Jan. 13, 1953 L. D. LONG 2,624,928

PRESS FOR MOLDING CONCRETE BUILDING ELEMENTS

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Fig. 1

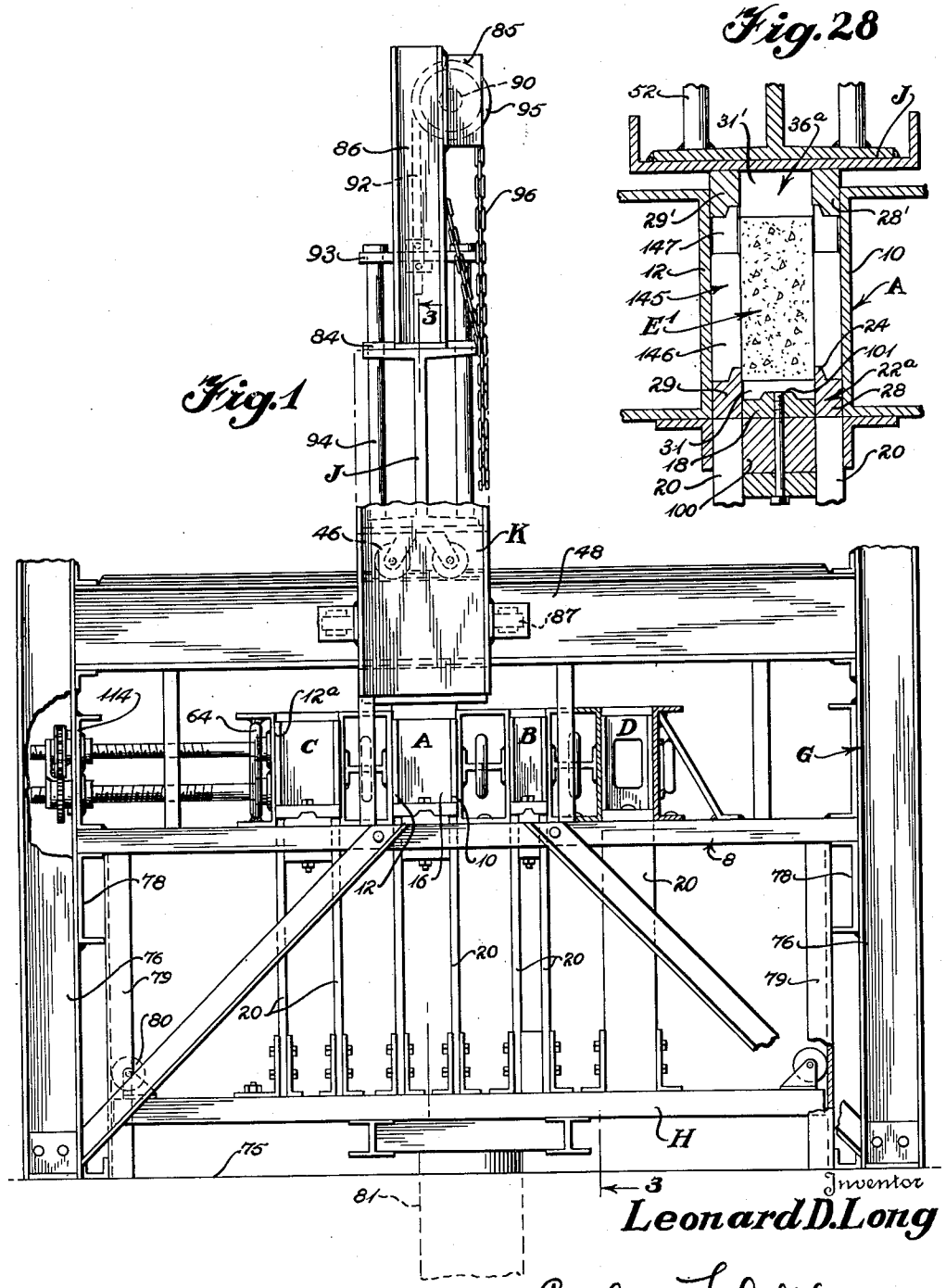


Fig. 28

Inventor
Leonard D. Long

By Cushman, Darby & Cushman

Attorneys

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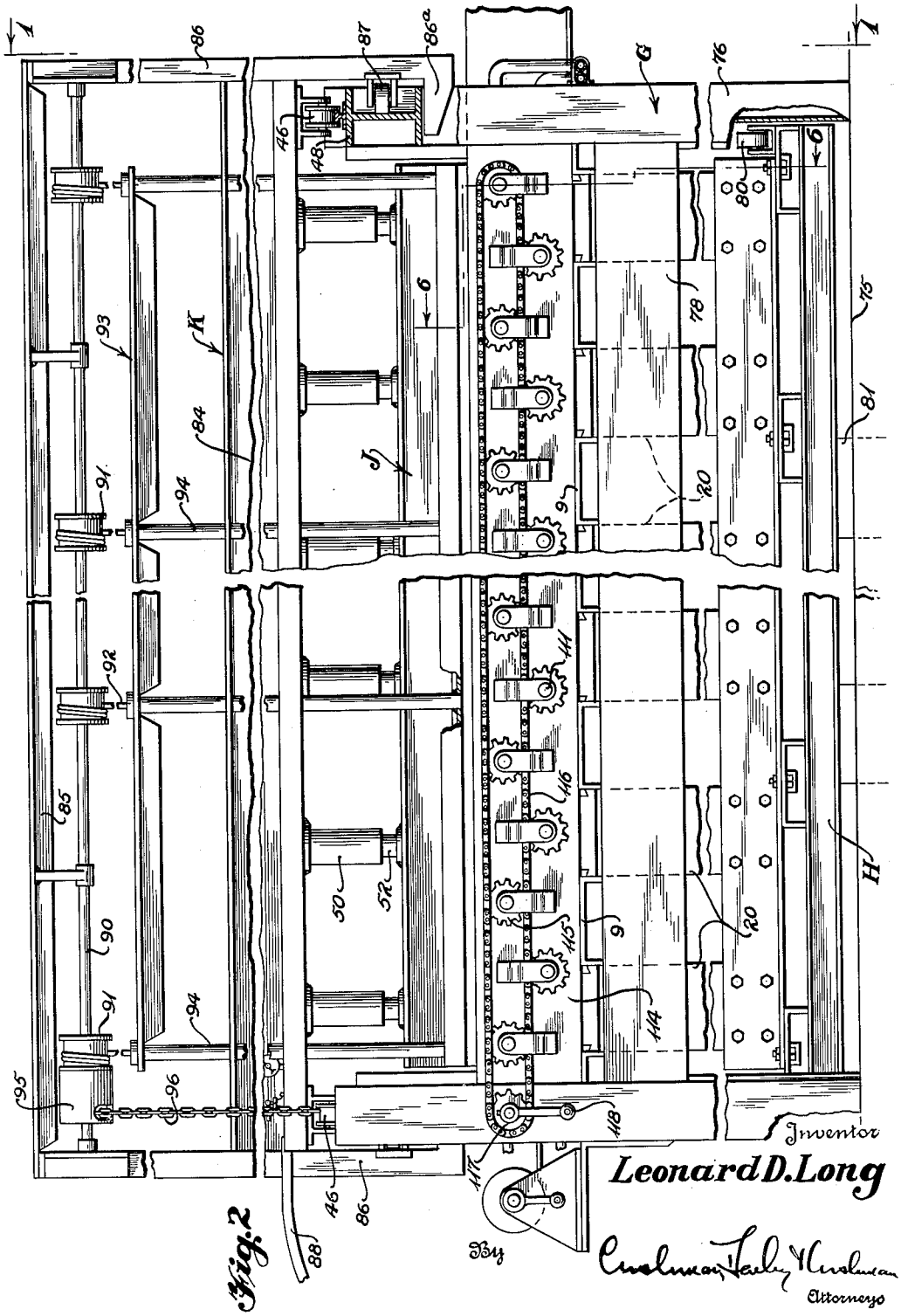


Fig. 2

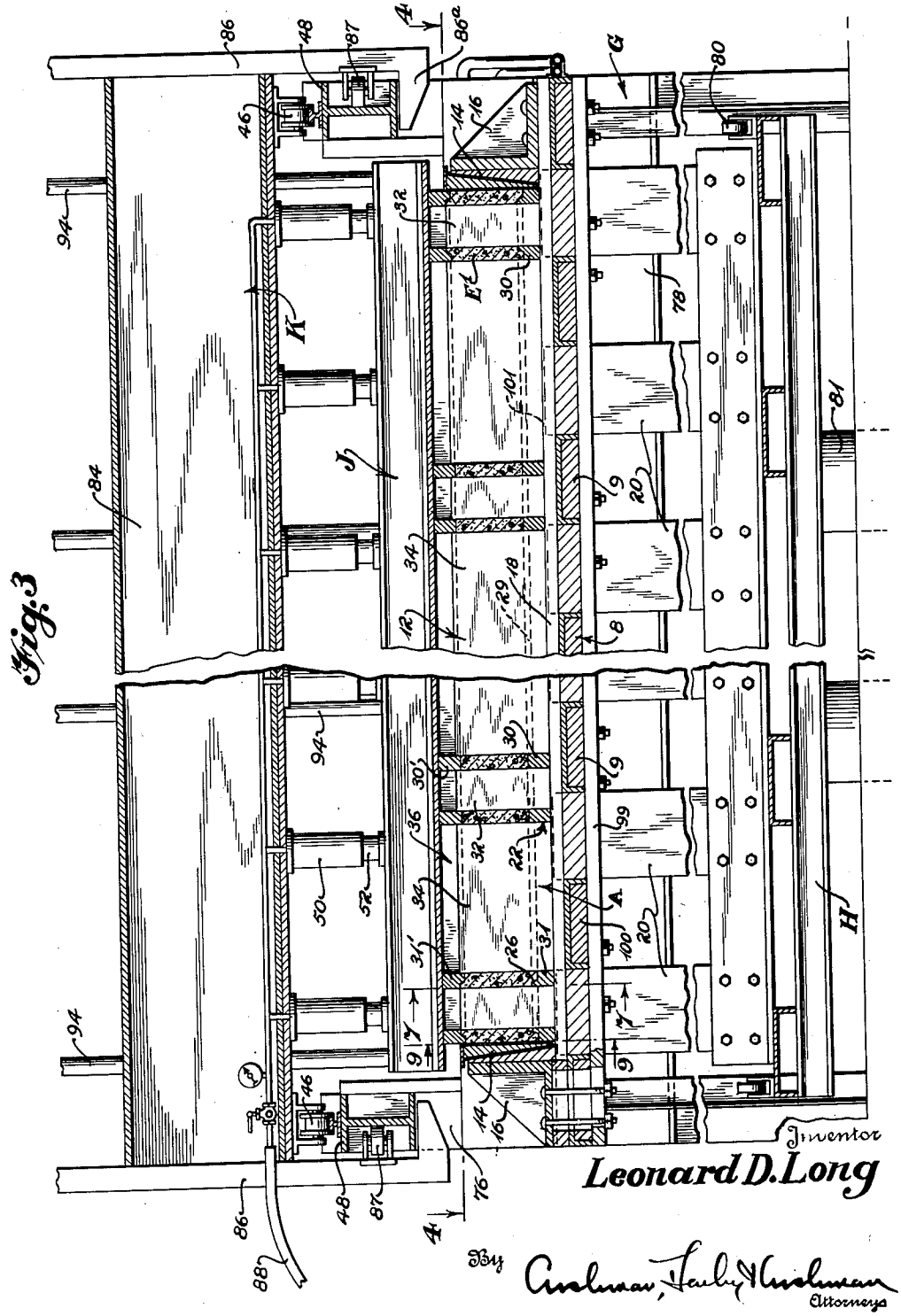
Inventor
Leonard D. Long

By Cushman, Darby & Cushman
Attorneys

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Fig. 4

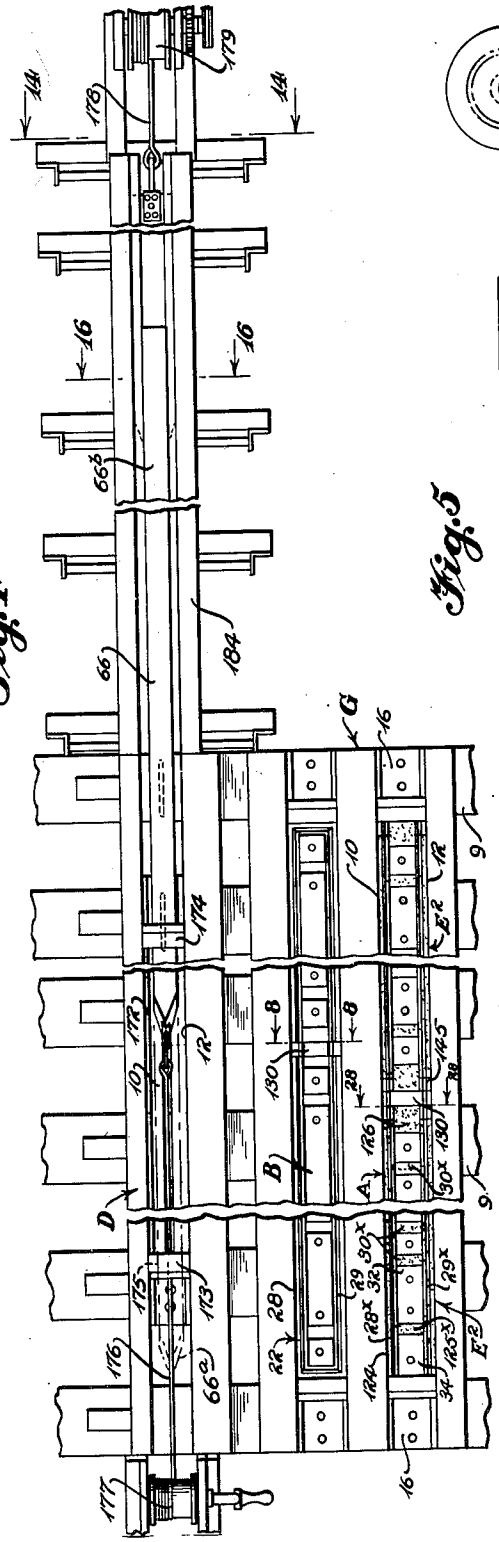
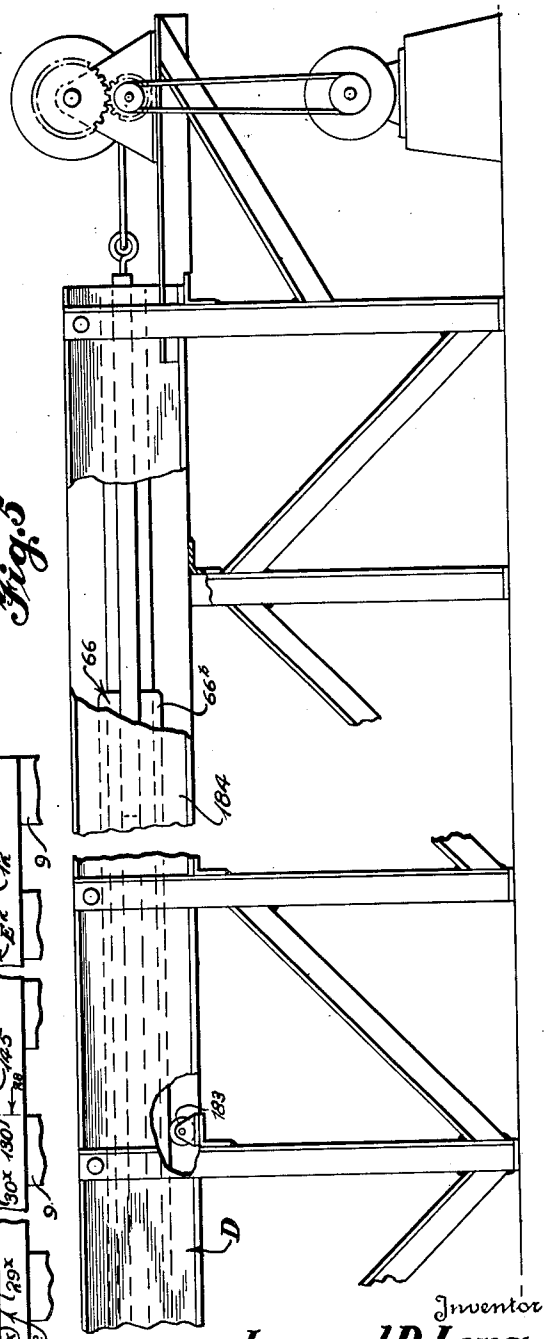


Fig. 5



Inventor
Leonard D. Long

By Cushman, Darby & Cushman
Attorneys

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Fig. 6

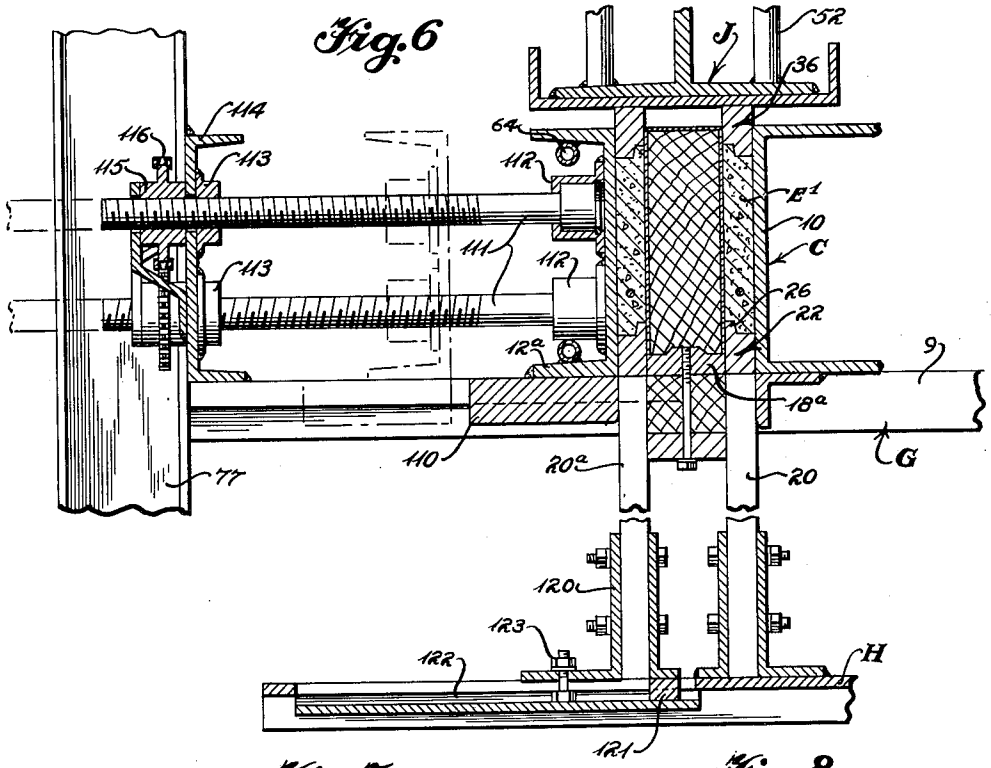


Fig. 7

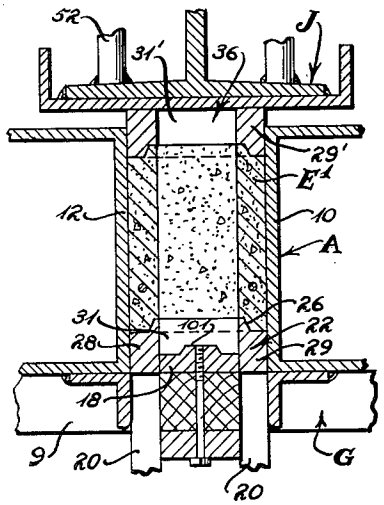
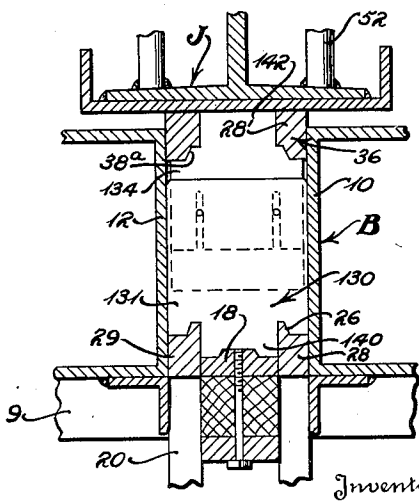


Fig. 8



Inventor

Leonard D. Long

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Attorneys

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Fig. 11

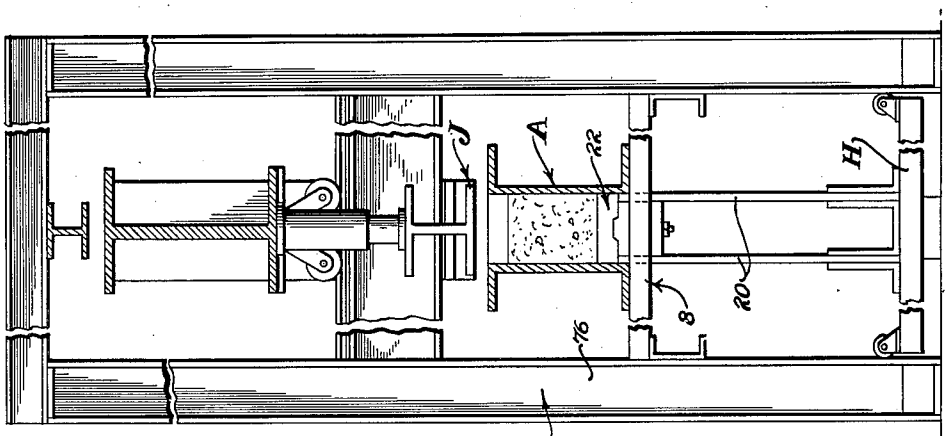


Fig. 10

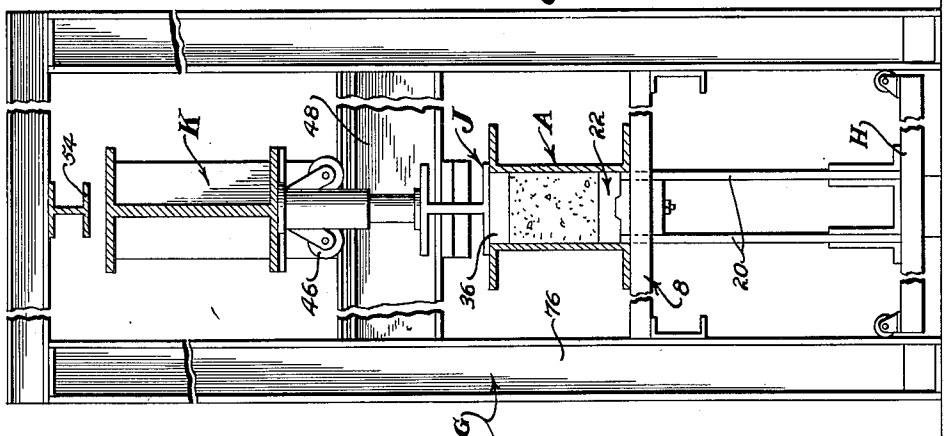
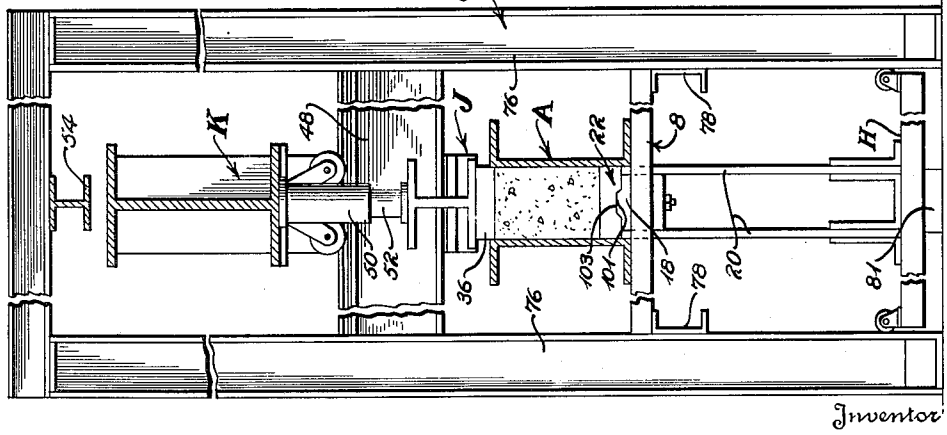


Fig. 9



Inventor

Leonard D. Long

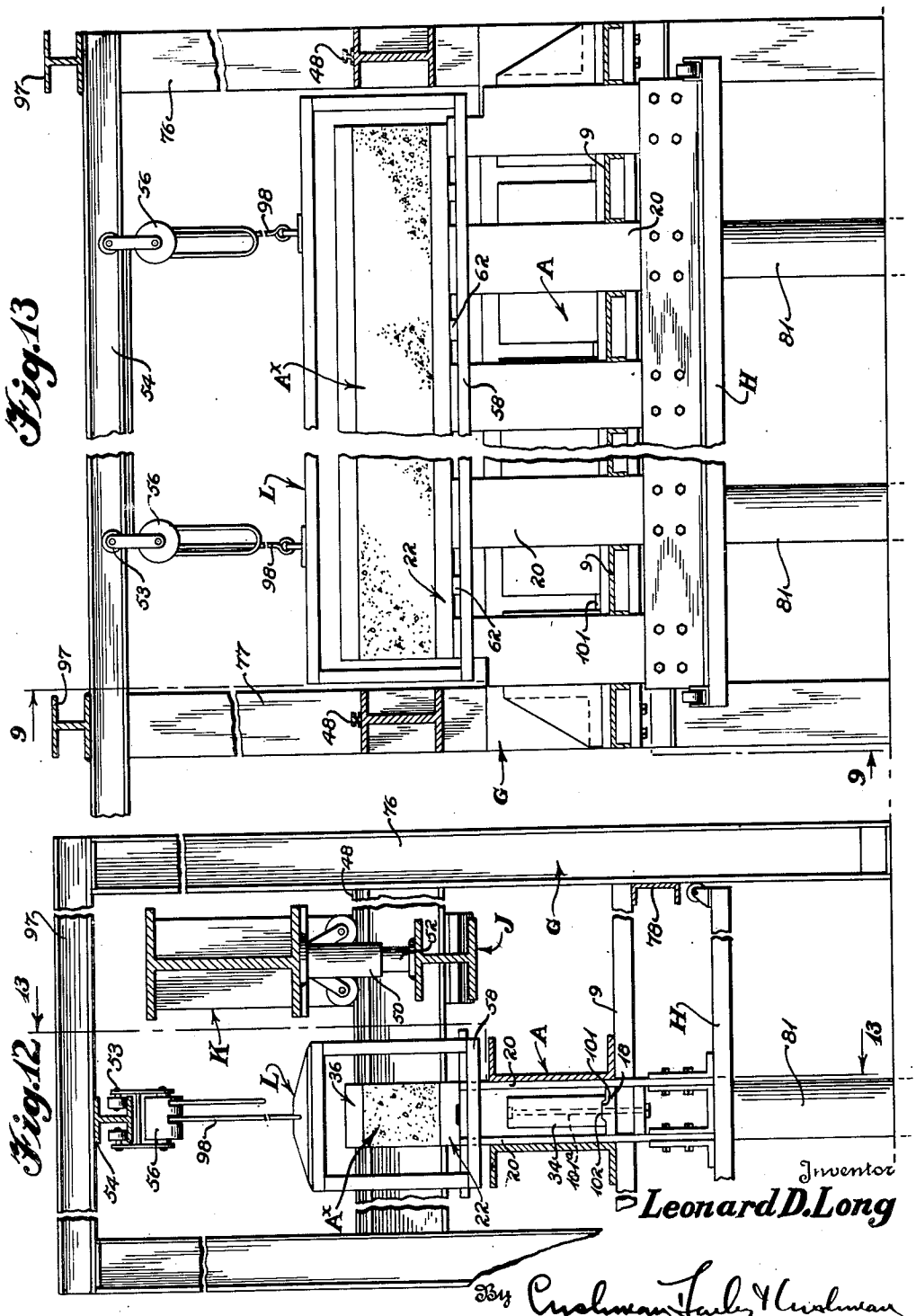
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Fig. 14

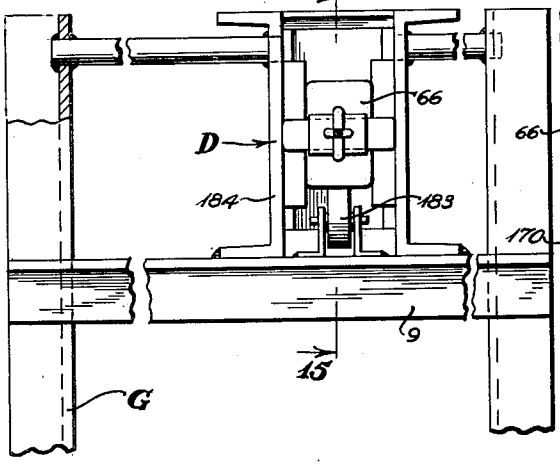


Fig. 15

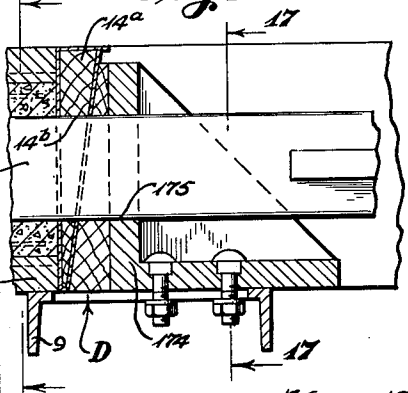


Fig. 16

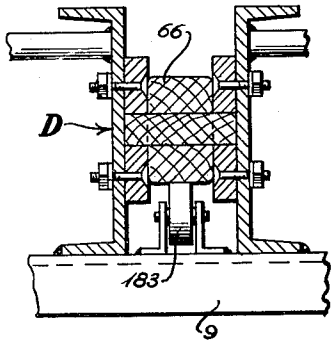


Fig. 17

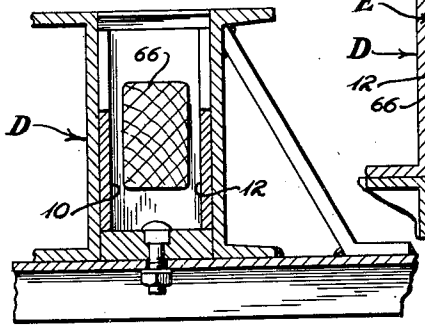


Fig. 18

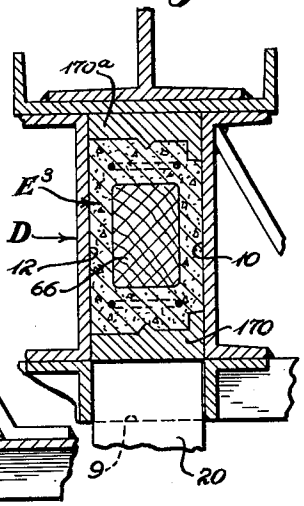
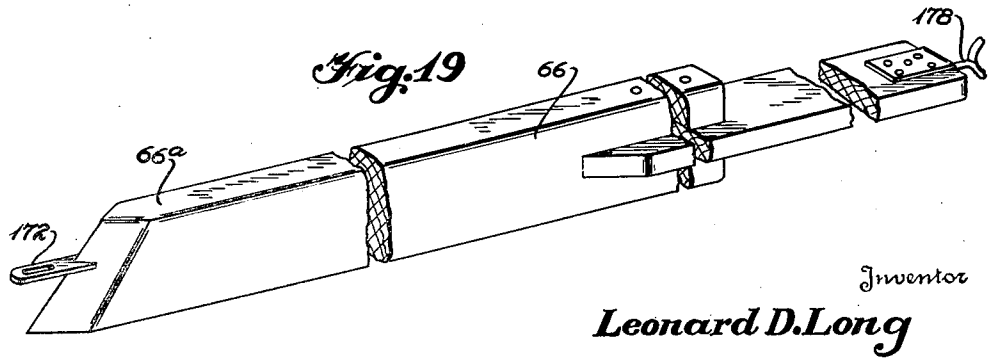


Fig. 19



Inventor

Leonard D. Long

By Cushman, Darby & Cushman

Attorneys

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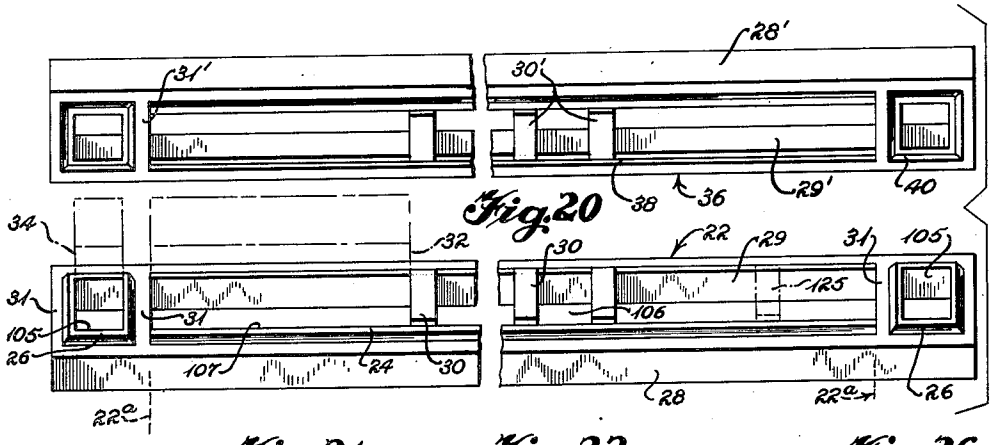


Fig. 20

Fig. 21

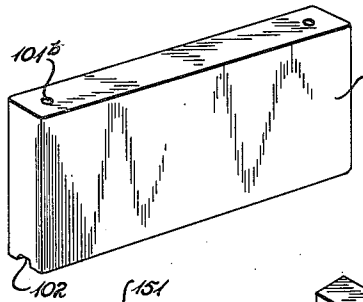


Fig. 22

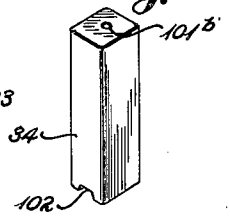


Fig. 26

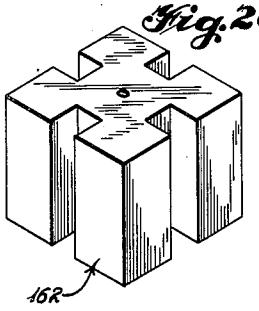


Fig. 23

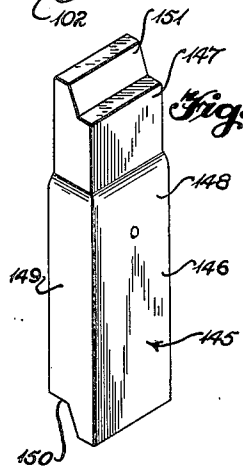


Fig. 24

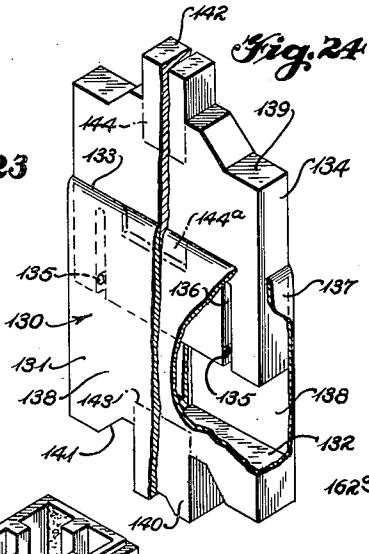


Fig. 27

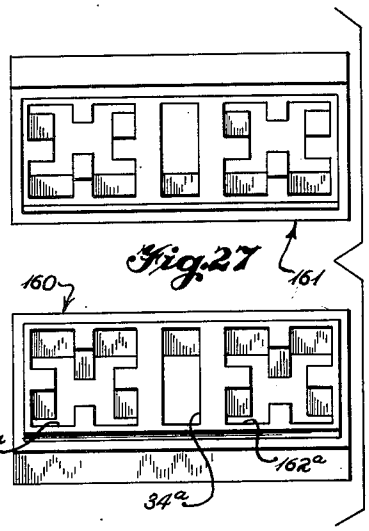
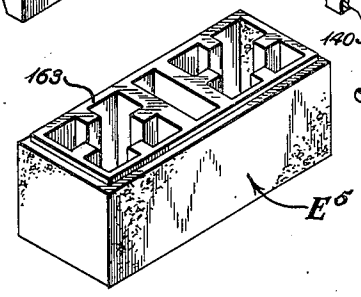


Fig. 25



Inventor

Leonard D. Long

By Cushman, Darby & Cushman

Attorneys

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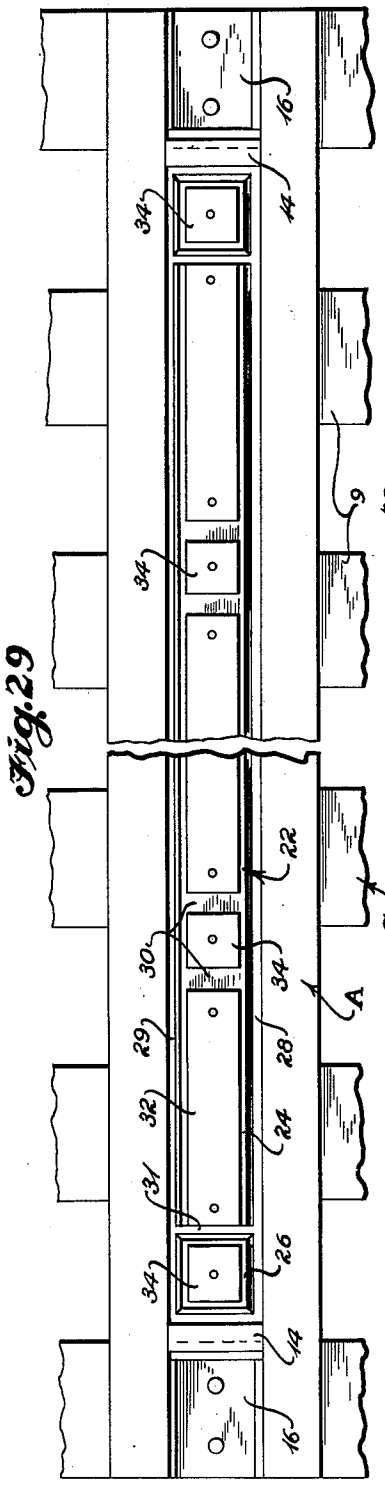


Fig. 29

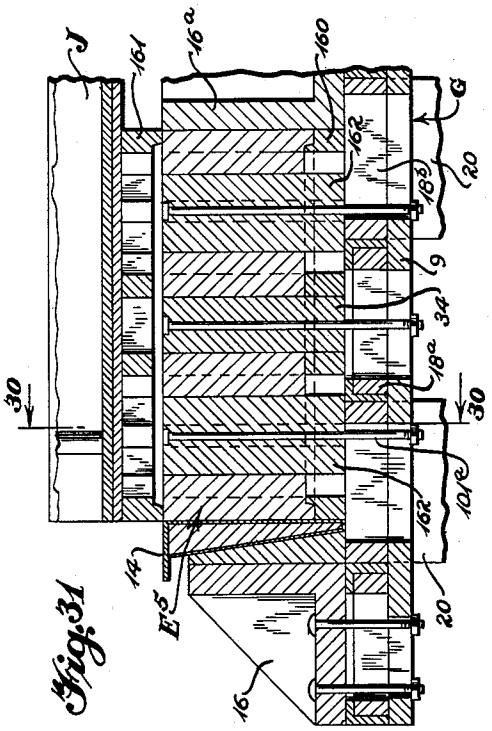


Fig. 31

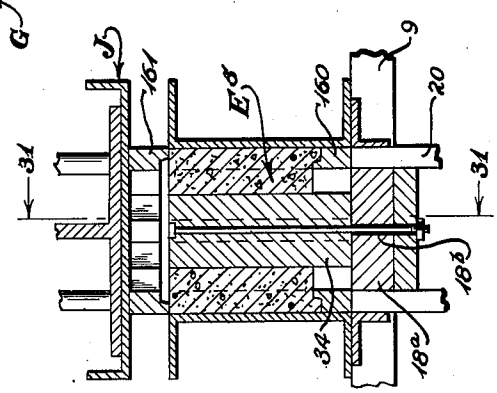


Fig. 30

Inventor
Leonard D. Long

By Cushman, Darby & Cushman
Attorneys

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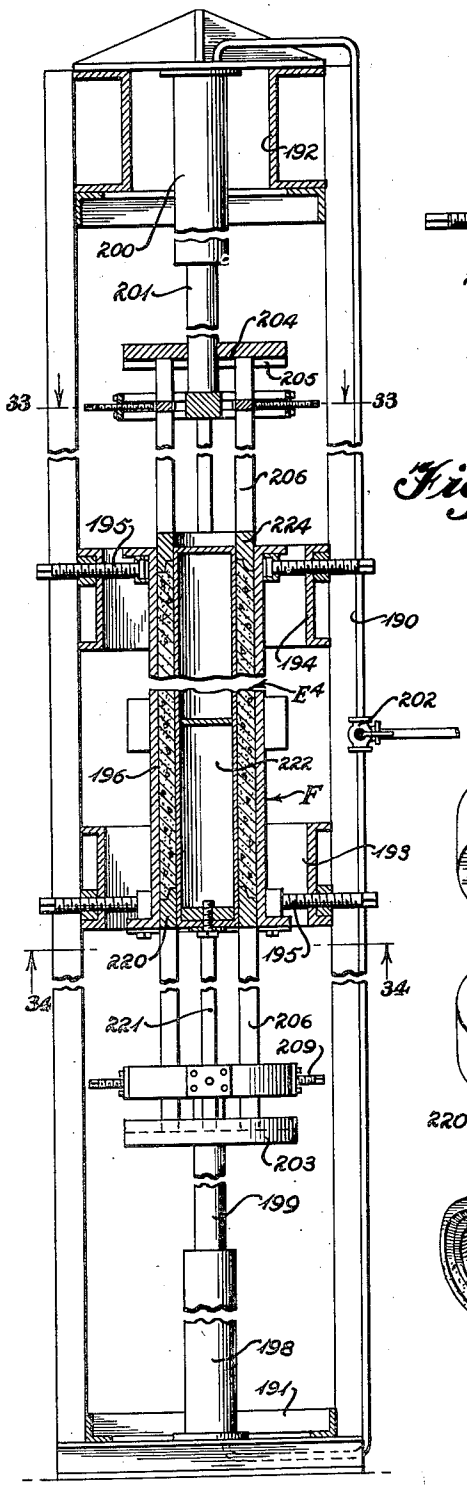


Fig.32

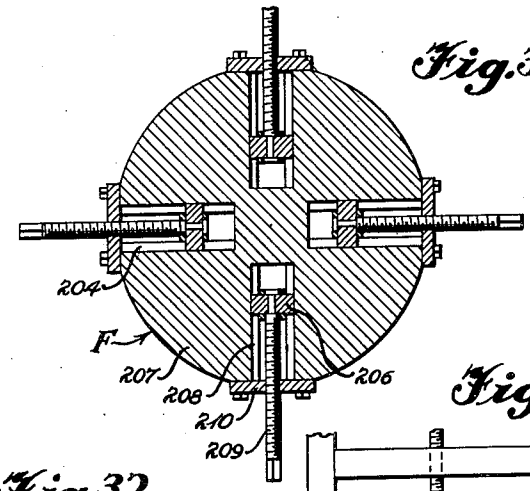


Fig.33

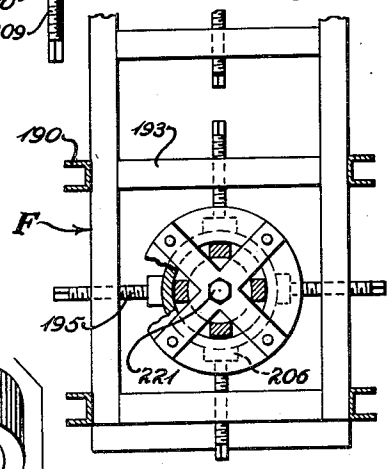


Fig.34

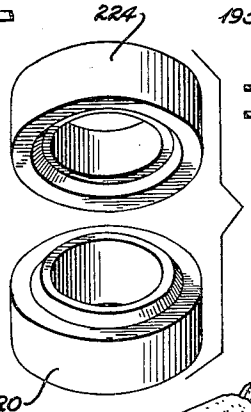


Fig.35

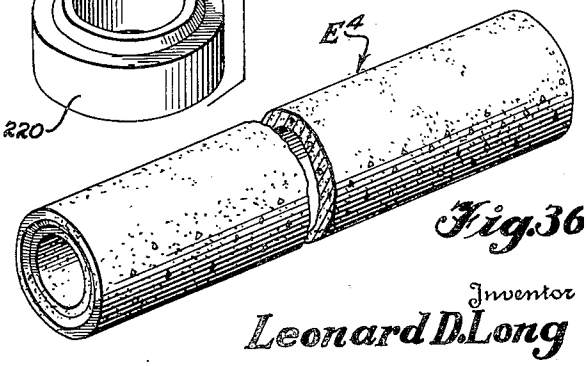


Fig.36

Inventor
Leonard D. Long

By Cushman, Darby & Cushman
Attorneys

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Fig. 37

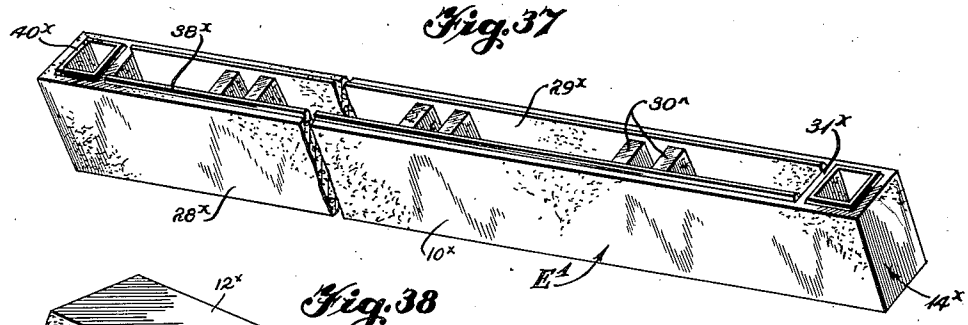


Fig. 38

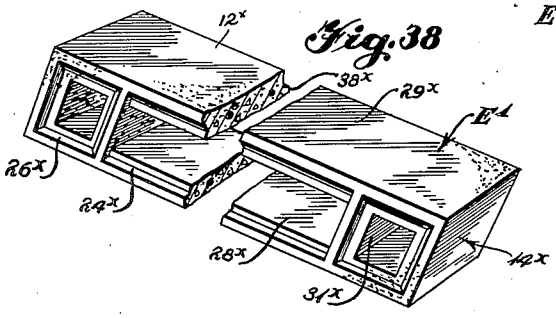


Fig. 39

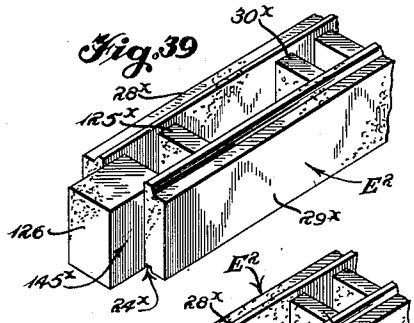


Fig. 41

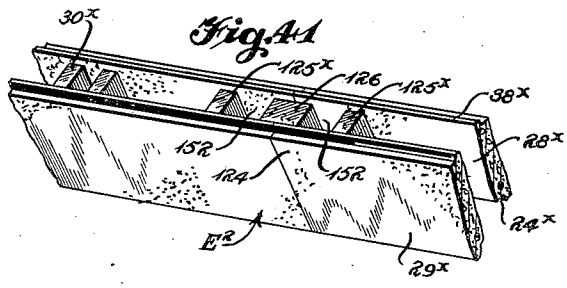


Fig. 40

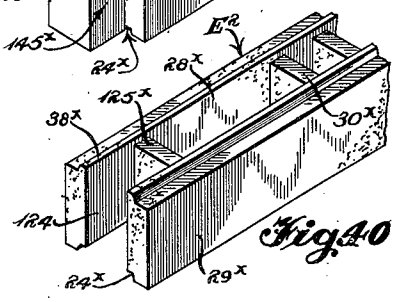
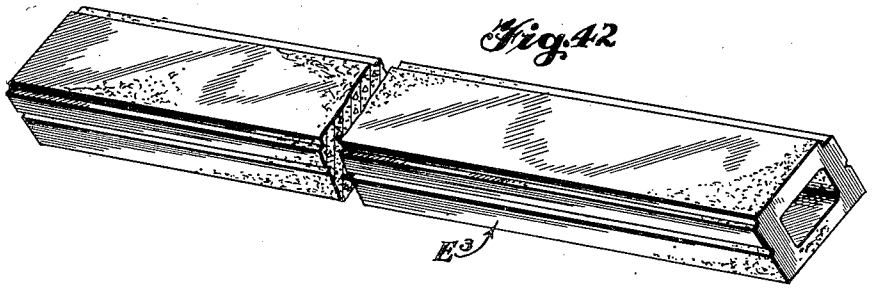


Fig. 42



Inventor

Leonard D. Long

By Cushman, Darby & Cushman

Attorneys

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Fig. 43

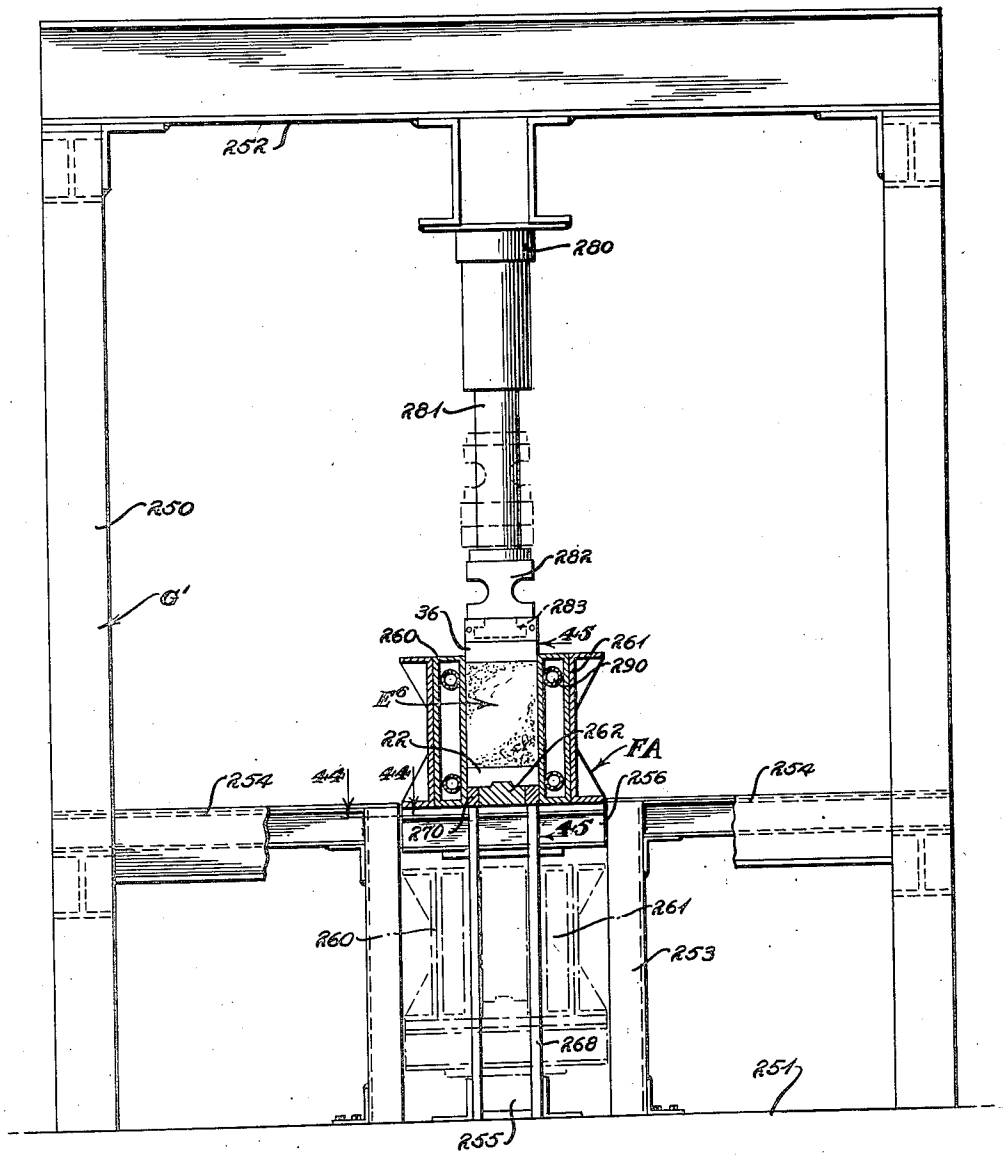
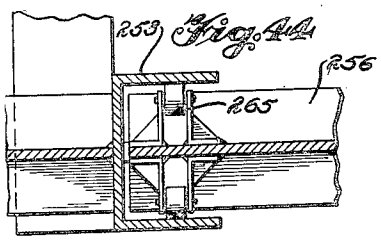


Fig. 44a



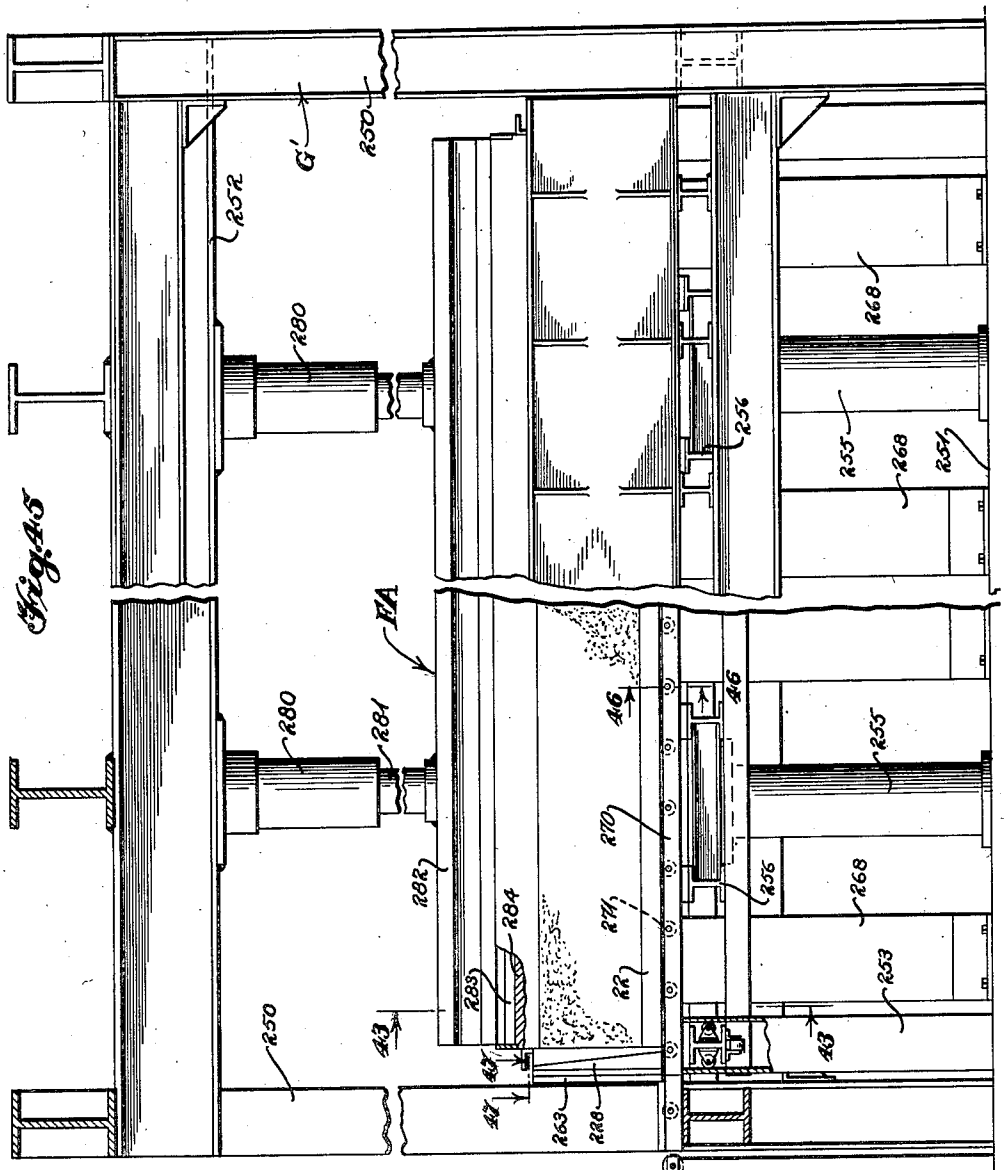
Inventor
Leonard D. Long

By Cushman, Darby & Cushman
Attorneys

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Inventor
Leonard D. Long
By Cushman, Darby & Cushman
attorneys

Patented Jan. 13, 1953 2,624,928

UNITED STATES PATENT OFFICE

2,624,928

PRESS FOR MOLDING CONCRETE BUILDING ELEMENTS

Leonard D. Long, Charleston, S. C.

Application June 21, 1948, Serial No. 34,166

5 Claims. (Cl. 25—83)

1

The present invention relates to apparatus for producing pre-cast building elements.

Apparatus now in use for producing pre-cast building elements are ordinarily only adapted for the manufacture of very small elements, for example, concrete or cinder blocks of very small dimensions. Furthermore, the blocks thus produced are almost invariably of the same design or shape.

An object of the present invention is to provide apparatus for making prefabricated building elements and which apparatus is readily capable of producing elements having a size range varying from the order of one foot up to at least twenty feet in length and which elements may be widely varied as to shape or design.

Another object of the invention is to provide an apparatus for producing pre-cast building elements in quantities and wherein the molding procedure will require a minimum of time and mechanical operations.

The apparatus of the present invention are such that elements of different sizes and shapes can be produced by use of matrices, core elements, spacers, and dividers provided by the invention. These various forming elements provided by the invention are so designed that they can be changed and shifted by unskilled labor. Because the filling of the forms and most of the other steps involved in the operation of the apparatus and the carrying out of the method do not require skilled labor, the cost of operating the apparatus is extremely low.

Another object of the invention is to provide an apparatus whereby the elements can be formed within an extremely short space of time, usually a matter of minutes, so that only a small number of mold units need be provided in a single plant.

Other objects and advantages of the invention will be apparent from the following specification and accompanying drawings.

Figure 1 is an end view of the apparatus, with the extreme upper portion being omitted, and one mold unit being shown in vertical section on the line 1—1 of Figure 4.

Figure 2 is a side view of the Figure 1 structure, the view looking toward Figure 1 from the left. Portions of vertically extending members of the apparatus are broken out in Figure 2 and the central portion of the apparatus is also broken away.

Figure 3 is a vertical longitudinal section on the line 3—3 of Figure 1, with portions broken away as in Figure 2.

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Figure 4 is a top plan view of some of the mold units illustrated in Figure 1, with portions broken away as in Figure 2.

Figure 5 is a fragmentary side elevation looking toward the righthand portion of the mold unit of Figure 4 from the bottom of Figure 4.

Figure 6 is a fragmentary transverse vertical section on the angled line 6—6 of Figure 2 and showing an adjustable width mold unit.

Figure 7 is a transverse vertical section through a mold unit on the line 7—7 of Figure 3.

Figure 8 is a transverse vertical section through a mold unit on the line 8—8 of Figure 4.

Figures 9, 10 and 11 are transverse vertical sections taken on the line 9—9 of Figure 3 and illustrate successive steps in the operation of a mold unit.

Figure 12 is a view similar to Figures 9 to 11 and shows a later step in the operation.

Figure 13 is taken on the line 13—13 of Figure 12 and shows the mold unit of Figures 9 to 12 in side elevation.

Figure 14 is a transverse vertical section on the line 14—14 of Figure 4.

Figure 15 is a fragmentary longitudinal vertical section on the line 15—15 of Figure 14.

Figure 16 is a transverse vertical section on the line 16—16 of Figure 4.

Figure 17 is a transverse vertical section on the line 17—17 of Figure 15.

Figure 18 is a transverse vertical section on the line 18—18 of Figure 15.

Figure 19 is a view of a core element used in the mold unit of Figures 14 to 18.

Figure 20 is an exploded view showing matrices used in a mold unit, the matrices being shown in bottom and top view, respectively, and including a dotted line showing of cores assembled with the lower matrix.

Figures 21 and 22 are side view of cores.

Figure 23 is a side view of a spacer.

Figure 24 is a side view of a second form of spacer, with portions broken away.

Figure 25 is a view of a chimney flue supporting element which may be formed by the apparatus.

Figure 26 is a view of a core used in forming the element of Figure 25.

Figure 27 is a view of upper and lower matrices used to form the element of Figure 25.

Figure 28 is a transverse section on the line 28—28 of Figure 4.

Figure 29 is a top view of a mold unit fitted with a matrix and cores in readiness for pouring.

Figure 30 is a transverse vertical section of a

mold unit equipped for casting the flue supporting element of Figure 25, the section being taken on the line **30—30** of Figure 31.

Figure 31 is a longitudinal vertical section on the line **31—31** of Figure 30.

Figure 32 is a central vertical section of a mold unit for casting cylindrical elements.

Figure 33 is a transverse horizontal section on the line **33—33** of Figure 32.

Figure 34 is a transverse section on the line **34—34** of Figure 32.

Figure 35 is an exploded view showing the two matrices used in the Figure 32 unit.

Figure 36 is a view of a cylindrical tubular element formed with the unit of Figures 32 to 34.

Figures 37 to 42 are views of structural elements which may be formed by the apparatus of the invention.

Figure 43 is a vertical transverse section on the line **43—43** of Figure 45 of a modified form of mold unit.

Figure 44 is a detail horizontal section on the line **44—44** of Figure 43.

Figure 45 is a view partly in vertical longitudinal section on the line **45—45** of Figure 43, and partly in side elevation (looking toward Figure 43 from the right).

Figure 46 is a transverse vertical detail section on the line **46—46** of Figure 45, and

Figure 47 is a horizontal detail section on the line **47—47** of Figure 45.

General description of apparatus and operation

The illustrative embodiment of the invention disclosed herein may be generally described as including mold units such as are respectively designated by the letters A, B, C and D in Figures 1 and 4, that designated F in Figure 32 and the unit indicated as FA in Figures 43 to 47. Each of the six units is adapted for molding or shaping various types and sizes of structural elements. Figures 1 and 4 show the four mold units A to D mounted in the same supporting frame G. However, it frequently will be more convenient to mount each unit in a single frame such as G or to mount a number of units of a single type in the same frame. As shown in Figure 1, the mold units of that figure are positioned on a platform **8** fixed substantially intermediate the height of frame G, the platform being formed by cross-pieces **9** (Figure 3).

The mold units A and B are of different widths and are particularly adapted for formation of structural elements E1 and E2 such as illustrated in Figures 37 to 41 which are provided with spaced cavities or recesses therein. The unit C is generally similar to the units A and B but is so constructed as to be adjustable for forming structural elements of various widths.

The mold unit D is particularly intended for production of hollow slabs, columns or building course elements E3 of rectangular section such as illustrated in Figure 42.

The mold unit F shown in Figure 32 is particularly adapted for forming tubular structural elements E4 of cylindrical section such as illustrated in Figure 42.

The mold unit FA shown in Figures 43 to 47 is used to form the same structural elements that can be formed by the units A, B and C of Figures 1 to 4 but operates in a different manner from that of the units A, B and C.

The elements E1, E2 and E3 shown in Figures 37 to 42 and mentioned above are disclosed and claimed in my application for Pre-Cast Building

Elements and Buildings, Serial No. 744,464, filed April 28, 1947.

The mold unit A illustrated in Figures 1, 4 and 7 may be generally described as including upright and spaced longitudinal wall elements **10** and **12** adapted to define or mold two longitudinal surfaces **10***x* and **12***x* of a structural element of the type illustrated at E1 in Figures 37 and 38. As is best shown in Figure 3, the ends of the unit A are fitted with inter-engaging wedge elements **14** bearing against a fixed end plate **16** and the innermost wedge element of each set will usually define an end **14***x* of the structural element E1. Referring to Figure 7, a plate **18** is provided at the bottom of unit A, plate **18** being fixed to frame G and of less width than the space between the wall elements **10** and **12**. In the space on each side of plate **18** the unit A will be provided with vertically extending ejectors **20** which, as illustrated in Figure 3 are spaced lengthwise of the unit. It will be noted from Figures 1 and 3 that the lower ends of the ejectors **20** are fixed to a table H vertically movable in the lower portion of frame G.

When concrete is to be poured in unit A to form a structural element such as E1 of Figures 37 and 38, the upper ends of the ejectors **20** (Figure 7) will be below the upper surface of the bottom plate **18** and a matrix **22** of the form shown in Figure 20 will be placed in unit A to rest on plate **18** and the ejectors. The matrix **22** is provided with ribs **24** and **26** on its upper surface which will form corresponding recesses **24***x* and **26***x* (Figure 38) in the element E1 to be cast. It also will be observed that matrix **22** is of open-frame form so as to include spaced longitudinally extending bars **28** and **29** joined by spaced cross-webs **30** and **31**. As is indicated by dash lines in Figure 20, cores **32** and **34** such as shown in Figures 21 and 22 will be fitted between the webs of the matrix. The cores will be secured to the bottom plate **18** of the unit by bolts, as shown in Figure 12. Then the wedges **14** will be driven tightly between each end plate **16** of mold unit A and the adjacent matrix **22** as shown in Figure 3. This assembly is shown in top plan in Figure 29.

Concrete, preferably a fairly dry mixture such as hereinafter described, will now be poured into the space above the matrix and between the cores and the inner surfaces of the vertical plates of the mold unit. Assuming that the structural unit is to be metal reinforced, after the concrete has reached a height of about two inches above the matrix 22, suitable metal reinforcing rods may be laid upon the concrete. The alternate placing of reinforcing elements and pouring of concrete can be continued until the mold has been filled to a level approximating that illustrated in Figure 9. Then the matrix **36** of Figure 20 will be placed upon the top of the mass, as also illustrated in Figure 9, the matrix being centered in the mold unit by engagement with the mold unit vertical walls.

It will be observed that matrix **36** is of the same form as matrix **22** in that it includes longitudinally extending bars **28'** and **29'** and cross webs **30'** and **31'**. However, the matrix **36** is provided with recesses **38** and **40** so that it will form ribs **38***x* and **40***x* (Figure 37) on the upper edge of the element E1. As shown in Figure 3, the cross webs **30'** and **31'** of the matrix **36** will lie between the upper ends of the cores **32** and **34**. These webs **30'** and **31'** and the cooperating webs **30** and **31** on the lower matrix **22** will respectively form the upper and lower surfaces of cross webs **30***x* and

31x as well as the upper and lower surfaces of the end walls 14x of the structural element E1 being produced.

All of the surfaces of the mold unit, including the fixed walls of the mold, the matrices, cores and end wedges, which come in contact with the concrete will be coated with metal and will have oil applied thereto before concrete is poured into the mold unit. This will not only enable the concrete element to have a smooth surface, but will insure that after the molding operation has been completed, the formed element readily can be stripped from the mold unit.

The next step of the operation will be to position the press element J above the mold unit A. As best shown in Figures 1, 3 and 9, press element J is supported by a beam or carriage K provided with rollers 46 at each end to engage trackways 48 at each end of the top of frame G. Cylinders 50 are fixed to carriage K and are connected to a suitable source of fluid pressure. The press element J is fixed to pistons 52 movable in the cylinders 50. Carriage K is movable transversely of the supporting frame G and when the press element has been vertically aligned with the mold unit A, as shown in Figure 9, hydraulic pressure may be applied to the cylinders 50 to force the press element downwardly. The degree of pressure used may be 400 lbs. per square inch and upwardly to as high as 600 lbs. per square inch. Even the latter figure is not a limit if the formed element must have a greater strength than would be obtained with that pressure.

It will be observed that the amount of concrete or other material to be placed in the mold must be so gauged that, with the desired pressure applied to move the upper matrix 36 down into the mold, as shown in Figure 10, the element E1 will have the proper height. Then press element J will be raised from matrix 36 as shown in Figure 11.

With the press element now moved from above the mold, a transporting carrier or conveyor L of the type shown in Figures 12 and 13 will be positioned above the mold. The carrier L is an open box-like frame suspended from wheeled trucks 53 movable on a track 54 fixed in frame G above mold unit A. Carrier L is adapted to be raised or lowered by means of sheaves 56 so that a pair of spaced and longitudinally extending beams 58 included in carrier L will be respectively positioned above each upper longitudinal edge of the mold unit A. Then the wedges 14 at the ends of the mold unit are loosened. The table H carrying the ejectors 20 then will be raised as shown in Figures 12 and 13 so that the upper ends of the ejectors will lift the lower matrix 22 and the structural element E1 supported thereby, so that matrix 22 will be above and clear of the cores 32 and 34 and the upper edge of the mold unit A. As the result, element E1 and the matrices 22 and 36 will be stripped from the mold unit outer walls and by a movement along the line along which molding pressure was applied. As is shown in Figure 12, element E1 and the matrices will now be within carrier L and the lower surface of matrix 22 will be just above the beams 58 of carrier L. Suitable crosspieces 62 will then be positioned upon the beams 58 and beneath matrix 22. The ejectors 20 will then be lowered, or the carrier L lifted slightly, so that the matrix 22 will rest upon the crosspieces. Carrier L will then be moved along its track 54 to convey the formed element E1 and the matrices out of the apparatus to a curing point.

The formed element and matrices can immediately be removed from the carrier and the matrices stripped from element E1. Element E1 can then be subjected to suitable curing as hereinafter described, when it will be ready to use for building purposes.

After all of the mold units, or any desired group thereof, have been filled, the press element J can be successively positioned above them to compress their charges. Then all of the formed elements can be simultaneously lifted by raising ejector carrying table H. Finally, a carrier L can be moved about each raised concrete element so that it can be removed for curing. The whole operation obviously requires but a few minutes.

As is hereinafter described in detail, the mold units will preferably have heating elements 64 associated therewith, usually in the form of steam pipes. These may be positioned alongside the exterior of each unit, as shown in Figure 1, so that the units will be heated sufficiently to drive off moisture in the mass of concrete. However, the molding operation is not ordinarily prolonged in any way to provide for heating. In other words, the principal purpose of the heating elements is to keep the units fairly hot and thereby assist in drying the concrete, but the molding operation preferably does not include any separate heating period.

Referring again to Figures 1 and 4, the mold unit B is of the same type as the mold unit A, just discussed, except that it is somewhat narrower. The mold unit C shown at the left of Figure 1 is similar to the units A and B, but is so constructed as to be of adjustable width. As is hereinafter explained in detail, the invention includes various devices which can be fitted on the molds to enable elements of less length than the molds to be simultaneously produced in one mold, as well as to vary the form of the finished element.

The mold unit D, shown at the right of Figure 1, and adapted to form hollow elements of rectangular outline such as shown in Figure 42, includes a core 66 best shown in Figure 19, which is longitudinally movable through the mold.

Further with regard to mold unit D, after press element J has been lifted from it, the core 66 can be withdrawn lengthwise of the unit so that the formed structural element E3 can be removed from the unit.

The unit F of Figure 32 adapted for casting tubular elements E4 of circular section is adjustable to form these elements of various diameters and thicknesses and its molding parts are preferably operated in a vertical plane.

Mold unit FA of Figures 43 to 47 is adapted to form the same types of structural elements as the units A to D but is so designed that stripping of a formed element from the unit is performed by moving the mold walls away from the formed element.

Detailed structure of apparatus of Figures 1 to 31

Referring to Figures 1 to 3, the frame G is mounted on a suitable foundation 75 and includes spaced uprights 76 at the front end of the apparatus, i. e., the end viewed in Figure 1 and the end shown at the right in Figures 2, 4 and 13 and at the left in Figure 3. Similar uprights 77 are spaced at the rear of the apparatus, the four uprights thereby forming the corners of the frame G.

As best shown in Figures 1 and 2, the uprights on each side of the apparatus are joined near

their lower ends by longitudinally extending beams 78 which support the spaced cross beams 9 of the fixed platform 8 on which the mold units A to D are supported. Referring to Figure 1, vertically extending tracks 79 are provided inwardly of the uprights 76 and 77 and beams 78 and these trackways guide rollers 80 journalled on the vertically movable table H which carries the ejectors 20. The trackways 79 extend from the base of the apparatus to the fixed platform 8. Table H is secured to plungers or rams 81 movable in the foundation 75 by means of fluid pressure or other suitable means. The transversely extending trackways 48 for the carriage K which supports press element J are secured to the uprights 76 and 77.

As is best shown in Figure 3, carriage K primarily comprises a lower horizontal beam 84, an upper beam 85 and two vertical beams or uprights 86. The beams 84 and 85 extend the length of the apparatus and are secured together by the uprights 86. The underside of lower beam 84 carries the rollers 46 to engage the trackways 48. Each upright 86 has a roller 87 journalled thereon to engage the side of the corresponding trackway 48. The lower end of each upright 86 includes a horizontal projection 86*a* which extends beneath the trackway 48. Hence, when fluid pressure is supplied through the flexible line 88 to the cylinders 50 carried by beam 84, upward movement of the carriage K and cylinders 50 will be limited so that the entire pressure will be exerted against the pistons 52 and the press element J.

As is illustrated in Figures 1 and 2, a rotatable shaft 90 is journalled below the upper beam 85 between the uprights 86 and a plurality of sheaves or pulleys 91 are fixed to shaft 90. Cables 92 secured to the sheaves extend downwardly to a bar 93, secured to the press element J by vertically extending rods 94 which may pass through apertures or guides in beam 84 of carriage K. The press element J is welded or otherwise secured to the rods 94. In other words, bar 93, rods 94 and press element J comprise an element vertically movable upon carriage K. The sheaves or pulleys 91 will all be actuated together by the drive sheave 95 shown at the left of Figure 2 and which is adapted to be actuated by means of a chain 96.

It will be observed that with the pressure in the cylinders 50 released, bar 93 and press element J can be raised and lowered together by operation of the chain 96. For example, when the press element J is to be operated, it can be lowered to a point adjacent the mold unit by operation of chain 96 and then lowered the remaining distance by fluid pressure acting in the cylinders 50.

Figures 1 to 3 do not show the extreme upper portion of the frame G which is illustrated in Figures 9 to 13 (Figures 9 to 13 are broken away to exclude the carriage K and press element J discussed in the immediately preceding paragraphs). As is illustrated in Figures 9 to 13 the fixed uprights 76 and 77 at the corner of frame G extend a substantial distance above the press-carrying carriage K and, at their upper ends, each pair of uprights is joined by a cross beam 97. The cross beams 97 support the trackways 54, one of which is fixed above each of the mold units A to D. As has been stated above in the general description, the trackways 54 support the trucks 53 for the sheaves 56 and cables 98 carried by these sheaves support the transporting carriers L, one of which is provided for each mold unit. The trackways 54 extend outwardly and beyond the front end of the apparatus so that the formed concrete elements can be moved to a point entirely clear of the remaining operating elements before they are taken from the carriers L.

Referring now to the mold unit A and, more particularly, to Figure 3, as has been stated above, this unit includes a bottom wall 18 secured to the spaced cross members 9 of the fixed platform 8. The two end cross members 9 of the platform 8 carry the end wall brackets 16. As illustrated in Figure 7, the side walls 10 and 12 of the mold element, which preferably are U-beams, are also supported on the cross members 9. As best shown in Figure 3, the bottom plate 18 of the mold unit A extends the length of the unit. A bar 99 extends beneath the beams 9 and parallel to mold bottom plate 18. Between the cross members 9 and directly beneath the bottom wall 18 of the mold, bar 99 carries spacers 100 as shown in Figures 3 and 28. By this arrangement, the bottom plate 18 of the mold is securely supported throughout its entire length. As is best shown in Figure 23, the upper surface of the bottom plate 18 of the mold is provided with a central and longitudinally extending rib or shoulder 101. This shoulder is adapted to cooperate with a groove 102 (Figures 21 and 22), formed in the undersides of core elements such as 32 and 34 to center the core elements, in addition to the core centering action provided by the matrices 22 and 36. The manner in which shoulder 101 cooperates with matrix 22 is hereinafter described. The core elements are removably bolted to the bottom plate 18 by means of bolts 101*a* (Figure 12) which pass through apertures 101*b* (Figures 21 and 22) in the cores and aligned apertures in bottom wall or plate 18. The cores will be of a width corresponding to the space between two opposed ejector fingers 20 or, stated another way, will have the same width as the bottom plate 18. If the core elements are formed of wood, they may be covered with sheet metal to provide a smooth surface.

Assuming that the mold unit A is to be used to form a concrete element E1 of the type illustrated in Figures 37 and 38, a matrix 22 such as illustrated at the bottom of Figure 20 will be positioned within the mold unit. As is best shown in section in Figures 7 and 8 and in plan in Figure 29, each longitudinally extending bar 28 and 29 of the matrix will lie between an adjacent side wall 10 or 12 of the mold unit and the opposed side wall of the bottom plate 18, while the cross webs 30 and 31 of the matrix 22 will extend across the top of the bottom plate 18. It will be observed from Figure 7 that the lower edges of the cross webs 31 and 30 of the matrix are cut away so as to be above or recessed with respect to the lower edges of the longitudinally extending bars 28 and 29 of the matrix. Hence, the cross webs can lie upon the matrix while the longitudinally extending bars lie alongside it. In addition, a notch 102 in each cross web of the matrix will fit the rib 101 which extends along the bottom plate 18. In other words, the matrix 22 rests upon and straddles the bottom plate 18 and the longitudinal bars 28 and 29 of the matrix rest upon the ejector fingers 20 and the cross beams 9 of the frame, while the cross webs of the matrix rest upon the bottom plate 18. The outer surface of the

longitudinal panels or bars 28 and 29 of the matrix will be in close contact with the side walls 10 and 12 of mold unit A.

It will be observed from Figure 20 that matrix 22 is provided with two cross webs 31 adjacent each end, the cross webs of each pair being spaced by a distance corresponding to the distance between the longitudinal bars 28 and 29 so that a square pocket 105 is formed. This pocket is of a size to closely receive the core element 34 of square cross-section. The upper surfaces of the end pairs of cross webs 31 lie flush with the upper surfaces of the bars 28 and 29, although the rib 26 extends above this surface.

The other cross webs 30 of the matrix 22 are arranged in pairs, the two webs of each pair being spaced by a distance corresponding to the distance between the longitudinal bars 28 and 29 of the matrix 22 to form other rectangular pockets 106 of a size to fit the rectangular core 34 illustrated in Figure 22. The spaces 107 between adjacent pairs of webs will be relatively long to fit the longer cores 32 illustrated in Figure 21.

The side bars 28 and 29 of matrix 22 have ribs 24 extending upwardly therefrom, which ribs terminate at the innermost surface of each end cross web 31. The ribs 24 and 26 will form grooves 24*x* and 26*x*, respectively, in the opposed surface of the element E1 of Figure 37.

In order that the inner cross webs 30*x* of the element E1 of Figures 37 and 38 will be of less height than their side panels 10*x* and 12*x*, the webs 30 of matrix 22 will project upwardly and beyond the side bars 24 as indicated in Figure 20.

When lower matrix has been positioned in the mold unit A to form its bottom wall, the two parts of each wedge element 14 may now be forced into tight engagement with each other and the adjacent ends of matrix 22 and the brackets 16. The innermost surface of each inner wedge element will thereby define the end surface of the structural element E1 which is to be cast or molded. It is desirable that when the wedges are in final position, they should not project above the side walls 10 and 12 of the mold unit.

A core element 34 will now be fitted in the pockets 105 at each end of the matrix 22, as well as the pockets 106, and a core element 32 will be fitted in each of the other and longer pockets 107 of the matrix, all as shown in Figures 3 and 29. The concrete for the element E1 will now be poured. As has been indicated above, assuming that the element E1 is to be metal reinforced, after about 2 inches of concrete has been poured, a reinforcing element of proper form may be laid upon the concrete. The pouring of additional concrete can be alternated with the placing of reinforcements, with a final pouring of concrete. Thus, the mold unit A is now completely filled as shown in Figure 9.

After the mold has been filled with concrete as described above, the matrix 36 will be laid upon the concrete as shown in Figure 9. As is indicated in that figure, all factors are so related that when the proper quantity of concrete has been placed in a mold unit to form a structural element of the desired height, the upper edges of the side and end walls of the mold will extend somewhat above the level of the batch of concrete so as to serve as a centering and guiding means for matrix 36. Also, as shown in Figure 3, the upper ends of the cores 32 and 34 will also extend upwardly above the batch of concrete to engage the pockets 105, 106 and 107 of the upper matrix 36 to further center the same. As is indicated in Figure 20, the upper matrix 36 is identical with the lower matrix 22 except that its lower surface is provided with recesses 38 and 40 instead of the ribs 24 and 26 formed on the lower matrix. If desired, the upper matrix may have its non-forming surface (shown uppermost in Figure 9) provided with notches 103 so that it may be used as a lower matrix and will thereby closely fit and straddle base plate 18.

With the matrix 36 now positioned on the mold unit A, the carriage K will be moved transversely of the trackways 48 to carry the press element J to a point above mold unit A and matrix. Then press element J will be lowered to the position shown in Figure 9 by operation of the cable or chain 96. Pressure will then be delivered to the cylinders 50 so that the press element J will be forced downwardly to the position indicated in Figure 10, forcing the matrix 36 downwardly with respect to the core elements and the side and end walls of the mold unit. The upper edges of the mold unit walls 10 and 12 will usually function as a stop for the downward movement of press element J.

Immediately the batch of concrete is placed in the mold unit, the fact that the unit is heated by means of the steam pipes 64 will start a drying action with regard to the moisture in the batch of concrete and this drying action will continue during the time that the concrete is in the mold unit. In addition, as is hereinafter mentioned, the concrete used with the present apparatus and method is an extremely dry batch.

The application of pressure to the batch requires only about two or three minutes and as soon as the press action is completed, the press element J is moved upwardly to a position such as indicated in Figure 11 and then moved along trackways 48 to be clear of the mold unit. Then the carrier L illustrated in Figures 12 and 13 is moved inwardly along the upper trackways 54 to a point directly above the mold unit. After the wedge elements 16 have been loosened, the table H carrying the ejectors 20 is then raised by means of fluid pressure acting upon the pistons or rams 61. As a result, the ejector fingers 20 will move upwardly from the position indicated in Figures 9 to 11, thereby acting upon the under surface of the lower matrix 22 to strip the formed element E1 from the side walls and cores of the mold unit A. It will be observed that this stripping action involves a translational movement of the formed element E1 with respect to the side walls of the mold unit and along the line along which pressure was applied. Because the matrices 22 and 36 move with the element E1 and also because all surfaces of the unit are smooth and oiled as mentioned above, there will be no tendency for the edges of the concrete element to be broken away during this stripping of the element from the side walls and cores of the mold unit. Aside from this, it is found that if an extremely dry mixture of concrete is used of the proportions hereinafter described, the application of at least 400 lbs. pressure per square inch will so compress the batch of concrete that there is no tendency for any portion of the element to break away during the stripping action.

The raising of the formed element E1 and the matrices 22 and 36 will continue until the lower surface of the matrix 36 is sufficiently far above

the lower bars 58 of carrier L to permit an operator to place the cross bars 62 upon the bars 58. Then the ejector-carrying table H may be lowered so that the ejector fingers 20 will move downwardly and the matrix 22 will come to rest upon the cross bars 62. Carrier L can then be lifted to clear the trackways 48 shown in Figure 13 and move from the apparatus along its trackway 54. The element E1 is then lifted from the carrier L while still supported upon the matrix 22.

Referring now to the mold unit B illustrated in Figures 1 and 4, this unit is of identical construction with the unit A described above except that it is of less width. Therefore, unit B may be used to make exactly the same form of precast elements as can be made with unit A, except that the elements made with unit B will ordinarily be of less width than those made with unit A.

Unit C illustrated in Figures 1 and 6 is of the same construction as the units A and B except that unit C is of adjustable width. In more detail, as best shown in Figure 6, the side wall 12*a* of unit C is formed by a U-shaped beam member, just as is the case with the corresponding side wall members of units A and B. However, member 12*a* is not fixed to the cross beams 9 but, instead, is provided with spaced shoes 110 which fit between the cross beams 9, the lower surface of member 12*a* resting on the upper surfaces of the members 9. Member 12*a* is therefore mounted for movement toward and from the other and fixed side wall 10 of unit C, with this movement guided by the shoes 110. Member 12*a* is moved with respect to member 10 by means of a spaced series of threaded shafts 111 rotatably mounted in fittings 112 secured to the outer surface of member 12*a*, the outer and threaded ends of the threaded shafts extending through threaded collars 113 fixed to a beam 114 which extends lengthwise of the apparatus. Each threaded shaft 111 has a sprocket 115 secured thereto, as is also shown in Figure 2, and all of the sprockets are adapted to be simultaneously rotated by means of a sprocket chain 116 which extends lengthwise of the apparatus and is adapted to be driven by a sprocket wheel 117 at one end of the apparatus. Sprocket 117 is fitted with an operating handle 118. If wall member 12*a* is of substantial height, as illustrated in the drawings, the shafts 111 may be arranged in upper and lower groups, with the shafts in one group threaded oppositely to the shafts in the other group and so that all may simultaneously impart the same movement to the wall member 12*a* by use of the single sprocket chain such as shown in Figure 2.

Referring to Figure 6, the ejector fingers 20*a* associated with the movable wall 12*a* of unit C are mounted for transverse adjustment with respect to table H. This adjustability is accomplished by having the lower mounting bracket 120 for the fingers fitted with keys 121 movable in keyways 122 in the table. The brackets 120 can be secured in adjusted position by means of nut and bolt arrangements such as indicated at 123.

It will be apparent that base plates 18*a* of different widths will be used according to the spacing between the walls 12 and 12*a* of unit C. The cores and matrices used with the unit will also be of different widths, depending upon the adjustment for which the unit is set.

The operation of the unit C in forming a precast element will be apparent from the above description of the operation of the unit A. The press element J provided with the apparatus will be of such width that it will cooperate with matrices of the greatest width which unit C can accommodate. Because press element J is movable transversely of the frame G, it readily can be centered with respect to unit C regardless of the width for which that unit is set. The track 56 for the transporting carrier L provided for the mold unit C will be centered with respect to the limit of expansion of that unit. Also, the carrier L for unit C will be of ample width to receive the widest structural units which can be produced thereon.

In the foregoing, the operation of the unit A has been discussed primarily in connection with the production of a relatively long precast wall course element such as disclosed in Figures 37 and 38, and it will be noted that the units B, C and FA can be operated to produce the same type of element. However, as is best indicated in Figure 4, the units A and B can be used to form other types of building elements. The same is true of the units C and FA. This manner of operation is discussed below.

Referring to Figure 4, this figure shows the unit A in top plan, the top matrix being omitted from the view so as to show two completed concrete elements E2 simultaneously formed by the unit. Figures 39 to 41 show a pair of completed elements E2 in perspective and, by considering those figures with Figure 4, it will be observed that element E2 is provided with pairs of interior cross webs 30*x* and longitudinal panels 28*x* and 29*x* generally similar to those provided in the element E1 of Figures 37 and 38. In addition, the elements E2 include ridges 38*x* on one surface and recesses 24*x* on an opposite surface, but extending the entire length of the longitudinal panels. However, the matrices 22*a* and 36*a* (Figure 28) used to form the elements E2 are of such shape that, in conjunction with cores 32 and 34 and certain collapsible cores or spacers hereinafter described, the matrices 22*a* and 36*a* will so form the left-hand element of Figure 4 that one end 124 thereof (the left-hand end of Figure 4 and the end shown in Figure 40) will not be provided with a cross web at its extreme end, though it will have a cross web 125*x* spaced somewhat inwardly of its extreme end. However, the opposite end (shown at the center of mold unit A in Figure 4 and also shown in Figure 39) has a cross web 125*x* spaced inwardly therefrom and also a projecting portion 126 to fit between the open end of an adjacent similar element E2 as shown in Figure 41.

In more detail, the lower matrix 22*a* used in Figure 4 has the same form as the portion of matrix 22 which appears between the dotted lines 22*a* of Figure 20, thereby lacking the cross webs 31. Also, as shown in dotted lines at the right of Figure 20, it will include a cross web 125 similar in outline to the cross webs 30 of matrix 22 and projecting above its ridges 24.

In order to form certain recesses in structural element E2, as well as to enable two such elements to be formed in one mold unit, a collapsible core element of the type indicated in Figures 23 and 24 may be used.

Referring to the collapsible core element 130 illustrated in Figure 24, it comprises an outer or casing member 131 including a closed end 132 and an open end 133. An inner member 134 fits in the open end 133 of member 131, the two members being slidable with respect to each other. The side walls of casing member 131 are formed of thin sheet material in order that it will have substantially the same horizontal dimensions as the inner member 134.

Casing member 131 has cross pins 135 extending crosswise thereof and the inner member 134 has slots 136 extending lengthwise thereof from its inner end to engage the pins 133. The slots 136 have their opposed walls very slightly converging toward the closed ends of the slots so that member 134 will not drop of its own weight into member 131. By this arrangement, member 134 will remain in adjusted position with respect to member 131.

The collapsible core 130 is intended to be so positioned in the mold unit that it will extend crosswise of the mold as indicated in Figure 4. In other words, the walls 137 of casing member 131 will be so spaced apart that they will contact with the walls 10 and 12 of a mold unit. The spacing between the walls 138 will vary; that is, in some collapsible core elements of the type indicated at 130 the spacing between these walls will be greater or less than that indicated in Figures 4 and 24.

The closed end 132 of casing member 131 and the free end 139 of the inner member 134 will be of an outline to conform with the position which they are to occupy with respect to upper and lower matrices such as 22 and 36. For example, if a collapsible core element 130 is to be positioned at such point along a matrix 22 or 22*a* that it will not rest upon a cross web 30 or 125 of the matrix, the lower wall 132 of the core element must include a central depending portion 140 which will extend downwardly into the matrix as shown in Figure 8 to engage the base plate 18 of the mold unit. In addition, the lower end of the collapsible core element must be notched as indicated at 141 to fit the upstanding ribs 26 on the matrix 22. As is shown in Figures 8 and 24, the free or upper end 139 of the inner member 134 of collapsible core 130 must, under these circumstances, include a central projection 142 to extend into the upper matrix used with lower matrix 22*a*. This upper end 139 will also include surfaces to closely engage the recesses 38 of the upper matrix.

If the collapsible core element 130 is to be of a type for positioning opposite an upstanding cross web such as provided at 30 on the matrices 22 and 36 of Figure 20, the casing member 131 will have its lower end notched as indicated by the dotted line 143 in Figure 24 and the free end 139 of the inner member 134 will be correspondingly notched as indicated by the dotted line 144. Casing member 131 would then also be notched at its upper end as shown at 144*a* in dotted lines. If core element 130 is not to be used opposite ribbed or recessed portions of a matrix, its upper and lower ends will not be notched to fit such ribs or recesses.

The collapsible core element 145 illustrated in Figure 23 includes an outer or casing member 146 and an inner member 147, the two members being connected together by a pin and slot in the same manner as the collapsible core element 130 of Figure 24. However, as is indicated in Figure 4, a collapsible core element of the type designated 145 is simply intended to block out a portion of the longitudinal walls 28 or 29 of the matrices and, therefore, its wall 148 and the wall opposed thereto are spaced by a distance corresponding to the thickness of a matrix wall or bar 28. The other two walls 149 of the core 145 will be of various widths, depending upon the length of matrix wall to be blocked out. The closed end of the casing member 146 will be recessed as indicated at 150 in Figure 23 so that it will fit upon the shoulder 24 of the matrix. The free end of the inner member 147 is notched as indicated at 151 to engage the recess 38 in a cooperating matrix 36. These ends can be varied in form just as has been described above in connection with collapsible core element 130.

Referring now to Figure 4, it will be observed that this figure shows the positioning of non-collapsible core elements 32 and 34 and collapsible core elements 130 and 145 with a lower matrix of the type designated by the dotted lines 22*a* in Figure 20. This assembly will produce at least two structural elements of the type designated E2 in Figures 39 to 41. It will be observed that collapsible core element 130 divides the molding space of mold unit A intermediate its length so that two elements E2 can be simultaneously molded. With regard to the collapsible core elements 145, it will be observed from Figure 4 that they primarily serve to form the notches designated 145*x* in Figure 39 with the result that the interlocking projection 126 will be formed at one end of the element E2. By means of this projection 126, a number of elements E2 can be assembled as illustrated in Figure 41. The space 152 between the projections 126 and the adjacent cross web 125*x* will preferably be square in horizontal section.

The mold unit B illustrated in Figure 4 has a collapsible core element or spacer 130 positioned therein intermediate of its length to enable two structural units of the type illustrated at E1 in Figure 37 to be simultaneously formed, each element being somewhat shorter than that illustrated in Figure 37. Also, the structural elements E1 shown being formed in Figure 4 may have interlocking ends by the proper use of collapsible core elements 145.

It will be perceived from the foregoing discussion of Figure 4 and the collapsible core elements in Figures 23 and 24 that numerous types of structural elements can be produced by the use of the collapsible core elements. In short, they enable numerous different types of structural elements to be produced from a small number of types of matrices because the collapsible core elements divide the mold unit casting area as desired.

When a collapsible core element of the type illustrated in Figures 23 and 24 is to be used, it is placed in the mold unit at the desired point before the batch of concrete is poured. At this time, the inner members 134 or 147 of the core elements are extended as indicated in Figures 23 and 24 so as to limit the concrete batch to the desired area of the mold unit. When an upper matrix is positioned upon the upper ends of the collapsible cores, the latter will support the weight of the matrix without collapsing. However, when the press element J is forced downwardly upon the upper matrix, the inner member such as 134 of the collapsible core will move downwardly into its casing member. The height of each casing member such as 131 or 146 of a collapsible core element will be such that when the application of pressure by press element J is completed, the inner member will be substantially collapsed into its casing member.

Figure 25 illustrates a chimney flue supporting block E5 adapted to be formed in a mold unit A, B, C or FA of the present invention by the use of matrices 160 and 161 shown in Figure 27 and a core 162 illustrated in Figure 26. Because the flue supporting elements E5 are relatively short in length, a number of them may be

simultaneously produced in any of the above-described mold units.

Superposed chimney flue supporting elements E5 such as shown in Figure 25 are adapted to form a chimney provided with two flues formed by hollow rectangular flue liners. Element E5 is of rectangular exterior form with inwardly projecting vanes to hold the liner spaced from the outer walls of the element. In order that the elements may be stacked to form a chimney, they are provided with ridges 163 at one edge and cooperating recesses at their opposite edge (the bottom edge. not shown, of Figure 25). Figures 30 and 31 show the manner of fitting a matrix 160 in a mold unit, then securing cores 162, as well as a core of the general form of 34, in the mold unit and with the concrete batch poured into the space with the mold unit and about the cores. It will be observed that the lower end of a core 162 will fit into each open area 162a (Figure 27) of the lower matrix 160, while the lower end of core 34 will fit in the central space 34a.

The side walls 10 and 12 of the mold unit, wedge 14, and a removable end block 18a will form the outer surface of element E5. The cores will define the element inner surfaces and matrix 160 will form its lower surface. Figure 31 illustrates the mold unit provided with a non-ridged base plate 18a and which is provided with slots 18b to enable the core securing bolts 101a, and thereby the cores, to be positioned at various points along the length of the base plate. Because these slots will always be covered either by a core or some part of a matrix, the concrete batch cannot move therethrough. With the concrete poured to the proper height, the core element 161 will be placed upon the batch and the press element J lowered. Further operations will be as described above in connection with the production of a structural unit such as E1.

The mold unit D of Figures 1, 4, 5 and 14 to 19 is primarily intended for the production of hollow open-ended structural elements of rectangular section; for example, floor slab elements of the type indicated at E3 in Figure 42. Such elements are disclosed in my above-mentioned application and include recessed upper edges and grooved side walls.

As is best illustrated at the top of Figure 4, because mold unit D will have its lower wall defined by a non-apertured matrix 170, or a series of such matrices, these matrices may rest directly upon the ejectors 22 and the cross beams 9. The ejectors may extend transversely of the unit as shown in Figure 18. Matrix 170 will form one side edge of the element E3, the side walls 10 and 12 of the mold unit will form the upper and lower faces of element E3, and the end walls 173 and 174 of the unit will form the ends of element E3. A movable core member 66 is slidable through and closely fits an opening 175 in each of the end brackets 173 and 174 as best shown in Figure 15. A cable 176 is detachably connected to an eyelet 172 (Figure 19) at the pointed and leading end 66a of core 66 and this cable passes about a drum 177. The trailing end 66b of the core element 66 has a cable 178 fixed thereto and which cable is secured to a power-driven drum 179. By proper operation of the drums 177 and 179, the core element can be moved into and out of the molding space. A guide frame or trackway 184 is provided between drum 179 and the molding space, this trackway being of sufficient length that core 66 can lie therein with its leading end 66a entirely clear of and out of the molding space.

In the use of the mold unit D, the end brackets 173 and 174 would be suitably adjusted to provide a space of proper length. With matrix 170 positioned as shown in Figure 18, wedge elements 14a will be driven to proper position as shown in Figure 15. The wedge elements 14a will be provided with apertures 14b which, when these elements are driven to proper position, will be in alignment with the openings 175 in the end brackets 174. Then the drum 177 will be operated to move the core element 66 from the right in Figure 4 and until its leading end 66a moves through the opening 175 in the left-hand end wall 173 and so that the leading end 66a of the core element will occupy the position beyond the molding space indicated in dotted lines in Figure 4. In order to guide the core element for the above-mentioned sliding movement, rollers 183 may be provided on the guide frame 184 as shown in Figure 5.

With the core element positioned as described above, the concrete batch may be poured into the space in the mold unit surrounding and above the core element 66, and matrix 170a can then be properly positioned. Thereafter, the press element J may be lowered as described in connection with the operation of the mold unit A to compress the batch. Cable 176 then will be disconnected from the bracket 172 at the leading end 66a of the core 66 and the core will be retracted so that its leading end 66a is completely to the right of the right-hand end wall 174 of the mold unit. This movement of the core element through the compressed but still uncured structural element E3 will not break away any portion of the element because the core element has smooth surfaces and will have been coated with oil before being used Furthermore, the concrete batch used will be of the relatively dry consistency heretofore mentioned.

The wedges 14a will now be loosened and removed and the platform element H raised so that its ejector fingers 20 will lift the structural element and the matrices out of the mold unit and into position for transportation to a curing point by means of the carrier L, just as has been described above in connection with the operation of the mold unit A.

The mold unit of Figures 32 to 35

The mold unit F of Figures 32 to 35 is primarily intended for formation of hollow pipe of the type indicated at E4 in Figure 36. Mold unit F includes a frame consisting of vertically arranged beams 190 secured to a base 191 and joined at their top by a cap element 192. Intermediate its height, the frame formed by the beams 190 is provided with horizontally arranged platform members 193 (Figure 34) and 194, the platform members being vertically spaced by a distance substantially corresponding to that of the longest tubular element E4 to be formed. Each platform member 193 and 194 has four horizontally arranged shafts 195 threaded therethrough, the shafts being arranged at right angles to each other as shown in Figure 35. The inner ends of the shafts 195 of the two platforms support the upper and lower ends of an outer and mold member 196 of tubular form.

The base 191 of mold unit F is provided with a cylinder 198 having a plunger 199 extending

upwardly therefrom, the plunger being movable by hydraulic pressure in the cylinder 198. A similar but downwardly facing cylinder 200 and plunger 201 is mounted in the cap piece 192 of the frame, the cylinders being operable by fluid pressure flowing through a three-way valve 202.

The lower plunger 199 has a plate 203 fixed thereto and an identical plate 204 is fixed to the upper plunger 201. As is indicated in Figure 33, the plates 203 and 204 are provided with radial slots 205 which receive the ends of rods 206, four rods being associated with each plate. The extreme end of each plunger has a frame 207 fixed thereto (Figure 33), which frame is provided with radially extending slots 208. The rods 206 extend vertically through these slots and the position of the rods radially with respect to the frame slots 208 and the slots 205 of the plates 203 and 204 is adjustable by means of threaded shafts 209, the shafts being threaded through brackets 210 secured to the outer surfaces of the frames. It will be observed that the foregoing arrangement permits the rods 206 to be adjusted radially with respect to the apparatus.

When an element of the form indicated at E4 is to be cast with the mold unit F, an outer tubular mold of the desired diameter will be positioned in the supporting members or platforms 193 and 194 for engagement by the threaded shafts 195. A lower matrix 220 of the form indicated in Figure 35 will then be positioned upon the lower rods 206 associated with plunger 199, these rods being adjusted by means of the threaded shafts 209 to the proper radial spacing to support the matrix. The lower plate 203 includes a central stem 221 on which a core element 222 will be supported and this core element will be moved upwardly into the outer mold element 196 with the matrix 220. Core element 222 is removable from the stem 221 to enable cores of various sizes to be secured to the stem. The lower supporting platform 193 is spaced sufficiently far above foundation 191 that core element 222 can be supported on stem 221 and with the upper end of the core entirely below platform 193.

With the parts arranged as described in the preceding paragraph, a batch of concrete will be poured into the upper end of the outer mold element 196 to fill the space between it and core 222 to the desired point. Then a matrix such as illustrated at 224 will be positioned in the top of the outer mold element 196. Thereafter, with plunger 199 held against movement, fluid pressure will be directed into the upper cylinder 200 to move its plunger 201 and the rods 206 downwardly against the upper matrix 224 to apply pressure to the batch of concrete. When the desired pressure has been applied in this manner, the lower plunger will be moved downwardly in unison with further downward movement of the upper plunger 201 so that the mold unit E4 will be stripped from the outer mold element 196. After the cast unit E4 is clear of the element 196, the upper plunger 200 will be retracted and the upper matrix 224 removed. Finally, the core element 222 will be disconnected from the stem 221 so that the core element and the cast element E4 can be removed to a curing point, where core 222 can be withdrawn from element E4.

It will be obvious that the mold unit F of Figures 32 to 35 is adaptable for the casting of tubular elements of various radial dimensions and thicknesses. An element of a length less than the spacing between the supporting platforms 193 and 194 can be obtained by not filling the element 196 to its full height. Alternatively, the platforms 193 and 194 may be mounted for vertical adjustment with respect to the frame formed by the vertical beams 190.

Mold unit of Figures 43 to 47

The mold unit FA of Figures 43 to 47 primarily differs from the mold units A, B and C in that, in unit FA, the structural unit which has been cast is maintained stationary during the stripping operation. In other words, the forming elements of the mold unit are moved away from the cast structural element.

The mold unit FA is supported in a frame G' consisting of beams 250 extending vertically from a foundation 251, the beams supporting a series of cross beams 252 at their upper ends. Centrally of the framework G' there are provided two rows of posts 253 extending longitudinally of the foundation. The upper ends of the posts 253 are joined to the vertical beams 250 of the frame G' by stringers 254. If desired, a flooring may be laid upon the stringers 254.

As is best shown in Figure 45, two or more hydraulically controlled plungers 255 are spaced along the framework G' and along the line extending centrally of the posts 253. At its upper end each plunger 255 has secured thereto a number of horizontally arranged beams to form a platform or frame 256 indicated in full lines in Figures 43 and 45. As shown in Figure 43, the platform 256 extends only the width of the space between the two rows of posts 253. Platform 256 supports the longitudinal side walls 260 and 261 and the base plate 262 of the mold. Base plate 262 is spaced from the side walls 260 and 261 by bars hereinafter described. As is also shown in Figure 45, the end bracket 263 of the mold is fixed to the base plate 262. The platform 265 is arranged to move vertically with the plungers 255, the vertical movement of the platform being guided by rollers 265 journalled on these members and which move along the channeled posts 253 as shown in Figures 44 and 45.

Vertical rods 268 are arranged in pairs along the line on which the plungers 255 are arranged. The rods 268 are fixed to the foundation 251 and their upper ends lie in substantially the plane of the limit of upward movement of the lower edges of the vertically movable mold walls 260 and 261. As shown in Figure 46, at their upper ends the rods 268 support bars 270 which extend longitudinally of the unit and which are provided with rollers 271 in their upper surfaces. The bars 270 lie between sides of the base plate 262 and the adjacent surfaces of the mold side walls 260 and 261.

It will be observed from Figure 46 that the base plate 262 includes a rib 272 extending lengthwise thereof by means of which core elements 273 may be centered upon the base plate. The core elements are secured to the base plate by bolts such as indicated at 274 in Figure 46.

A number of cylinders 280 are secured to the upper framework 252 of the apparatus, these cylinders being provided with fluid operated plungers 281 having a press element 282 fixed to their lower and free ends. The press element 282 is of inverted T-form at its lower end, as indicated at 283, so that a face plate 284 may be positioned thereon by horizontal movement.

In the operation of the apparatus of Figures 43 and 47, with the press element 282 elevated to the dotted line position of Figure 43 and with the plungers 255, mold base plate 262 and mold

side walls **260** and **261** in the solid line position of Figure 43, a matrix **22**, for example, of the form illustrated in Figure 20, will be positioned upon the base plate **262**. The matrix thereby also rests upon the upper ends of the rods **268**. The cooperating wedge elements **288** may then be positioned between the adjacent end of the matrix **22** and the end bracket **263** fixed to the base plate **262** at each end of the mold space. The mold then may be filled with the concrete batch in the manner described above in connection with the unit A. An upper matrix, for example, of the form indicated at **36** in Figure 20 will then be positioned upon the batch. Then the press element **282** will be lowered to exert the desired pressure upon the upper matrix and, thereby, upon the concrete in the mold unit. This pressure will be resisted by the base plate **262** supported by the frames **256**, as well as by the fixed uprights **268**. During the time that the batch is in the mold unit, it may be heated by the heat radiating pipes **290** supplied with hot water or steam by means of flexible piping, not shown.

When the desired pressure has been applied, the press element **282** will be raised. Then the wedge elements **228** and the upper matrix **36** may be removed.

The plungers **255** will then be operated to move the base plate **262** end brackets **263** and the side walls **260** and **261** of the mold unit downwardly to the position indicated in dotted lines in Figure 43, leaving the cast structural unit E6 resting upon the lower matrix **22**. Matrix **22** and the cast structural element may then be moved to the left as viewed in Figure 45, so as to carry these parts out of the mold unit and on to a roller trackway **295**. The provision of the rollers **271** in the bars **270** will assist this movement. Structural element E6 may then be moved to a curing area just as has been described above in connection with the operation of the mold unit A.

The method of the present invention and as followed in the operation of all the apparatus described above may be used with various formulae of concrete or other moldable material. However, as a typical example, highly satisfactory results are obtained with a mixture consisting of one cubic foot of Portland cement, two cubic feet of sand (made up of ½ cubic foot of fine sand and 1½ cubic feet of coarse sand) and four cubic feet of aggregate, consisting of pea-size gravel or small size crushed stone. This formulae can be adjusted for particular localities, depending upon the types of sand or aggregate more readily available. Four and one-half gallons of water would be added for each cubic foot of cement, i. e., four and one-half gallons of water to seven cubic feet of the above proportions of cement, sand and aggregate.

In the formation of the structural elements of the type disclosed herein and in my prior application, a pressure of the order of 400 lbs. per square inch will be exerted upon the mass in the mold if only a reasonably smooth surface, and not a highly finished surface, is desired.

The pressure mentioned above will vary according to climatic conditions but 400 lbs. pressure per square inch for a reasonably smooth surface is usually sufficient under temperature and humidity conditions such as prevail in the coastal portion of South Carolina. In cooler and less humid areas the pressure may be decreased to obtain the same finish. The reasons for this are hereinafter more fully set forth.

One important result of the use of pressure is the compression of the structural elements to such consistency that they may immediately be removed from the molds. This result is assisted if the mold is heated so as to further drive moisture from the mixture. However, with a batch as dry as that stated above, to obtain proper heating, it is not necessary to leave the mixture in the mold for any longer than is necessary to carry out the placing of the material in the mold and the application of pressure. In other words, it is not necessary to prolong the operation in any way to further heat the material or the structural element. The heat required ranges from 100° to 600° F., the variance primarily depending on the atmospheric humidity and the finish desired. In other words, greater heat would be applied if the atmospheric humidity is high, or if a smoother finish is desired.

The temperatures stated must be uniform over the working faces of the mold walls. The heat will be applied to the sides walls which, being of metal, readily transfer it to the concrete mass.

If a smooth surface equal to that of finished plaster is desired, a pressure of 3,000 lbs. per square inch may be applied. As is hereinafter discussed, even this is not a limit under all conditions, though the pressure exerted must not be so high as to crush the aggregate.

As mentioned in the foregoing, the surfaces of the mold unit must be smooth and should be sprayed with oil to prevent the compressed concrete elements from being marred during removal from any portion of the mold unit.

The curing of the fabricated concrete elements can be performed in several ways. Under one system, curing can be accomplished by placing the element in a high humidity storage space for about eight hours, after which they can be removed and used in construction. A second curing method involves immersing the concrete element in a vat of water at room temperature immediately after it has been formed and leaving it so immersed for about eight hours, after which it can be removed and used in construction. Steam curing also may be used. The preferred method of curing is to spray the elements with water at normal temperature and then permit them to stand, protected from weather conditions in an enclosed storage shed, for about five days before they are used in construction. Because the present invention obviates the necessity of keeping the element enclosed in a form, curing is expedited.

By the methods of producing concrete structures heretofore generally used, whether pre-cast or molded in situ, concrete has not reached maximum or ultimate strength for twenty-eight days, even when curing is performed for seven days. In contrast to this, by the method of the present invention, the maximum or ultimate strength is reached within about nine days.

The formulae of concrete described above for use with my invention has heretofore ordinarily resulted in an element having a compressive strength of approximately 2,500 lbs. per square inch within twenty-eight days. By using the same formula with my present method, the ultimate compressive strength of the elements will reach a minimum of 20,000 lbs. per square inch in twenty-eight days. However, if the curing treatment is one of the four types I have stated should be used, viz., storage in a humid space, immersion, spraying with water, or steam curing, then the present method, involving application

of pressure during molding, results, within nine days, in a compressive strength which will be at least 4,000 lbs. per square inch.

The above-mentioned gains in strength of the finished product appear to be largely due to the application of pressure to the concrete mass, though the gains will also vary according to the mix used. In more detail, it is well known that some mixes give greater strength under usual procedure. The same holds true with my invention, but with a great increase in strength because of the pressure applied during molding.

If sufficient pressure is applied to the mass in the mold, no water need be used except that normally present in the sand. Moist sand contains approximately one quart of water per cubic foot; moderately wet sand contains approximately two quarts of water per cubic foot, and very wet sand contains approximately three quarts of water per cubic foot. Taking this into consideration, it will be observed that a mixture of the proportions stated above, viz., one cubic foot of Portland cement, two cubic feet of sand and four cubic feet of aggregate, would contain from one-half gallon to one and one-half gallons of water if the sand used is either moist, moderately wet or very wet. With one and one-half gallons of sand-carried water in the mix, no additional water need be added if the pressure is increased to the order of 1500 lbs. per square inch. If the pressure is still further increased, even the half gallon of sand-carried water resulting from the use of moist sand in the mix will enable the constituents to be properly bonded. In fact, if the pressure is increased sufficiently, only the moisture present in the sand by reason of atmospheric humidity will suffice to hold an element together for removal from the mold and transportation to the curing area. That is, application of enough pressure will cause the mass to become so dense that it will hold together with only the moisture present by reason of atmospheric humidity and the cement in the powdered form will be compressed into all of the voids to thereby form a bonding agent.

After the element has been transported to the curing area, any of the four types of curing mentioned above will, of course, result in increase of moisture in the element for the necessary hydration.

It has been indicated above that with a mix including a given amount of moisture, an increase of pressure will result in a smoother finish. Likewise, if the amount of moisture is decreased, it usually follows that a given amount of pressure will result in a smoother finish. This is due to the fact that the less water the mixture contains, the less possibility there is of water-formed pockets on the surface of the element. The increase in pressure causes the moisture to be more evenly distributed within the mass so that fewer pockets will be present on the surface of the element by reason of moisture.

Another way in which too much moisture will result in a less smooth-surfaced element is because of the tendency of the moisture to make the mix tacky so that surface portions of the compressed element will adhere to the mold when the latter is stripped from the element, or vice versa. Increase of pressure will reduce the tackiness to some extent because it will cause the moisture to be thoroughly distributed within the element.

It will be apparent from the discussion of the effect of moisture set forth immediately above, that in areas which are cooler and less humid than coastal South Carolina, the pressure may be reduced with loss of smoothness of finish. That is, the less humid atmosphere will result in less moisture naturally present in all constituents and, therefore, not as much pressure will be required to distribute the moisture within the element. Correspondingly, with less moisture in the mix, less heating of the mold will be required to drive off moisture.

The surfaces of the structural elements can be colored or decorated in any desired manner, for example, by placing colored frit or the like in the molding space before the concrete mass is placed therein, or by placing such colored particles upon the mass before the upper matrix is placed thereon.

Because my method enables the elements to be quickly shaped to finished form and then removed from the mold for curing, the actual labor involved requires only a short period of time. The briefness of the molding operation also enables a relatively small amount of equipment to be so used as to result in a large output.

It will be obvious that the method and apparatus of the present invention are applicable to the production of numerous forms of structural elements other than those described herein.

The terminology used in the specification is for the purpose of description and not of limitation, the scope of the invention being defined in the appended claims.

I claim:

1. In an apparatus for producing concrete structural beams, a mold including a form supporting portion comprising horizontally extending fixed members extending transversely of the length of the form, said members being spaced from each other, a plate supported on said members and extending lengthwise of the form, and vertically extending ejectors positioned between adjacent of said members, said ejectors being arranged in two series with the respective series positioned adjacent the opposite longitudinal edges of said plate, a form portion comprising vertically extending pairs of side and end walls supported on said transverse members, a bottom matrix including a pair of longitudinal and parallel bars supported on said transverse members and the upper ends of said ejectors, said matrix further including transversely extending and spaced webs extending between the matrix bars and across said plate, cores supported on said plate intermediate the webs of said matrix, and an upper matrix and superimposed press element, said upper matrix being of the same form as said bottom matrix and adapted to be positioned on a mass of concrete in the form portion with its webs extending between the upper ends of the cores.

2. An apparatus of the character described in claim 1 including means to move the ejectors vertically.

3. An apparatus of the character described in claim 1 including means to apply pressure to said press element.

4. An apparatus of the character described in claim 1 wherein one series of ejectors of the form supporting portion is adjustable transversely of the form supporting portion, and one side wall of the form portion is adjustable transversely of the form portion.

5. An apparatus of the character described in claim 1 including bodily and vertically telescopic

members positioned upon the bottom matrix intermediate the length of the latter.

LEONARD D. LONG.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
384,295	Stockwell	June 12, 1888
646,964	Esch	Apr. 10, 1900
785,272	Robbins	Mar. 21, 1905
795,488	Coxe	July 25, 1905
1,429,459	Schol	Sept. 19, 1922
1,619,734	Jeppson et al.	Mar. 1, 1927
1,695,327	Goldston	Dec. 18, 1928
1,777,660	Dahl	Oct. 7, 1930
2,007,063	Rolland	July 2, 1935
2,193,847	Strong	Mar. 19, 1940
2,271,066	Ehrenhaft	Jan. 27, 1942
2,290,339	Leach	July 21, 1942
2,303,884	Krehbiel et al.	Dec. 1, 1942
2,334,804	Atterbury	Nov. 23, 1943
2,395,216	Fitzpatrick	Feb. 19, 1946
2,427,044	Burns	Sept. 9, 1947