. These are set forth in the application referred to and will be given here later. The present invention provides a construction which makes possible the creation of a fairly sharp corner between the bottom of the slab and the sides. It is well known that any elastic material cannot have too sharp a bend without damaging the material at the bend. Consequently, in making a one piece casting form where the bottom and

the sides of the form are integral, it is possible to obtain a sharp corner at the bottom of the form only if the form wall is comparatively thin. Thus for example, steel having a thickness of about $\frac{1}{8}$ inch can be bent at right angles to form a fillet having a radius of about $\frac{3}{16}$ of an inch. Such a fillet is sharp enough for casting slabs. However, $\frac{1}{8}$ inch steel does not have the strength and the characteristics to be used alone in the manufacture of a one piece casting form. Accordingly, this invention contemplates a generally U-shaped one piece casting form of comparatively thin material as plastic or steel reinforced along the outside of the form at the bottom by a heavy steel plate having desired stress characteristics.

The use of thin material, such as $\frac{1}{8}$ inch steel, for the casting form proper provides substantial advantages. The side walls at the grout keys are easily shaped to definite and sharp outlines. This makes for a better grout key in the finished slab. Smaller and lighter machines and the bending tools for shaping the form reduce costs. Such machines are available whereas machines for handling heavier metal are scarce and require very expensive tooling. With such a casting form, it is possible to have very smooth steel for the casting surfaces. This is easily obtainable in thin gauge, as $\frac{1}{8}$ inch. With heavier gauge metal, particularly steels having high stress characteristics, smooth surfaces are not common due to the heat treatment. Such material requires special finishing operations.

The new casting form embodying the present invention has reinforcements at the sides. The new form has its molding or casting surface easily shaped but reinforced as to make it possible to handle the form as a one piece casting form and spring the form to release a casting without damage to the form.

In order that the invention may be understood, it will now be explained in connection with the drawings wherein:

FIGURE 1 is a diagrammatic representation of the principles underlying the design of a casting form.

FIGURE 2 is a perspective view of a length of casting form embodying the present invention.

FIGURE 3 is a transverse section of a length of casting form embodying the invention with a suggested means for springing the form illustrated in dotted lines.

FIGURE 3A is a detail illustrating the relative movement of the casting liner and rest of the casting form.

FIGURES 4 to 8 inclusive, are diagrams illustrating different modes of stripping and showing the moment diagrams.

FIGURE 9 is a diagrammatic showing of a tongue and groove modification.

Referring first to FIGURE 1, the form has bottom portion 10 and sides 11 and 11'. Between bottom 10 and sides 11 and 11' are curved fillets 12 and 12' of suitable curvature. For convenience, one side of the form will be considered. Side 11 continues upwardly (the direction is with reference to the open top of the form) and has inwardly extending grout key forming portion generally indicated by 15 and free edge 16. Grout key forming portion 15 consists of top and bottom portions 17 and 18 meeting at key peak 20. Portion 17 extends toward side wall portion 11a which continues to free edge 16. Portion 18 extends to side 11. Portion 11a may be of any size and is laterally offset from side 11 toward the inside of the form. The grout keyway formed will therefore have a narrow mouth or opening at the slab face.

It is understood that the casting form extends lengthwise for a desired length. Peak 20, which is a point on the sectional view, will be a straight line. If a continuous, uninterrupted keyway for a slab is desired, then peak 20 will lie on a straight line extending the full length of the form. However, it may be desirable to interrupt a keyway along the length of a slab. In such case, a transverse section of a slab at the key interruption point will show a simple rectangular outline for a slab or may show a keyway which is shallower. The stripping problem however

will be present in such forms and the worst conditions will be determined by the maximum depth grout keys. It is understood therefore that the key outlines illustrated in the drawings represent the deepest key portions along the length of a casting form.

Similarly, other parts 11, 11a, 18, 17, and 16 are surfaces extending along the form.

Rigidly attached to side 11 is channel 22 having flanges 23 and 24 and web 25. Web 25 is welded or otherwise rigidly attached to side 11 at a number of places extending from fillet 12 to free edge 16 and it is understood that these places of attachment extend at suitable intervals along the length of the form. A spacer bar is disposed between the form side adjacent free edge 16 and web 25 to provide for the lateral displacement of portion 11a and edge 16.

Key portion 15, the part below peak 20, of the form side must meet the following geometrical condition.

Point 28 on the form bottom is taken as a center. The distance from side 11 along the form bottom may be as little as about $\frac{1}{4}$ of the form width and as great as $\frac{3}{4}$ of the form width, depending upon the manner of stressing the form bottom for stripping. With the distance between point 28 and peak 20 as a radius, an arc is drawn toward the extension of the form bottom. All points on the form side below peak 20 must lie on or inside of this arc. Next take a second point adjacent to but below peak 20 as a radius and from point 28 draw an arc toward the form bottom. The second arc must lie on or within the first arc and all points on the form side below this second point must lie on or within the second arc. This procedure can be carried on, point by point until the bottom of the key is reached. After side 11 has been reached, the vertical side will satisfy the above conditions so no further analysis is required. Different ways of stressing the form bottom to be described will require different locations for the center or origin of the radius vector. In general, however, the center point will range from about $\frac{1}{4}$ to $\frac{3}{4}$ of the form width away from the side being analyzed.

Where the height of the peak above the form bottom is small, say less than one-half the form width, great care must be exercised in the key design. Slabs which are wide in comparison to depth, for example 4 inches by 24 inches, must have their keyways designed not only for stripping from the casting form but also for strength of the concrete between the key and the adjacent cored out passage. Hence the part of the key below the peak should slope outwardly as much as possible. On the other hand, the downward component of the slope is essential for clearing the form during stripping. The technique in analyzing a key for stripping clearance is of great importance in shallow forms. Because casting forms are difficult to manufacture and expensive to test, the theoretical analysis is of great value. As will be shown later, the stress characteristics of the steel making up the form bottom stress supporting plate is an important factor in the actual design of a casting form and is tied in with the key design. Therefore, in testing a casting form, a full scale and practical casting form must be made.

It is understood that the form can be in a normal position shown by dotted lines with the bottom arched and the sides diverging. In such case the form sides will have to be closed toward each other during the casting operation.

In theory, the center point taken at the form bottom should be taken at the stress support plate provided below the form bottom as hereinafter described. In practice the form bottom thickness is inconsequential, compared to other dimensions, so that there is little difference in final results.

Casting forms having great length (as much as 50 feet) are difficult to handle in connection with the manufacture of the casting form itself. The form sides are provided with key-shaping portions along the length of the form. These key-shaping portions must be accurate. It is easier

to shape than steel than to cut thick steel in connection with the key forming portions. Where high strength steel is used, it is difficult to work, shape or fabricate if the steel is thick. It is of course possible to make a U-shaped casting form of heavy steel and weld key forming portions into position. However, it is desirable to have the casting surface of one continuous piece of material (not necessarily steel) including the sides and reinforce the structure with steel so that a one piece composite structure is provided. This composite structure involves the same problems and difficulties present in a truly one piece casting form as disclosed and claimed in the copending application referred to.

As pointed out in the patents referred to previously, the keyway in the side of each slab comes into use after a slab is positioned alongside of a companion slab. The keyways of two adjacent slabs cooperate to produce a grout joint which must be strong enough to provide an interlock. The keyway in the slab must therefore have substantial depth (this is in a direction parallel to the slab width).

A keyway which is strong enough to provide an interlock between adjacent slabs will obviously produce an interlock between a casting and the casting form. Stripping requires that the form sides be opened enough to free the slab.

A composite casting form which is sufficiently strong to maintain its transverse shape without external supports when filled with concrete mix obviously requires heavy gauge steel. To this must be added the requirement that the steel must be strong enough to withstand normal conditions of use in a plant. This means careless handling by workmen, collision with other objects and supporting the casting form on uneven surfaces, which may be irregular because of stones, sand and other debris found in a plant of this type.

From geometrical conditions it is obvious that the deeper a key is and the nearer the key is to the form bottom, the greater is the deflection of the form side to unlock the casting. The form sides and form bottom come together to form corners of substantially 90° and these corners are maintained substantially intact during form opening. Consequently, moving the form sides results in arching of the stress plate below the form bottom and this creates stresses. Conventional beam theory points out that the stresses created in the stress plate increase with steel thickness for corresponding curvature. Theoretically, the thinner the steel that is arched, the lower the stresses. Hence, other things being equal, thin steel is less likely to be overstressed during stripping than heavier steel.

This invention provides constructions having keyways in slabs which are deep enough to satisfy slab requirements and yet at the same time make possible the construction of self-supporting casting forms.

Referring now to FIGURES 2 and 3, a practical form construction embodying the invention is illustrated. The casting surface or mold portion consists of a sheet of suitable metal or plastic which is thin enough to be bent to a relatively sharp corner. As an example, steel having a thickness of about $\frac{1}{8}$ inch may be used.

The casting surface includes bottom 30 having sides 31 and 32. Between bottom 30 and sides 31 and 32 fillets 33 and 34 are provided. These fillets in the example given may have a radius of about $\frac{3}{8}$ inch and the curvature may even be smaller. Sides 31 and 32 are shaped to provide key forming portions 35 and 36 and terminate in edges 37 and 38. The key forming portions of the sides are shaped in accordance with the requirements previously set forth in connection with FIGURE 1.

A casting form of this character may have a length of as much as 40 or 50 feet and would not be self-supporting, particularly laterally of the form, without additional metal. Accordingly, below bottom portion 30 of the sheet metal casting form there is disposed stress support-

ing plate 42. Plate 42 may have a thickness of $\frac{1}{4}$ inch and may be of a high strength steel. As an example, plate 42 may be of low carbon heat treated alloy steel available in the trade as type T1 manufactured by the United States Steel Corporation. This type T1 steel is more fully described in a booklet entitled "United States Steel Presents T1," printed by the United States Steel Corporation as USS publication No. ADVL-317-REV 55. As disclosed in this publication, the principal alloying constituents are manganese, silicon, nickel, chromium, molybdenum, vanadium and copper in small percentages. This steel has a modulus of elasticity in tension of 30,000,000 p.s.i. and is available in various grades of hardness. However, ordinary steel may also be used.

Plate 42 is welded to bottom part 30 of the casting form at a number of regions disposed along center line 30a. Plate 42 is not welded to part 30 at any regions away from the center line. Due to the fact that casting form bottom 30 is comparatively thin and is not rigidly joined to plate 42 in bimetal fashion, the stresses in bottom 30 are independent of stress plate 42. Hence design calculations for the thickness and yield point of plate 42 will disregard the presence of bottom 30. In other words, casting bottom 30 may be considered simply as a thin skin, the stresses in which are negligible during stripping but which could not function to sustain the casting form as a self-supporting member heavy enough by itself to withstand abuse.

It is necessary to reinforce the sides of the form and accordingly channels 44 and 45 are provided. Channel 44 has flanges 47 and 48, the latter lying over extension 49 of plate 42. Spacing rod or block 50 is provided between the side of the form and adjacent flange 47. Channel iron 45 is similarly disposed.

The channels are welded to parts 49 of the stress plate at various points along the length of the plate. Sides 31 and 32 of the form are also rigidly attached or welded to spacers 50 and 51 along various regions along the form length. It is important to have corners 33 and 34 of the casting form free of attachment to the channels or to stress plate 42. The latter is insured by restricting the zone of attachment between part 30 of the casting form and stress plate 42 substantially to the center line of the casting form. The former is obtained by leaving sides 31 and 32 free of the channels from corners 33 and 34 upwardly toward keyway forming parts 35 and 36. In practice regions 53 about $\frac{1}{8}$ or $\frac{1}{4}$ the way up to the free edges of the form represent the location of the lowest weld points between the casting form and channels. When the form is open, the form sides and corners 33 and 34 of bottom 30 can pull away slightly from channels 44 and 45, and move slightly relative to stress plate 42, as illustrated in FIGURE 3A of the drawing.

The separation of parts illustrated in FIGURE 3A is exaggerated. Some relative movement must be allowed; otherwise the stress plate and liner will act as a unit and would have to be considered together for stress purposes. The actual movement is slight.

Instead of restricting the junction between stress plate 42 and bottom 30 of the casting form to extend along the center line as illustrated, it is also possible to combine stress plate 42 and bottom 30 to form what in effect would be a bi-metallic or two-layer structure. Thus the welds between the two could be located at random regions laterally of the center line almost up to corners 33 and 34. In such case, the form sides would not have to be free of the channel members above corners 33 and 34, as illustrated in FIGURE 3A, since there would be no relative movement of the channel and casting liner. Since the stress plate and form bottom act as a unit in regard to stress incident to arching, it must now be necessary to consider the thickness of the stress plate and form bottom together in calculating the stresses. This can be most easily accomplished by applying the stress analysis,

particularly as set forth in equation 3 given later wherein t equals the total thickness of both plates. In this formula and for the bimetallic construction, f would have to be less than the lower yield point value for the stress plate steel or casting form bottom steel. The form bottom and stress plates may be of different thicknesses and may have different steel specifications.

In the figures discussed (FIGURES 2 and 3), the stress plate is shown as extending below the bottom flanges of channels 44 and 45 to the free ends of these flanges. It is possible to have portions 49 of the stress plate stop short of these free ends of the flanges. It is also possible to have the free edge of stress plate 42 meet the web of channels 44 and 45 so that the lower flange of a channel is located below the level of the stress plate. This is suggested in FIGURES 4 and 5 to some extent.

Various means for bending bottom stress supporting plate 42 and bottom part 30 of the casting form may be provided. A simple means utilizes contour plate 55 which is adapted to be operated on by means of one or more inflatable bags 56. Suitable anchoring means such as pivoted hooks may be applied to bottom flange 48 to force the plate and form bottom to curve.

Various other means for bending the form bottom may be employed.

It is of course understood that whether plate 42 and bottom 30 is normally straight or normally curved, is unimportant. Whatever the normal condition, the plate must assume an abnormal condition which will not exceed the elastic limits of the steel. Thus, if plate 42 and form bottom 30 are normally curved to the shape shown for example in dotted lines for contour plate 55, then it will be necessary to force the form sides and channels together to straighten the form and plate and maintain the same in that position while casting is being accomplished.

The bending characteristics of the form bottom 30 are controlled by stress supporting plate 42. Form bottom 30 follows the curvature of stress plate 42. Plate 42 is selected for its strength and bending qualities both in type of material and thickness while bottom 30 is selected for easy bending or forming qualities and smooth surface by using another type of material and of a lesser thickness. Having a lesser thickness the form bottom 30 has lower flexing stresses than the thicker plate 42. The type of steel and properties thereof used for plate 42 will depend upon the amount of curvature necessary to obtain the release of a casting and is related to the depth of the key joint. Since stress plate 42 does not have any sharp bends, it becomes possible to use steel having the desired thickness and required yield point. As will be shown, the abnormal bending of the steel plate makes severe requirements on the stress characteristics. Thus, special alloy steels may be used in the new construction to withstand these requirements. The uniqueness of this invention is the composite combination of the ease in construction and smooth surface finish of the form bottom and sides with the strength and bending qualities of the stress supporting plate.

In the design of a casting form embodying the present invention certain design considerations will have to be observed if the elastic limit of the steel for plate 42 is not to be exceeded. By observing the design considerations, a closer control over the thickness and quality of steel used is possible. If R is the radius of curvature for the form bottom when it is releasing a casting, then a preliminary value for R can be obtained by using the following formula:

$$(1) \quad R = \frac{.95LV}{H+C}$$

where L is one-half the form width, V is the height of the point being examined for critical clearance while stripping, in this instance the point is the peak, from the stress supporting plate, C is the stripping clearance be-

tween a form key peak and the widest part of the casting and H is the distance inwardly of the key peak from the slab side. A more precise value of R can be obtained by the following formula:

$$(2) \quad R = \frac{L+C}{\sin\left(\frac{L}{R}\right)} + H \cot\left(\frac{L}{R}\right) - V$$

The solution to Equation 2 is accomplished by setting arbitrary values for R until both sides are equal to at least four significant figures. The angle L/R is in radians. Curves for various values of R can be drawn, where the X-axis shows the width of the form and the Y-axis shows the full height or depth of the form from the free edges of the sides to the form bottom. A family of such curves may be used for ready reference to obtain R corresponding to a given form width and depth. The above formulas apply to bottom stress supporting plate 42.

After the value of R has been obtained, it can be used to calculate the steel characteristics,

$$f = \frac{nEt}{KR}$$

where f is bending stress of the plate, t is the thickness of steel, K is approximately 1.82, E is the modulus of elasticity, R is the radius of curvature and n is a safety factor. In practice, a safety factor of about 1.2 can be assumed. In the above formulas, the linear dimensions are in inches and E is given in pounds per square inch. Factor n can be about 1.2. The value of f should in all cases be less than the yield point of the steel used.

By taking f as the yield strength of any special steel, a minimum value for R can be found from Equation 3. Then when R is found, the curves for Equation 2 can show the form dimensions for that value of R .

In the above equation, f should be considered for the stress plate alone if the stress plate and casting form are joined together only along the center line. If the two are joined in other regions, as illustrated in dotted regions in FIGURES 2 and 3, so that essentially a bimetallic structure is provided, then f must be determined for the combined plate thickness.

The above formulas apply particularly to a contour plate type of stripping where the contour plate is arcuate. Other stripping methods will alter the mathematical analysis to some extent.

It is understood of course that the key profile must in every instance conform to the requirements previously set forth. Where a slab has cored out passages—the area of the void being between about 40% and about 50% of the total slab section—the peak of the key should be well up toward the top surface of the slab. Insofar as the slab height and width are concerned, these will be determined by general engineering requirements in connection with the design of a slab. As hereinbefore pointed out, slabs may have quite a range of thicknesses or heights and quite a range of widths. Whether the cored out passages are circular in cross-section or non-circular will depend on the ratio of slab height to slab width. A slab which is quite wide in comparison to its height or depth can conveniently have non-circular passages to provide the desired void area in a slab section.

To prevent the wall thickness of the concrete from going to an undesirably low value, the peak of the key should be located in the upper corner of the slab where there is considerable concrete to work upon. That part of the grout key above the peak will be determined by engineering considerations relating to the use of the slab after casting. The part of the grout key below the peak will be determined by stripping considerations.

As previously pointed out, the analysis of the stress in a casting form depends upon the intended mode of stripping. Referring now to FIGURE 4, a diagrammatic sketch relating to the previously described contour block

stripping is shown. In part A of this figure, a simple illustration of a casting form disposed on a contour block is provided. In this figure, the bottom of the casting form is tangent to the contour plate. Assuming that force is applied to pull the sides of the casting form about the contour plate, then a moment diagram A_1 can be drawn. With the center of the casting form as the origin, a point marked C.R. is located at $\frac{1}{3} L$ distance from the center toward the side where L is one-half the form width. C.R. is the center of rotation. During the bending of the bottom of the form, the bottom of the form acts as a cantilever beam with reference to the midpoint of the bottom of the form.

As the stress supporting plate and form bottom begin to bend and at which time there is only point contact between the stress supporting plate and the contour plate, the stress plate acts as a cantilever and introduces phase 1 of motion of points on the side wall and the resulting bending moment A_1 . All points on the side of the form move about the center of rotation which is located at

$$\frac{L}{3}$$

During this phase, the radius of the curvature of the center of the form decreases from infinity to the radius of the contour plate. The stress supporting plate along with the form bottom now being to bend around the contour plate and introduces phase 2 of motion of points on the side wall of the form. For all deflection beyond this condition, one part of the form is restrained to the curvature of the contour plate while the remainder continues to bend in cantilever fashion. This motion progresses until the entire stress supporting plate of the form makes full contact with the contour plate. The resulting bending moment diagram is shown in sketch A_2 and the center of rotation is located at

$$\frac{L}{2}$$

In FIGURE 5, there is illustrated stripping of a casting form by the use of an inflated tube. The flanges of the channels will be held down, as indicated by arrows. The bag, as fluid pressure therein rises, arches the form bottom.

Referring now to FIGURE 6, if a concentrated force is applied to the center of the bottom of the form, and the ends are forced downwardly as illustrated, then the entire bending motion and moment diagram is substantially the same as A and A_1 of FIGURE 4.

In FIGURE 7, one side of the casting form is assumed as stationary and all of the bending force is applied to the other side. The bending moment diagram for this is illustrated in A_1 .

In FIGURE 8, a still different stripping method is suggested. In this method, the top edges of the form sides are spread outwardly. The form sides are supposed to be rigid so that all of the stress of the arching is taken up by the form bottom. The moment diagram for this type of stripping is illustrated in A_1 .

In FIGURE 9, there is illustrated a casting form wherein a so-called tongue and groove type of grout key is provided. As will be evident from this figure, the tongue part extends outwardly rather than inwardly. The basic analysis previously given in connection with assuming a center and drawing arcs applies equally well to the tongue part at the right-hand side of this figure.

For convenience in simplifying the language of the claims, only the keyway hereinbefore described will be identified as having the general outline of a bottle with a wide bottom and a narrow bottleneck when two such keyways are disposed opposite each other as would be the case when the slabs containing such keyways are laid side by side.

This is a continuation-in-part of my abandoned application Serial No. 844,013, filed October 2, 1959.

What is claimed is:

1. A straight steel casting form for casting concrete slabs, said form having a length which is of a higher order of magnitude than the transverse dimensions of the form, said casting form having one part providing a casting surface extending straight along the length of the form and in transverse section being channel shaped with the bottom of the part as the web of the channel being substantially flat during casting and the part sides, corresponding to the flanges of the channel, extending upwardly substantially at right angles to the bottom during casting, said sides terminating in free edges lengthwise of the form, said one part sides and bottom meeting to provide two corners, said one part sides having portions along the form length shaped to provide slab locking keyways, there being a keyway for each slab side, a finished casting in said casting form being locked by said keyways to the form sides against lateral removal from said one part, said one part being in one integral piece providing the total bottom, side and corner casting surfaces, said one part consisting of material which is at least as easy to shape as, and is no stronger than, about $\frac{1}{8}$ " steel, said one part by itself being too weak to provide a casting form which will be self-supporting and will maintain its transverse shape during normal use in the absence of external supports, a steel stress plate covering the entire outer surface of the bottom of the one part, said stress plate extending transversely at least to the corners of said one part, steel reinforcements at the outer faces of the sides of said one part extending the full length of the casting form and extending from the stress plate toward the free edges of said one part sides, means for rigidly attaching said side reinforcements to the stress plate so that said side reinforcements maintain a fixed angular relationship to said stress plate at the regions of the corners, and means for joining said one part to said stress plate and to said side reinforcements at least along sides of said one part, said one part being free at and adjacent the corners, said stress plate during stripping being bent transversely of the casting form to arch it and force said one part bottom inwardly of the casting region, said side reinforcements remaining rigid and diverging the sides of said one part away from each other during the arching of said stress plate sufficiently for stripping, the keyways being deep enough laterally of the form sides so that a casting form must be sprung substantially enough to create large stresses in steel heavy enough to be self supporting, said stress plate having bending stresses during stripping which are substantially no greater for the same arching than would be present in the bottom of said one part were it made of steel having a thickness of about $\frac{1}{4}$ ", whereby the form has a stress plate thin enough to withstand repeated stripping stresses while the form retains easy fabrication characteristics for said one part having the casting surface, said casting form as a whole being heavy enough to withstand abuse of every day handling incident to use.
2. The casting form according to claim 1 wherein said stress plate extends beyond the corners of said one part and wherein said side reinforcements include angle shaped portions extending the full length of the form, the angle shaped portion being disposed along each side of said one part and rigidly secured to the portions of the stress plate extending laterally beyond the corners of said one part.
3. The casting form according to claim 1 wherein said one part has the bottom portion thereof secured to the stress plate substantially along a longitudinal center portion thereof, the remainder of the bottom of said one part laterally of said center portion up to and including the corners being free of said stress plate, said stress plate being about $\frac{1}{4}$ " thick.
4. The casting form according to claim 1 wherein said stress plate extends laterally beyond the corners of said one part and wherein said side reinforcements comprise

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channels disposed so that the web of a channel is against said one part side with the flanges extending away from said one part side, the bottom flange of each channel being rigidly attached to the extension of the stress plate beyond the corner.

5. The construction according to claim 1 wherein said one part is secured to said stress plate only along the longitudinal center line of the bottom of said one part and is otherwise free of said stress plate, said stress plate being about $\frac{1}{4}$ " thick and extends laterally beyond the corners of said one part and wherein said side reinforce-

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ments comprise channels disposed so that the web of a channel is against said one part side with the flanges extending away from said one part side, the bottom flange of each channel being rigidly attached to the extension of the stress plate beyond the corner.

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