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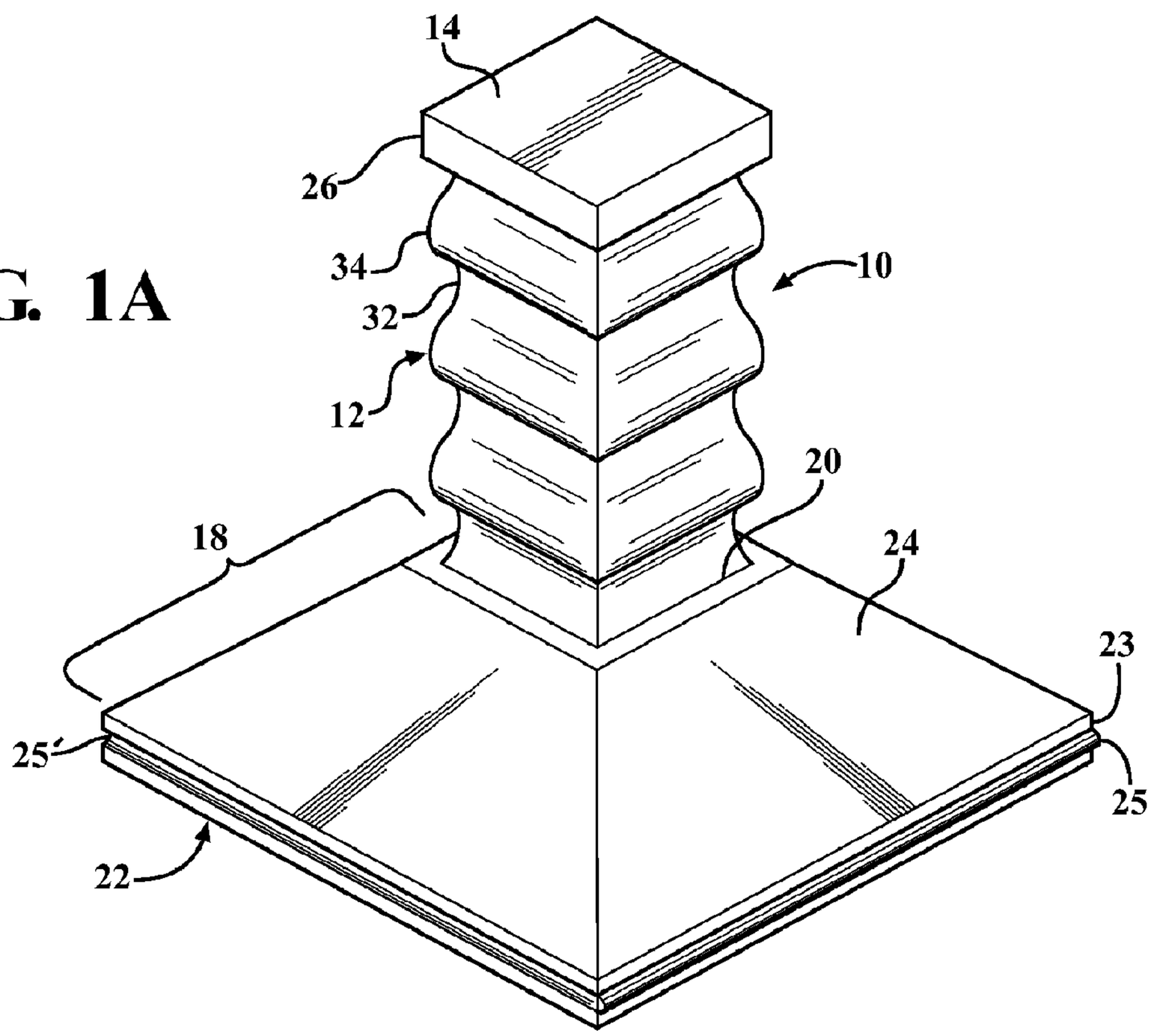
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(54) Titre : ELEMENT STRUCTURAL REFRACTAIRE
(54) Title: REFRACTORY STRUCTURAL ELEMENT

FIG. 1A



(57) Abrégé/Abstract:
A refractory strucutral element is provided that is useful for lining the inner surface of a construct typically used as a kiln or other high temperature system. An element includes a stem portion associated with a flared end block portion whereby the flared end

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(57) Abrégé(suite)/Abstract(continued):
block portion is compatible with other strucutral elements to form a substantially continuous tiled surface when a plurality of refractory structural elements are laid adjacent to each other. The stem portion optionally has a plurality of protrusions decorated on its outer surface that may serve to adjust heat dissipation from the element.

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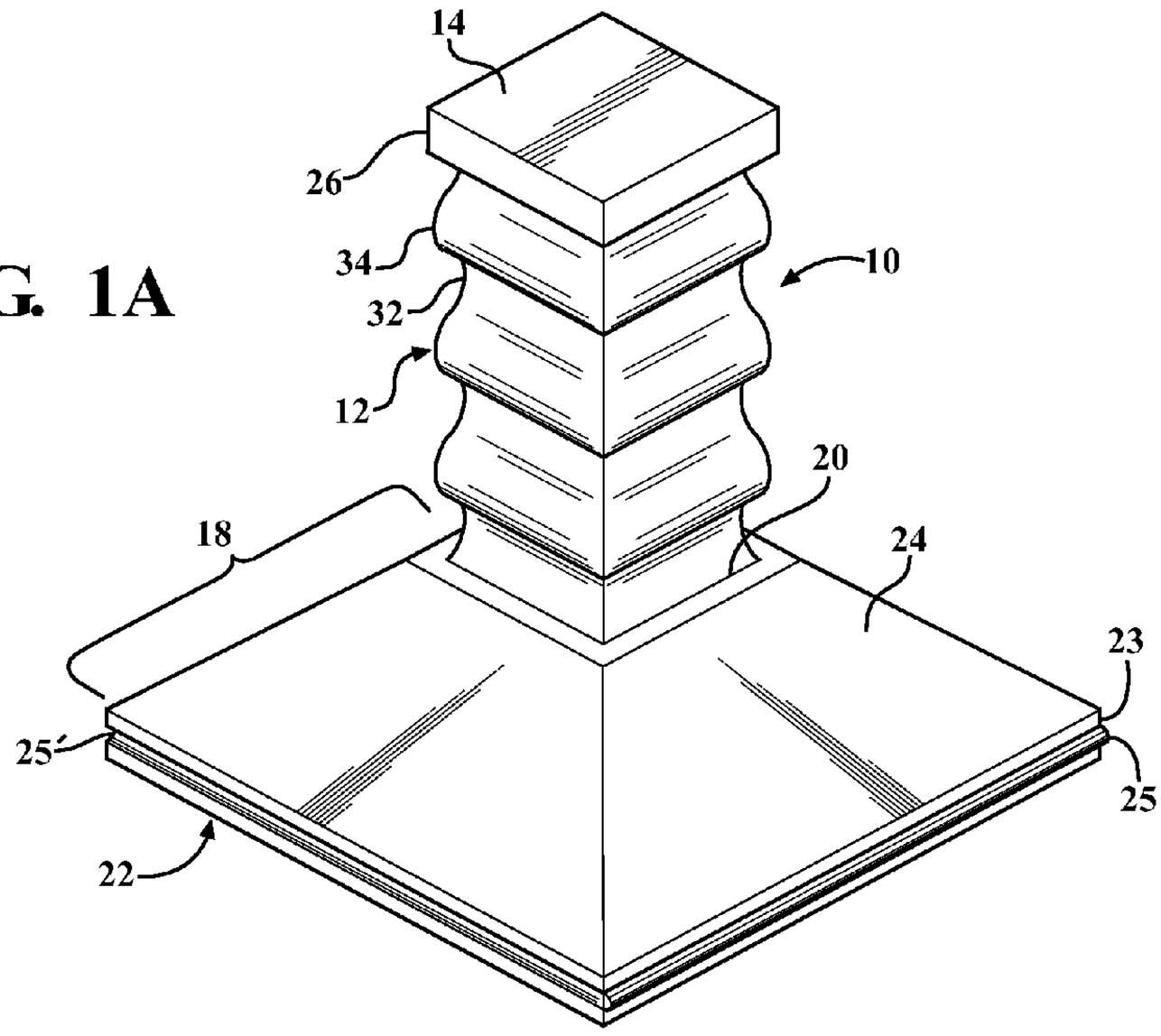
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[Continued on next page]

(54) Title: REFRACTORY STRUCTURAL ELEMENT

FIG. 1A



(57) Abstract: A refractory strucutral element is provided that is useful for lining the inner surface of a construct typically used as a kiln or other high temperature system. An element includes a stem portion associated with a flared end block portion whereby the flared end block portion is compatible with other strucutral elements to form a substantially continuous tiled surface when a plurality of refractory structural elements are laid adjacent to each other. The stem portion optionally has a plurality of protrusions decorated on its outer surface that may serve to adjust heat dissipation from the element.

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REFRACTORY STRUCTURAL ELEMENT

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application depends from and claims priority to U.S. Provisional Patent Application No. 61/362,489, filed July 8, 2010, the entire contents of which are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to refractory materials and in particular to a cast structural element from which furnaces, kilns, and other high temperature forms are constructed.

BACKGROUND OF THE INVENTION

[0003] A conventional high temperature construct such as a furnace or kiln is based on the interlocking of rectilinear bricks to form a desired construct. The sides of the bricks often are produced with undulations to facilitate interlocking and limit material and heat transfer along the sides of such bricks. Specialized variants of such conventional bricks have a rearward facing end relative to the face defining a surface of the kiln or furnace, the rearward end engages a hanger so as to form a roof portion for such a construct.

[0004] These conventional bricks suffer a number of limitations that add to the cost of creating a high temperature construct and the maintenance thereof. These limitations include an inefficient use of material along the sides of the brick between the face defining a surface of the high temperature construct and the rearward face, as well as a limited ability to tailor the properties of a construct formed from such bricks to the conditions of temperature and corrosivity associated with the intended usage of the construct.

[0005] Thus, there exists a need for a refractory structural element that more efficiently forms a portion of a high temperature construct. There also exists a need for a refractory structural element that is readily tailored so as to match the thermal and compositional conditions that the construct will experience in operation.

SUMMARY OF THE INVENTION

[0006] The following summary of the invention is provided to facilitate an understanding of some of the innovative features unique to the present invention and is not intended to be a full

description. A full appreciation of the various aspects of the invention can be gained by taking the entire specification, claims, drawings, and abstract as a whole.

[0007] A refractory structural element is provided that can be made of a variety of cementitious materials that is useful for lining a construct exposed to high internal temperatures or other extreme conditions. A refractory strucutral element is formed in a shape having a stem portion, the stem portion having a first end and a second end, the second end associated with a flared end block portion, the flared end block portion including a face, the face having a cross sectional dimension that is greater than a cross sectional dimension of said stem portion. This provides an element that creates a space filling end and a space behind the space filling end.

[0008] The stem portion is optionally continuous with the flared end block portion or is formed of a separate material (same or different) that is then physically associated with the flared end block portion either fixedly or removably. A stem portion has a cross sectional shape. A stem cross sectional shape is optionally circular, ellipsoidal, or polygonal. The side of the stem portion is optionally decorated with protrusions. These protrusions increase the surface area of the stem portion relative to that of a smooth cylinder. Such protrusions may be in a variety of shapes including undulations, spirals, ridges, irregular scores, or a combination thereof. A stem portion also optionally includes a flange operable to engage a fastener for securement of the element to a substrate such as the interior surface of a construct.

[0009] The space created by the shape of an element optionally includes fill material surrounding the stem portion. A fill material is optionally ceramic fiber, perlite, vermiculite, or combinations thereof.

[0010] The face of the flared end block portion is intended to be directed to the interior of a construct. The shape of this face is optionally planar or arcuate. An arcuate face is optionally convex, concave, irregular, or other shape. The flared end block portion has a first edge that optionally includes a contour feature where the contour feature is shaped to interlock with a complementary feature of a complementary refractory article to be located adjacent to the refractory structural element. A second edge of a flared end block portion optionally includes a complementary contour feature. A complementary contour feature optionally has a complementary shape to a contour feature. The shape of a contour feature or a complementary contour feature is optionally a tongue, groove, pin, socket, or combinations thereof.

[0011] On a side opposing a face, a flared end block portion optionally is shaped to include one or more walls extending from an edge of the flared end portion to the second end of the stem. The walls are optionally angled relative to a plane of the face where the plane is defined

by the outer edges of the face. A flared end block portion has a thickness that is optionally uniform over the plane of the face. Optionally, the thickness of the flared end block portion at a central point is greater than the thickness at an edge of the flared end block portion.

[0012] A heat refractive cementitious material is optionally used to form a refractory structural element. A cementitious material is optionally a phosphate-bonded cement.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Fig. 1 is a partial cutaway view of an inventive refractory structural element (A) with a flange associatable with a fastener (B);

[0014] Fig. 2 is a perspective view of an alternate embodiment of an inventive structural element;

[0015] Figs. 3A-3C are exemplary end block portions of an inventive refractory structural element; and

[0016] Figs. 4A-4C are exemplary edge profiles of stem portions of an inventive refractory structural element.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0017] The following description of particular embodiment(s) is merely exemplary in nature and is in no way intended to limit the scope of the invention, its application, or uses, which may, of course, vary. The invention is described with relation to the non-limiting definitions and terminology included herein. These definitions and terminology are not designed to function as a limitation on the scope or practice of the invention but are presented for illustrative and descriptive purposes only.

[0018] The present invention has utility as a structural element for the construction of a refractory construct such as an incinerator, kiln, oven, or furnace; or conduits or other structures in thermal communication with such a construct. An inventive element is operative in forming various surfaces of the construct including a base, a side wall, a roof, or tubular structure.

[0019] Referring now to Fig. 1A, an inventive refractory structural element is shown generally at 10. The element 10 includes a stem portion 12 having a first end 14 and a second end 16. A stem portion has a length and a cross sectional dimension. A length is optionally from 5 to 50 cm, or any value or range therebetween. A cross sectional dimension is optionally from 0.5 to 10 cm. A stem portion has a cross sectional area that is optionally circular, elliptical,

or other irregularly curved shape, or polygonal such as triangular, square, pentagonal, hexagonal, or other polygon of any number of sides.

[0020] A flared end block portion 18 is associated with a second end 16 illustratively by being continuous with or joined to the second end 16. While the unitary, joined version of an element 10 is depicted in Fig. 1, a dashed line 20 is provided to depict an optional joinder from a multipart element 10. It is appreciated that a flared end block portion 18 is made from the same material or a different material than the stem portion 12. The flared end block portion has a face 22. The face 22 is intended to be proximal to a heat source or otherwise define a confinement surface of the construct. Optionally, the face 22 is shaped to be space filling. As used herein, "space filling" is defined as able to propagate through and cover a space only with resort to translation of the face shape. With joinder of multiple elements 10, the face 22, and duplicates thereof or complementary faces, readily tile a planar or curved space that is operative in the context of a construct to form a floor, side wall, or roof of a construct.

[0021] A face optionally has a cross-sectional dimension that is from 10 to 50 cm, or any value or range therebetween. A cross sectional dimension is optionally the length of an edge, a diagonal, a diameter, or other dimension across the face from one edge to another edge.

[0022] A flared end block portion has a thickness that is either uniform across the cross sectional dimension of a flared end block portion, is irregular, or sloping. A thickness is appreciated to be sufficient at the narrowest dimension to provide sufficient heat refraction for operation. Illustratively, a thickness is from 1 to 10 cm, or any value or range therebetween.

[0023] In some embodiments, an element has one or more walls extending from an edge 23 to the second end 16. The walls are optionally sloped such that the flared end block portion has a thickness in the center that is greater than at the edge. The ratio of the thickness of the center to the thickness of the edge of a flared end block portion is optionally from 0.1-1 to 1-0.1. As such, the central point of a flared end block portion is optionally thicker or thinner than the thickness at an edge. The number of walls is optionally identical to the number of edges of a flared end block portion. Illustratively, the number of walls is 3, 4, 5, 6, 7, 8, or more. A wall optionally slopes at an angle relative to the plane of a face of the flared end block portion. Such angles are optionally from -20 degrees to 60 degrees, or any value or range therebetween depending on the relative dimensions of the flared end block portion and the stem portion. The slope of a wall is optionally uniform so as to provide a substantially flat wall, or is curved. A curved wall optionally increases in angle from the edge to the stem portion, or decreases in angle from the edge to the stem portion. In some embodiments, a single wall is present such as a

conical or globed wall that is continuous with the outer edges of the flared end block portion. While the walls of FIG. 1A are substantially pyramidal in shape, it is appreciated that a flared end block portion need not have pyramidal sloped walls 24 or a face 22 that is planar. Alternative flared end block portions relative to 18 are provided in Figs. 3A-3C.

[0024] The stem portion 12 has a side 32 optionally including protrusions shown generally at 34. The protrusions 34 decorate the side 32 or are integral with the side 32. The protrusions may take a variety of forms illustratively including undulations, spirals, ridges, regular or irregular scores, or combinations thereof. The protrusions, regardless of the form, function to increase the surface area of the side 32. This additional surface area on the side 32 allows for additional radiative heat dissipation as well as provides additional surface area for interlocking of element 10 with other joining pieces and/or mortar. In addition to the protrusions 34, other illustrative side profiles for such protrusions are depicted in Fig. 2 and Figs. 4A-4C. Optionally, any shape to the protrusions are operable so long as the presence of the shape increases the surface area of the side relative to a smooth cylinder.

[0025] As depicted in FIG. 1B, a stem portion 12 optionally has a first end 14 configured to be complementary to a fastener 28, either conventional or specific to the first end 14. A fastener 28 is fixedly or removably associated with an anchoring optionally formed from refractory brick that forms the inner surface of a construct. As depicted in FIG. 1B, a first end 14 optionally includes a flange 26 that is complementary to the fastener 28 to provide fixed or removable association of the element 28 with the fastener. While FIG. 1B illustrates a flange in a circular or ellipsoidal configuration, it is appreciated that other shapes are similarly operable such as a any pentagonal shape, or an irregular shape.

[0026] Optionally, the flared end block portion 18 has an edge 23 that has a contoured feature 25 to interlock with a complementary feature on another refractory article (not shown), the other refractory article optionally being another element 10, or an element with a shape complementary to the end block portion of the element 10, to better join an inventive element to neighboring elements and thereby form a more robust refractory construct. A flared end block portion optionally has 3, 4, 5, 6, 7, 8, or more edges. A contour portion on a flared end block portion on a first edge is optionally a complementary feature to a contour portion on a different edge.

[0027] While contour feature 25 is shown as a protrusion, a complementary contour feature as a recess (e.g. groove) is depicted at 25′. In addition to the tongue-and-groove contour features depicted in Fig. 1A, it is appreciated that other contour features are operative herein illustratively

including dovetails, pin and socket, and other such complementary features conventional to the joinder arts. As such, a contour feature is optionally a tongue (optionally rectilinear or curved), groove (optionally rectilinear or curved), angular so as to form a dovetail joint, pin shape such as a tenon or cylindrical protrusion, or socket shape such as that of a mortise (rectangular or curved).

[0028] A edge optionally includes a plurality of contoured features, complementary features, or both. Contoured features and complementary features are optionally interdispersed, optionally to form an undulating surface for interlocking with another refractory structural element or other surface. The number of contoured features or complementary features is optionally 1, 2, 3, 4, 5, 6, or more.

[0029] FIG. 2 is a perspective view of an alternate embodiment of a structural element shown generally at 40. The element 40 is readily formed from the same materials and by the same techniques as element 10. Additionally, element 40 is also amenable to formation of the stem portion 42 and the flared end block portion 48 as unitary or joined portions consistent with the above description relative to element 10. The face 52 of element 40 is noted to be a regular hexagon in shape and also suitable for space filling to tile a plane or other shaped surface. The end block portion 48 optionally has walls 54 extending approximating parallel to the face 52 in this or other embodiments. The stem 42 is depicted as having a side 62 defined by a spiral protrusion. A first end 44 of the stem portion 42 has a flange 56 and adapted to fixedly or removably engage an anchoring fastener optionally the like of those conventional to the art. In addition to a stem portion 42 having a circular cross section, it is appreciated that this cross section is readily distorted to form an ellipsoidal cross section. Additionally, it is appreciated that the face 52 in addition to being planar is also formed to be arcuate to form either a concave or convex surface, optionally as illustrated in exemplary form in Figs. 3A-3C.

[0030] Owing to strength properties at elevated temperatures above 1000° Celsius and nonwetting properties relative to molten metals, phosphate bonded cements can be used as a substance from which an element is formed. It is appreciated that other cementitious materials can be used to form a refractory structural elements depending on the eventual exposure requirements of the element.

[0031] In some embodiments, a refractory structural element is made from a phosphate bonded cementitious material that is formed from a phosphate based component and an alkali earth component such as that described in U.S. Patent 7,503,974. The alkali earth ion component has as a majority source a calcium aluminate calcium ion source of dodeca-calcium hepta-

aluminate, or tricalcium aluminate. Magnesium oxide that has been fused and crushed to a size of less than 200 microns, alone or in combination with the calcium aluminate calcium ion source is also provided as the alkali earth ion component.

[0032] An exemplary phosphate based component includes phosphoric acid, calcium phosphate, potassium phosphate, magnesium phosphate, sodium phosphate, aluminum phosphate, ammonium phosphate, zinc phosphate, boron phosphate, and combinations thereof.

[0033] An alkali earth ion component optionally includes magnesium oxide, dolomite, zinc oxide, aluminum oxide, calcium oxide, lithium carbonate, barium carbonate, barium sulfate, molybdenum oxide, calcium hydroxide, aluminum hydroxide, tin oxide, nickel oxide, nickel hydroxide, cobalt oxide, cobalt hydroxide, vanadium oxide, magnesium hydroxide, iron oxide, titanium oxide, chromium oxide, chromium hydroxide, dolomite, manganese oxide, zirconium oxide, zirconium hydroxide, NaOH, KOH, sodium carbonate, and potassium carbonate.

[0034] The alkali earth ion component may be predominantly dodeca-calcium hepta-aluminate (C_1A_7 or mayenite), tricalcium aluminate (C_3A), or a combination thereof. The calcium aluminate optionally has a mean particle size of less than 100 microns, optionally 60 microns or less. Typical loadings of $C_{12}A_7$ in a fully formulated cementitious material inclusive of aggregate is from 0.5 to 5 total weight percent with $C_{12}A_7$ typically being present at about one-fourth the weight percent of CA and/or CA_2 calcium aluminate used in other cementitious materials. C_3A is typically present from 0.3 to 4 total dry weight percent of a cementitious material used to form a refractory structural element.

[0035] Other materials may be included in a cementitious material are illustratively, one or more tackifiers such as: carbohydrates such as saccharides and polysaccharides; starch and derivatives such as pregelatinized starch, dextrin, and corn syrup; naphthalene sulfonate formaldehyde condensate polymers; melamine sulfonate formaldehyde condensate polymers; polyhydroxy polycarboxylic compounds such as tartaric acid and mucic acid; lignosulfonic acid; and salts of any of the aforementioned acid moieties of tackifiers. A tackifier is optionally present at 0.01 to 6 total dry weight percent. Plasticizers and strength enhancing agents such as insoluble phosphate are optionally included. Some embodiments include one or more dispersants such as polycarboxylates and conventional surfactants conventional to the field. Optionally a cementitious material includes one or more deflocculants such as a polyalkylene glycol optionally at 0.05 to 1 weight percent.

[0036] A refractory structural element is optionally cured in a drum heater with internal heating units. A heating temperature in the range of 75°F (23° C) to 150° F (66° C) is commonly

used for this purpose. Heating also promotes the flowability of viscous material. Exemplary types of heaters include band heaters, immersion heaters, and heating cabinets. A band heater is equipped with aluminized steel shell which delivers up to 3,000 Watts of heating power with operating heating temperatures in the range of 60° F (75° C) to 400° F (205° C). Additionally, an area blanket or quilt is used to insulate a drum heater. Optionally, a temperature shutoff device is installed with a heater for the purpose of preventing overheating of phosphate based component.

[0037] In other embodiments, a refractory structural element is formed from a cementitious material that includes a plurality of aggregate ceramic particles and a binder sintered to the plurality of aggregate ceramic particles, where the binder includes crystalline aluminum orthophosphate distributed in the binder as the result of reaction of aluminum metaphosphate with alumina. The plurality of aggregate ceramic particles optionally includes bauxite particles. In some embodiments, the plurality of aggregate ceramic particles includes at least one of silicon carbide, fumed silica, or mullite.

[0038] With the refractory aggregate containing alumina, Al_2O_3, the aluminum metaphosphate reacts to form crystalline aluminum orthophosphate, $AlPO_4$. Aluminum orthophosphate is the thermodynamic product upon heating to a temperature greater than about 580° Celsius with a decomposition temperature of about 1650° Celsius. The resultant cementitious material is amenable to incorporation of reinforcing materials such as steel fibers and is operative with aggregate particulate including silicon carbide, mullite, alumina, titania, and combinations thereof. Such a cementitious material is readily formed with a density of greater than 90%, a theoretical density and cold crush strengths in excess of 88 Newtons per square millimeter. Through control of water content and conventional additives, the cast form of refractory structural element has sufficient green strength to be handled and optionally machined prior to firing to provide a refractory structural element with superior strength and alkali resistance, as compared to conventional materials.

[0039] A bindery for a cementitious material optionally includes aluminum metaphosphate that is mixed aggregate ceramic particles and processed under conditions to afford aluminum orthophosphate as a crystalline binder. The binder aluminum orthophosphate optionally has berlinite as a predominant phase. It is appreciated that aluminum metaphosphate as binder precursor is amenable to inclusion in a kit as aluminum metaphosphate is far less hygroscopic as compared to phosphoric acid, more pH neutral (around pH 5) and is commercially available in a variety of particle mesh sizes. The reaction of aluminum metaphosphate with alumina (synonymously termed bauxite herein) to form a crystalline binder phase of aluminum

orthophosphate (synonymously referred to herein as berlinite) is detailed with respect to the following equation:

$$Al(PO_3)_3 + Al_2O_3 \rightarrow 3\ AlPO_4 \quad (I)$$

[0040] Aluminum orthophosphate appears to be a thermodynamically stable phase that is formed upon heating the reagents to a temperature above about 580° Celsius. Aluminum orthophosphate is noted to have a decomposition temperature of about 1650° Celsius at ambient pressure. It is appreciated that the formation temperature of aluminum orthophosphate varies according to predictable thermodynamic relationships when the reaction proceeds at pressures other than atmospheric pressure. It is appreciated that formation of a refractory composition according to the present invention readily occurs through firing the green form of an article through hot isostatic pressing (HIP). It is appreciated that a mixed metal orthophosphate is readily formed according to the reaction:

$$Al(PO_3)_3 + Al_{2-x}MO_3 \rightarrow Al\ Al_{2-x}MPO_4 \quad (II)$$

where M is Sb, Bi, B, Cr (III), Er, Gd (III), In (III), Ni (III), Rh (III), Sm (III), Sc (III), Tb (III), Ti (III), W (III), V (III), Yb (III), or Y (III); and x is 0, 1, or 2.

[0041] The amount of aluminum metaphosphate present to form a matrix around refractory ceramic particulate depends on factors including size of the ceramic particulate, desired interparticle separation, morphology, size of primary crystals and oxide state. Optionally, aluminum metaphosphate is present between 2 and 20 total weight percent of the fully formulated cementitious material casting slurry. Alumina is optionally present in excess of molar stoichiometry of alumina metaphosphate. It is appreciated that alumina is present as aggregate ceramic particles or alternatively is added as a minor quantity of the ceramic particles for reaction with the alumina metaphosphate.

[0042] To facilitate mixing of ceramic particle aggregate and alumina metaphosphate as a binder precursor, a quantity of water or organic solvent is added to afford a slurry of a desired viscosity. Such organic solvents illustratively include alcohols, ketones, esters, ethers, amides, amines, glycols, alkanes, and the like. Optionally, such organic solvents are liquids below 200° Celsius, and optionally, are liquids at 20° Celsius. Loadings of water or solvents optionally range from 2-20 total weight percent of a fully formulated cementitious material slurry. Optionally, additives are included that are consumed during berlinite formation, these additives provided to promote ease of handling. Such additives illustratively include surfactants; polymerizable organic monomers or oligomers, deflocculants; polymers; and organic acids such as citric, and oxalic. While one of ordinary skill in the art can readily adjust slurry viscosity and

green strength through the inclusion of such additives, typically each such additive is present from 0.01-5 total weight percent of a fully formulated refractory composition slurry. It is appreciated that the inclusion of organic monomeric or oligomeric polymerizable materials that upon cure can improve the green strength of the composition prior to firing or reaction according to Equation (I) or (II). The resultant polymer is decomposed and therefore not present in the resultant refractory composition. Exemplary of such organic polymers are acrylic acids, acrylates, polyethylene glycols, and polycarboxylate ethers, which are added as polymeric precursors or slurry soluble preformed polymers.

[0043] Handling properties of a cementitious material slurry and the green strength of a refractory structural element formed therefrom after drying are also optionally modified through inclusion of nonfacile additives. While the amount of such nonfacile additives is controlled by factors including desired green strength, refractory composition, working environment, temperature and corrosivity, desired cold crush strength, and setting time, working time and curing time, typical loadings of such nonfacile additives range from 0.1 to 10 total weight percent of a fully formulated cementitious material slurry. Representative nonfacile additives operative herein include calcium aluminate cement, sodium silicate, fumed silica, alkali metal or alkali earth polyphosphates, and organic salts like citric, oxalic or nitric acids, calcium silicate cement, potassium silicate, lithium silicate. Optionally, a nonfacile additive is present in a quantity such that the aluminum orthophosphate forms a continuous matrix phase.

[0044] Ceramic particle aggregate embedded within an aluminum orthophosphate binder according is limited only by the desired properties of the resultant cementitious material and compatibility with aluminum orthophosphate binder. Operative ceramic particle aggregates illustratively include bauxite, tabular alumina, mullite, silicon carbide, fused silica, rutile, and andalusite, sillimanite, magnesite, forsterite, kyanite, Mg spinell, and chromium oxide. Typical loadings of aggregate ceramic particles range from 50-95 weight percent of a fully formulated refractory composition slurry. Typical aggregate particle sizes range from 0.1 to 1000 microns. It is appreciated that the aggregate particles can be in a variety of forms including spherical, polyhedral, irregular, and combinations thereof.

[0045] A cementitious material optionally includes strengthening fibers such as steel fibers as detailed in U.S. Patent Nos. 4,366,255. Additional, illustrative reinforcing fibers include nickel and chromium fibers and synthetic fibers such as polypropylene (PP), polyethylene (PE), and polyethylene terephthalate (PET). Optionally steel fibers are used containing aluminum within the steel alloy to form a protective layer of alumina on the steel fiber at elevated

temperature. Optionally, the steel fiber has from 0.05 to 8 atomic percent aluminum content. Other strengthening fiber fillers operative herein include carbon fibers with the recognition that firing occurs in a reducing atmosphere. Typical loadings of fibers are from 0 to 50 total weight percent of a refractory composition used to make a refractory structural element.

[0046] A cementitious material used to form a refractory structural element optionally includes one or more aggregate components. An aggregate component is typically present from 50 to 95 total dry weight percent. Typical aggregates illustratively include: flint clay, mulcoa, basalt, olivine, diatomite, vermiculite, perlite, molochite, gibbsite, kyanite, mullite, chromite, tabular alumina, silicon oxide, silica, calcined bauxite, chrome oxide, zirconia, phosphate rock, and mixtures thereof.

[0047] A refractory structural element is optionally cast from a variety of cementitious materials other than those disclosed herein such as a variety commercially available materials from Stellar Materials, Inc., Boca Raton., FL. Illustrative examples of materials and methods of their production can be found in U.S. Patent Nos. 6,447,596; and 5,888,292.

[0048] The element, depending on particulars of the shape, is readily cast from two part or multiple part molds through techniques conventional to the art.

[0049] In operation, a refractive structural element forms a space created by projection of the flared end portion backwards towards the first end created by the smaller dimensions of the stem portion and the space surrounding the sides. This space is optionally filled with a fill material illustratively including ceramic fibers, perlite, vermiculite, and combinations thereof alone or retained within a bonded matrix. Space filling with one or more fill materials allows a user to adjust the radiative heat dissipation or insulative characteristics of a construct associated with one or more refractory structural elements to the user's needs.

[0050] One of skill in the art will appreciate that a refractory structural element affords more efficient use of cementitious material from which the element is formed and also through the use of a comparatively small dimension stem relative to the element face, and the ability to form cavities within the element so that adjustment of the operational properties of the element are readily controlled, as compared to conventional bricks.

[0051] The shape of a refractive structural element is optionally used to line the surface of a construct with one or more of many different surface geometries. Refractory structural elements are capable of forming planar or curved surface areas while retaining a desired tight association between the faces of multiple elements.

[0052] Various modifications of the present invention, in addition to those shown and described herein, will be apparent to those skilled in the art of the above description. Such modifications are also intended to fall within the scope of the appended claims.

[0053] It is appreciated that all materials are obtainable from sources known in the art unless otherwise specified.

[0054] Patents and publications mentioned in the specification are indicative of the levels of those skilled in the art to which the invention pertains. These patents and publications are incorporated herein by reference to the same extent as if each individual patent or publication was specifically and individually incorporated herein by reference.

[0055] The foregoing description is illustrative of particular embodiments of the invention, but is not meant to be a limitation upon the practice thereof. The following claims, including all equivalents thereof, are intended to define the scope of the invention.

CLAIMS

1. A refractory structural element comprising:

a cementitious material in a shape having a stem portion, the stem portion having a first end and a second end, the second end associated with a flared end block portion, said flared end block portion including a face, said face having a cross sectional dimension that is greater than a cross sectional dimension of said stem portion.

2. The element of claim 1 wherein the flared end block portion is continuous with the stem portion.

3. The element of claim 1 wherein the stem portion has a side decorated with protrusions.

4. The element of claim 3 where the protrusions are undulations, spirals, ridges, irregular scores, or a combination thereof.

5. The element of claims 1 or 3 further comprising fill material surrounding the stem portion.

6. The element of claim 5 wherein said fill material is ceramic fiber, perlite, vermiculite, or combinations thereof.

7. The element of claims 1 or 3 wherein the first end of the stem portion includes a flange operable to engage a fastener for securement of the element to a substrate.

8. The element of claims 1 or 3 wherein said face is space filling.

9. The element of claims 1 or 3 wherein the face is planar or arcuate.

10. The element of claim 8 wherein the face is planar, convex arcuate, or concave arcuate.

11. The element of claims 1 or 3 wherein said flared end block portion has a first edge contoured with a contour feature, said contour feature shaped to interlock with a complementary feature of a complementary refractory structural element.

12. The element of claim 11 wherein said contour feature is shaped as a tongue, groove, pin, or socket.

13. The element of claim 11 wherein said element has a second edge with a complementary contour feature.

14. The element of claims 1 or 3 wherein said stem portion has a circular or ellipsoidal cross sectional shape.

15. The element of claims 1 or 3 wherein said stem portion has a polygonal cross sectional shape.

16. The element of claims 1 or 3 wherein said flared end block portion has a plurality of sloped walls, each wall extending from an edge of said flared end portion to the second end of said stem.

17. The element of claims 1 or 3 wherein said face has a central point and the thickness of the flared end block portion at said central point is greater than the thickness at an edge of said flared end block portion.

18. The element of claims 1 or 3 wherein said cementitious material is a phosphate-bonded cement.

19. The element of claims 1 or 3 formed of a cementitious material substantially as described herein.

20. A refractory structural element substantially as described herein.

FIG. 1A

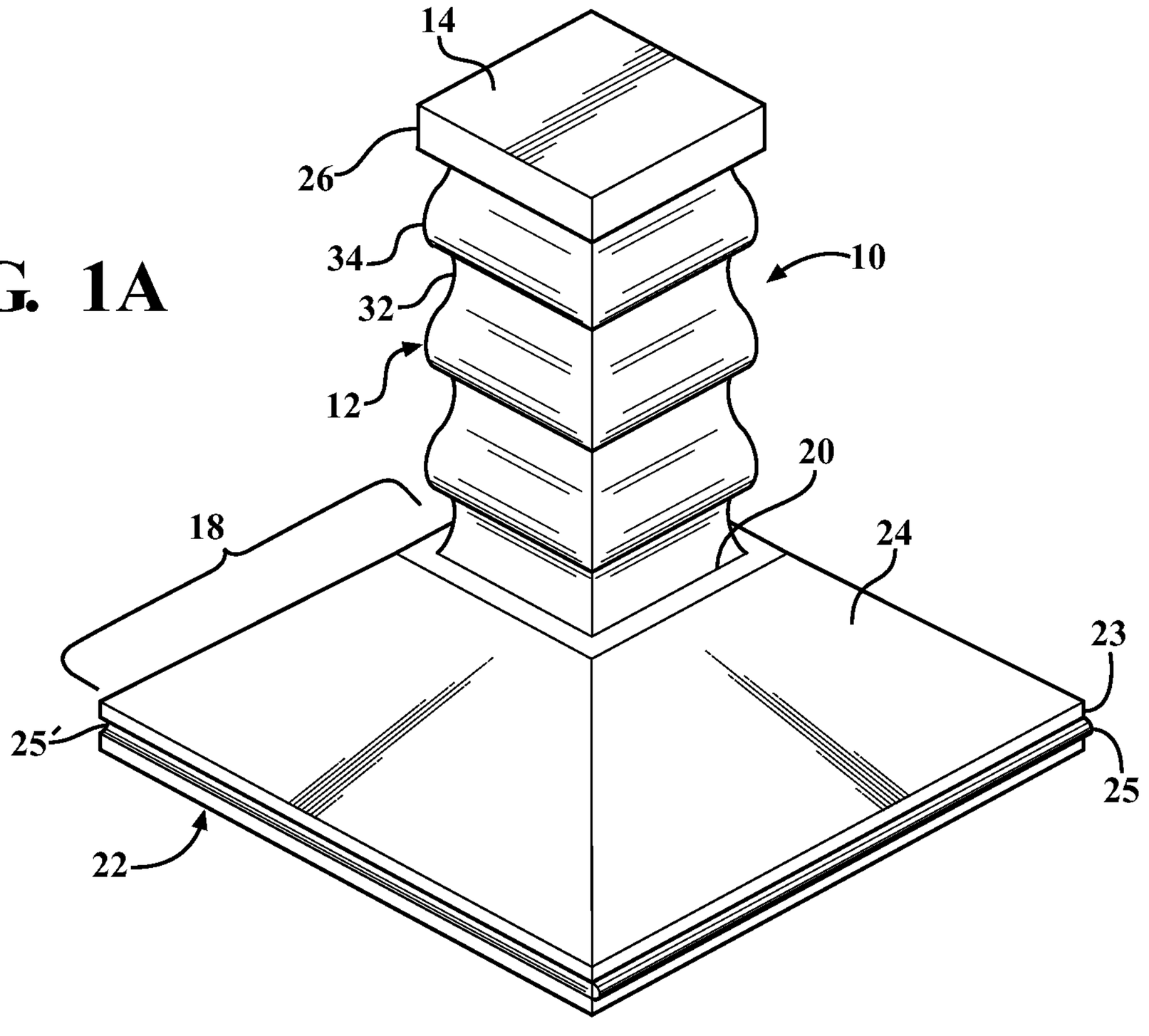
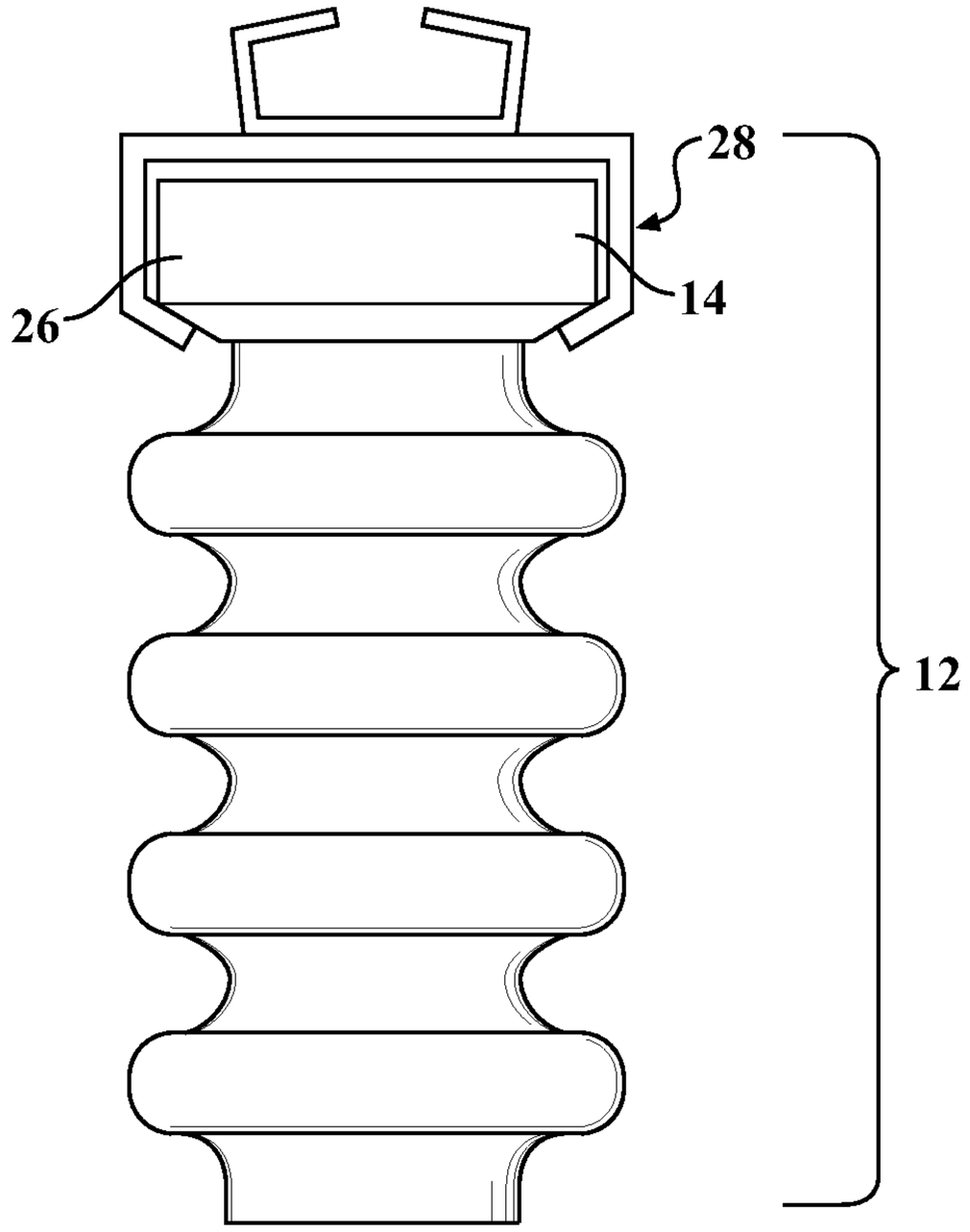


FIG. 1B



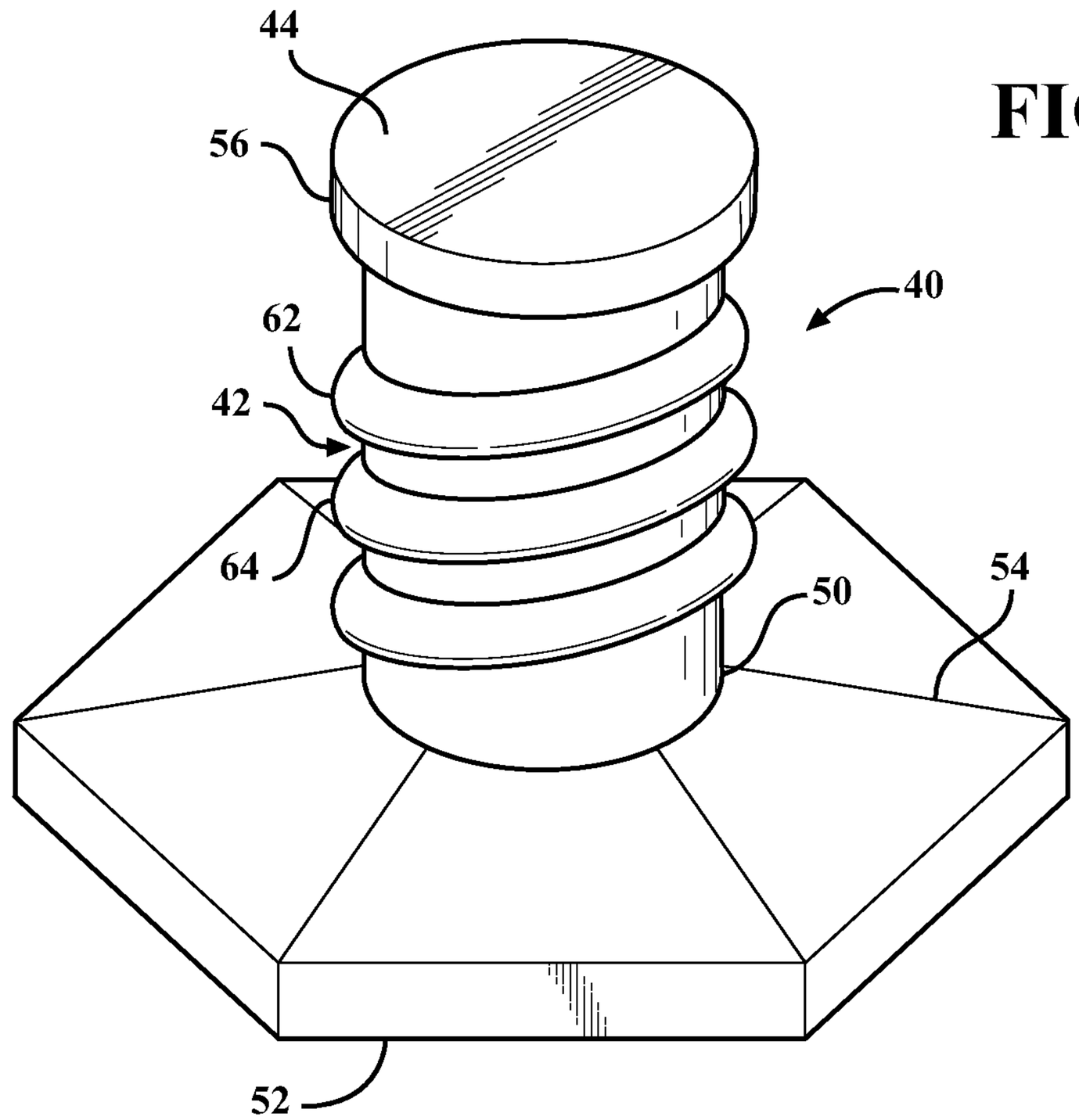


FIG. 2

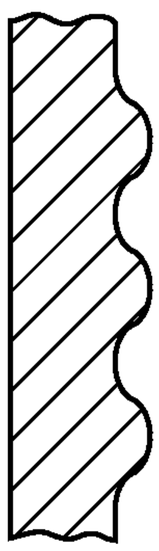


FIG. 4A

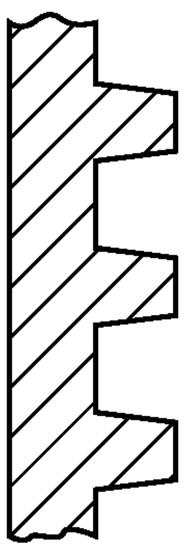


FIG. 4B

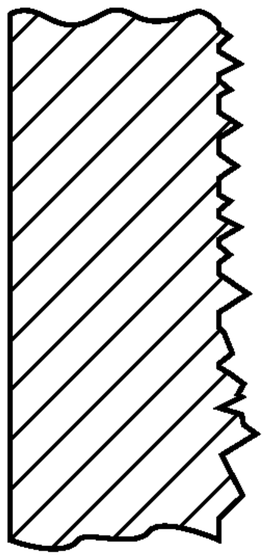


FIG. 4C

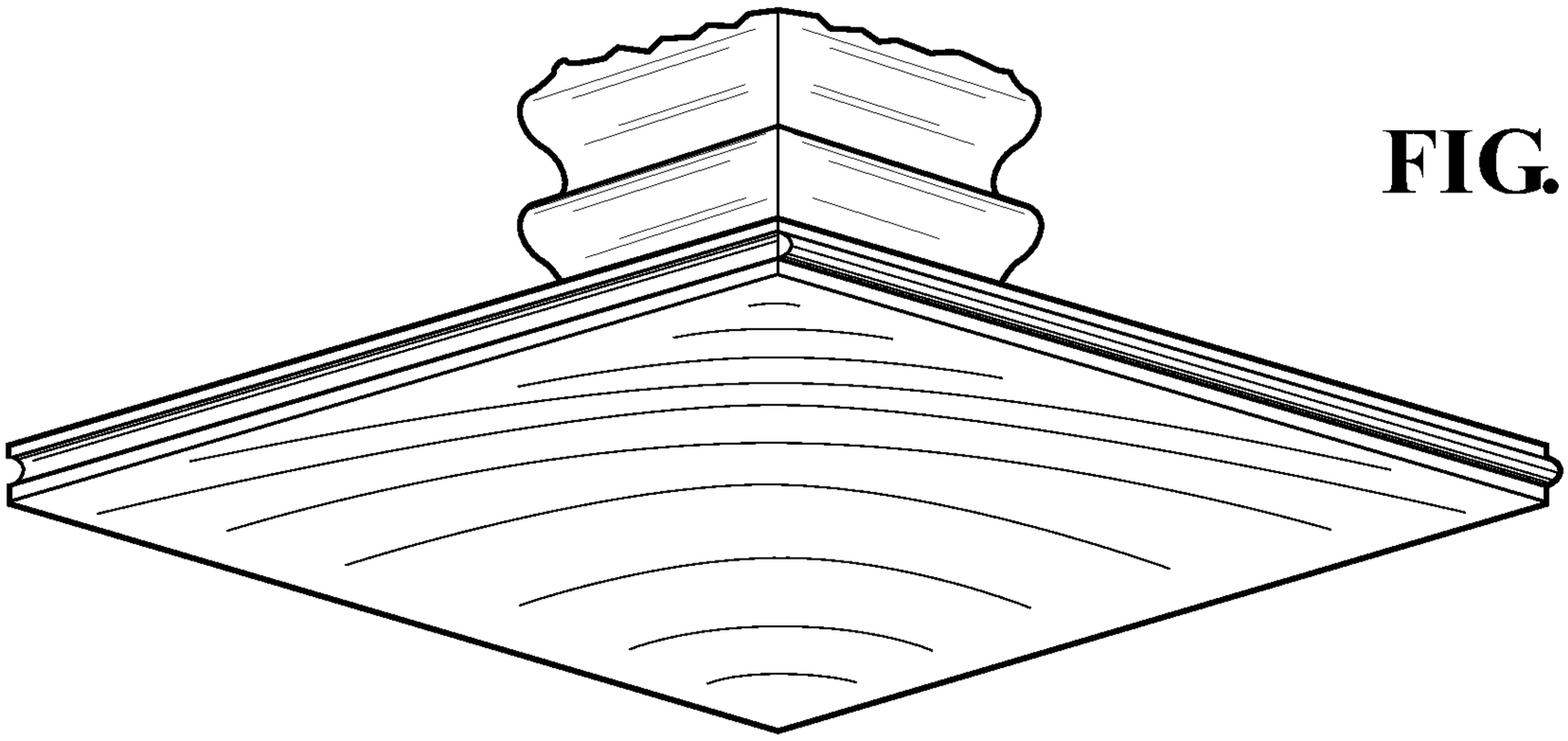


FIG. 3B

FIG. 3B

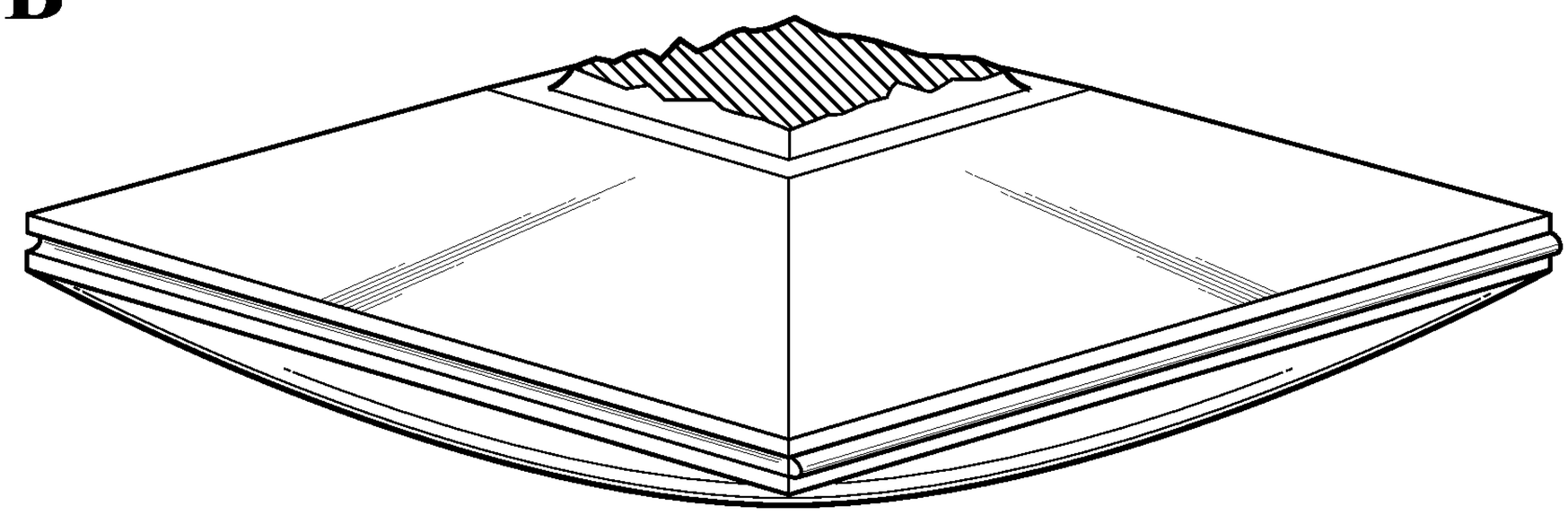


FIG. 3C

FIG. 1A

