This invention relates to a building for the processing of explosives, and particularly to an earth-mounded and covered building which will quickly vent the gases generated on detonation of the explosives within the building in a safe direction as regards neighboring buildings, while simultaneously retaining all the missiles originating within the building confines, and at the same time being adapted to prevent ingress of missiles from a neighboring building in the event an explosion has occurred there.

This invention is particularly applicable to use in connection with the manufacture of dynamite where, as is well known, the most hazardous operations consist of the detonation of nitroglycerine, the mixing of nitroglycerine with the solid adsortents and other ingredients which go into the final charging composition, and the loading of the charging composition into the dynamic containers or shells. Customarily, these operations are conducted in wooden frame buildings which are separated far enough from one another so that an explosion occurring in one building will not be propagated by sympathetic detonation to any other buildings. However, a serious problem exists as regards missiles which emanate from an explosion site and extensive damage to adjacent buildings has been known to result from this cause, including even the detonation of explosives stored within these buildings. Resort has been had to surrounding the individual buildings with barricades of various types for the purpose of stopping missiles, but this has not been too successful for the reason that such barricades are effective only against missiles having flight paths substantially parallel to the earth and a great many missiles travel along high angle courses, such as out through the roof of a building in which an explosion has occurred, and thus completely evading all barricades. Accordingly, the use of conventional designs of buildings and barricades has necessitated a large measure of geographical isolation for individual explosives processing buildings to reduce the extent of damage which can be expected to result from accidental explosions.

A primary object of this invention is to provide an explosives processing building adapted to substantially reduce the hazards of blast and at the same time completely eliminate the hazard of missiles arising from an explosion occurring within the building. Another object of this invention is to provide an economical building construction adapted to achieve the primary object. Another object of this invention is to provide an explosives processing building which permits safe close spacing of the individual buildings of an explosives manufacturing establishment with respect to one another, with resultant savings in manufacturing operations and the cost of facilities employed in such manufacturing. The manner in which these and other objects of this invention are attained will be apparent from the following description and the related drawings, in which:

FIG. 1 is a roof plan view of a second embodiment of this invention, wherein the design is such as to vent explosion gases horizontally out a preselected wall of the building.

FIG. 5 is a sectional view taken along line 5-5 of FIG. 4, and FIG. 6 is a front elevation view taken along line 6-6 of FIG. 4.

Generally, the objects of this invention are achieved by providing a building shell upon and around which is mounded sufficient loose earth, or its equivalent in coarse sand or pebbles or the like, to absorb, by its inherent resilience under self-compaction, all energy released by an explosion within the building not vented to the surrounding atmosphere, as well as to arrest the flight of any missiles which constitute parts of the original contents of the building or any of the building components, the building shell being provided with suitable vent ports for the quick relief of pressure to a level below that at which substantial roof and side mound displacement occurs, which ports are oriented in a safe direction with respect to neighboring buildings or structures. It should be particularly mentioned that the building shell which can be constructed of any of the common building materials, such as wood, concrete or the like, the only requirement being that the structure have sufficient inherent strength to support the mounded earth laid over and against it and, preferably, that the walls and roof yield under the blast in directions tending to equalize the explosive loading thereagainst, to in this way transmit the pressure more or less evenly to the mounded earth.

Referring to FIGS. 1-3, inclusive, a preferred embodiment of this invention for venting most of the pressure released by an explosion upwardly, consists of the explosive processing room proper 10, defined by conventional reinforced concrete earth-supporting side walls 11, end walls 12 and roof 13, carried by footings 14. As shown in the drawings, the cross-sections of the walls and roof of the building shell have been proportioned in accordance with predetermined load-supporting requirements of the economy in the use of materials of construction, it being understood that members of uniform thickness may be employed throughout provided the building possesses the necessary structural strength. The building shell hereinabove described may be designed solely on the basis of affordable support for the mounded earth at sides and top and of accommodating interloadings between the several building members, which simplifies the construction. The enclosure may be completed by a concrete slab floor, 20, also carried by the footings. One end of the structure is provided with an open vent shaft 16, which extends from the top of the mound laid over roof 13 to floor level. The opening between the working area of room 10 and shaft 16 is closed by a light curtain wall 17, such as plaster board laid over wood studding, or the like, which presents relatively zero resistance to explosive disruption as compared to the load-carrying walls and roof of the building but nevertheless furnishes protection against the weather for operations carried on within the working area. An open passage 15 communicating with tunnel 30, hereinafter described, is shown as separated from room 10 by partition wall 18 and from shaft 16 by partition wall 19, both of which may be of the same light construction as curtain wall 17.

The building illustrated specifically in FIGS. 1-3 is a dynamite mix house, wherein the manufacturing operation conducted is the mixing of nitroglycerine with the other ingredients making up the complete mixture, which is subsequently loaded into the conventional paper con-
tainer shells at a different location. In this operation it is convenient to utilize a dry mixer having an impeller
shaft hydraulically movable in a vertical plane and a
cupola 21 is provided on roof 13 for overhead clear-
ance of the support shafts at the topmost point of eleva-
tion. Since explosive pressures diminish with distance of
travel of the shock wave, it is desirable, within reason-
able limits of convenience, in the utilization of building
volumes, to locate the greatest average concentration of
explosive centrally of the building, and the location of the
mixer herein above mentioned is in general accordance
with this principle.

The building is provided with an open portal for in-
gress and egress of personnel, this being a poured con-crete
tunnel 24, which may be provided with a light door at
the entrance end adjacent room 10 and with an upstanding
bulkhead 25 for retention of the overhead slope of
mounted earth. In addition, there is provided a portal
opening into tunnel 27, having an earth-supporting bulk-
head 26, as a passageway for the supply of mixture in-
gredients and another portal having a tunnel 30 with an
earthing supporting bulkhead 31 for the removal of mixed
product. Since it is convenient to employ a reversible
mechanized conveyor for transportation of product from the
mix sub-house to subsequent processing buildings, the
conveyor is preferably isolated from room 10 by location back of spark-blocking partition wall 18, suitable operator-controlled communica-
tion means, not detailed herein because unrelated to this
invention, being provided for loading product from room 10 past wall 18 into the conveyor. Although not essential to this invention, a fourth portal is shown in
communication through tunnel 34, fitted with bulkhead
35, with vent shaft 16, which portal permits entrance to
the shaft for periodic inspection or cleaning. If this
portal is eliminated it is desirable at least to provide a
ground drain for leading off rainwater which might other-
wise accumulate in the shaft.

It is of the utmost importance that the outside open-
ings of all of the portals be directed against barricades,
not shown, or that they be oriented away from the portals of
neighboring explosives-containing buildings, because
they constitute blast vents upon the occurrence of an ex-
losion within the building, and any objects in line with
these openings will accordingly be subjected to high
explosive forces. In practice, where the building arrange-
ment is congested, the outside portal openings are pref-
erably directed against the earth mounds of neighboring
buildings constructed according to this invention.

The location of the inside openings of the portals here-
before described is of importance from the standpoint of
arresting missiles originating within the building, and
it is good practice to orient these openings so that they
are not in direct line with the points at which an explosion
might be anticipated to occur. As will be apparent in
FIGS. 1-3, all of the portals are disposed so that they
present an abrupt angle with radial lines drawn from the
mixer location, and all of the passageways are backed
with earth and are of sufficient length to present a com-
plete block to missiles, either in original flight or in ricochet.

The mounded earth 33 covers the entire building and,
since complete reliance is placed upon the inherent
resilience of the earth under self-compaction to absorb the
very heavy explosive pressure transmitted to it from the
roof and walls of the building without displacement en
masse, the earth is compacted so that the earth during cover-
ing of the building only enough so that it will remain
in place under exposure to the weather. Retention of the
earth in situ is facilitated by the planting of grass or
other root cover to stabilize against erosion by rain or
wind.

A building of the design detailed in FIGS. 1-3 was
constructed of reinforced concrete in conventional manner
to support loosely compacted mounded earth (sandy clay)
cover on the roof to a depth of about 8'-0", sloped at an
angle of approximately 45° with the horizontal and with a
minimum thickness at the intersections of roof and walls of
approximately 8'-0". The earth cover loading on the roof
was in the range of 720-800 lbs./sq.ft. The overall
thickness of the concrete walls and roof averaged about
16" and the inside dimensions of room 10, inclusive of
passage 15 but exclusive of vent shaft 16, measured ap-
proximately 20' x 13'-3" x 13'-3" (average). The inside cross-sectional area of vent shaft 16 was
9' x 20' and the end wall of the building serving as the highest side of the vent shaft (refer FIG. 2) was 25' in
height while the height of the upper edge of the opposite
wall was 23', the side walls connecting these two walls
tapering approximately linearly along the top edges. The
volume of room 10 plus passage 15, excluding vent shaft
16, measured 5400 cu.ft.

The combined area of the vent shaft cross section and
all portal openings was 337.5 sq.ft. while the total area of the
blast-disruptible curtain wall, made up of wall 17 to-
gether with wall 19, FIG. 1, was 270 sq.ft.

In a performance test, the equipment contents of a
typical diagram mix house were simulated as to size,
mass and location of one, weighing 400 lbs., was placed in
the topped scrap metal dummies at the locations in the build-
ing indicated by the reference letters A, B, C, D, and E
of FIGS. 1 and 2. A total explosive charge of 1000 lbs.
of dynamite (equivalent to 1150 lbs. of T.N.T.) was em-
ployed in the test, this being divided into five separate
packets of which one, weighing 400 lbs. was placed in
mixture A, the base of which was disposed 4' above the
floor, two, weighing 100 lbs. each, were placed in the
square tanks B and C having their bases disposed at levels of
5' and 6.5' above the floor, respectively, and two, weighing
200 lbs. each, were placed in the cylinders D and E hav-
ing bases resting on the floor.

On simultaneous detonation of the parcels making up
the total explosive charge, it was observed that explosive
pressures were very rapidly vented through the portals and
vent shaft of the building, high speed moving pictures dis-
closing that a cloud of hot gas approximately 60 ft., in di-
diameter escaped from the top of the vent shaft within the
short time interval of approximately 0.06 second. Al-
though very extensive damage was done to the interior of
the building, the structure withstood the test without local-
ized break-through at any point. The mounded earth re-
main ed in place along the sides and over the top of the
building until the forces of the explosion had been dissi-
ipated. All missiles were retained within the building and
consequently would have constituted no hazard whatever
to any neighboring structures. It was observed visually
that the venting of explosion gases occurred primarily
through the vent shaft, although there was appreciable
venting through the portals, portal venting being probably
somewhat impeded by the offset relationship of the portals
with respect to the explosion site. Thus, it was apparent
that the building design was entirely satisfactory for ex-
plosive loadings of at least 0.25 lbs. on the T.N.T. basis
per cubic foot of working room volume. Surprisingly,
buildings constructed according to this invention were thus
found capable of temporarily withstanding calculated
instantaneous explosive pressures of the order of 60 tons/
sq.ft., even though the weight of the weakest structural
member, i.e., the roof, together with the earth cover there-
over, totaled less than 3'/ton/sq.ft.

The results of the test conducted on the full scale build-
ing as hereinabove described were verified by tests on
scale models using both higher and lower explosives load-
ings than above reported.

1/2 Scale Model

The building shell was fabricated with wood side walls, wood portal tunnels and a concrete roof and vent shaft and
of crushed stone 54 is interposed between the rear wall and the backing earth to facilitate ready drainage of any collecting rain water in this region. The front wall 46, which in this case is the curtain wall, is composed of light material, such as plywood or the like, having little strength, so as to permit its complete disruption under explosion with consequent free venting of explosion gases out of the front of the building exclusively. Wall 46 is provided with a door or other entryway indicated generally at 55. The forward edge of the building is provided with a concrete bulkhead 47 and the front sides with wings 48, all cost integral with the building proper, to sustain the mounded earth heaped over the roof and along the side walls, as indicated at 49 and 59, respectively. The building is built with a cast concrete floor 51, supported on footings 52, only one of which is shown, and the floor may be extended, as by an apron 53 disposed at the front, to facilitate supply and removal of manufacturing materials. The particular building so far described is of two-story internal construction, with a trestle built on apron 53 to permit easy transport of material into and out of the upper story; however, none of this detail is pertinent to this invention and therefore is not further elaborated herein.

The dimensional data for a typical building constructed according to the embodiment of FIGS. 4-6, and intended for the safe processing of 3000 lbs. of dynamite, or the equivalent, is as follows:

- Inside dimensions of building—24'6"*16'6"*18'11"
- Inside volume of building—12,376.5 ft. ³
- Area of curtain wall 46—26.7 ft. * 18.92 = 505.2 ft. ²
- Depth of earth cover on roof—10'0", sloping in forward third of the length of the roof to 6'-0" at bulkhead 47.
- Depth of earth cover at shoulders—10'-0".
- Overall thickness of reinforced concrete roof—2'-6".
- Overall thickness of reinforced concrete side and rear walls, and floor—2'-4".

A 1/9 scale floorless building was constructed entirely from wood in accordance with the design of FIGS. 4-6, the building shell being 3.17" * 3.33" * 2' with the front side (i.e., the side opposite the 3.33' wall) open except for a 3/4" plywood curtain wall. The inside dimensions of this enclosure was 21.11 ft. ³. Earth cover was applied to the roof to a height of 3.33 ft., corresponding to a loading of 290 lbs./sq. ft.

A centrally disposed test charge of 4.1 lbs. of dynamite, equivalent to a loading of 0.28 lb. of T.N.T./ft. ³, was exploded in this building to test the building in full dispersion of its explosive force through the side closed only by the curtain wall and without objectionable displacement of the mounded earth around and over the building.

It will be understood that the embodiment of our invention shown in FIGS. 1-3 affords a practically complete barrier to the escape of all missiles whatever, especially if the explosives in process are loaded centrally of the building. The embodiment of FIGS. 4-6 stops all missiles in original flight through five bounding surfaces out of a total of six, and the missile retention efficacy of this embodiment can be further enhanced in practice by placing as many of the loose or disengageable objects in the building between the concentration of explosives in process and one of the walls other than the blast-disruptible curtain wall. Most important, however, is the fact that all missiles with high angle trajectories, such as those which impinge on the ceilings, are completely stopped in both embodiments and this protection is especially important, because this type missile has the maximum range and, usually, a course line of return to earth which makes protection at the receiving and most difficult and expensive.

It will further be understood that the most dangerous missiles are those in original flight from the explosion site, because these missiles have extremely high energies. In contrast, missiles which have ricocheted one or more times within the building work space before exit there-
from have already had their energies greatly reduced and their range of flight correspondingly limited, so as to constitute a problem of relatively less severity. Finally, for all missiles, regardless of their nature, it is obviously advantageous to constrain the flight paths to predetermined lines of projection which can be relied upon with complete certainty as being regions of potential danger, while all the neighboring surroundings remain safe, and this is the general principle served by this invention.

From the foregoing description it will be apparent that this invention can be modified in many respects as regards construction details, materials, designs and the like without departure from the essential spirit, for which reasons it is intended to be limited only by the scope of the following claims.

What is claimed is:

1. An explosives processing building for the containment of equivalent explosive loadings of at least 0.15 lbs./cu. ft. of trinitrotoluene comprising a rigid shell constructed above ground having sufficient strength to support earth mounded thereover and against the walls of said shell, said shell being provided with at least one gas venting opening and an interior explosives working space substantially square in plan and with a floor-to-ceiling height varying from about one-half to about one length dimension of said working space in extent and being covered completely with a minimum of about 8 ft. of earth, substantially uncompacted except under the load of its inherent weight, mounted over the roof and around said walls except in the region of said venting openings, the mass of said earth being sufficient to absorb by substantially static self-compaction all of the forces of an explosion occurring within said working space not dissipated by venting within a time interval of about 0.1 second while arresting any missiles originating within said working space having flight paths out of direct line with said venting opening and Preventing penetration of said missiles through said earth, at the same time constraining the projection of all other missiles to paths in substantial prolongation with said venting opening.

2. An explosives processing building for the containment of equivalent explosive loadings of at least 0.15 lbs./cu. ft. of trinitrotoluene comprising a rigid shell constructed above ground having sufficient strength to support earth mounded thereover and against the walls of said shell, said shell being provided with an interior explosives working space substantially square in plan with a floor-to-ceiling height varying from about one-half to about one length dimension of said working space in extent, substantially one entire side of said working space being open to the essentially unimpeded venting of gases generated by an explosion occurring within said working space, and said shell being covered completely with a minimum of about 8 ft. of earth, substantially uncompacted except under the load of its inherent weight, over the roof and around said walls except in the region of said side open to said free venting of gases and in the region of any other openings into said explosives working space, the mass of said earth being sufficient to absorb by substantially static self-compaction all of the forces of an explosion occurring within said working space not dissipated by venting within a time interval of about 0.1 second while arresting any missiles originating within said working space having flight paths out of direct line with said venting opening and preventing penetration of said missiles through said earth, at the same time constraining the projection of all other missiles to paths in substantial prolongation with said openings.

3. An explosives processing building for the containment of explosive equivalent loadings of at least 0.15 lbs./cu. ft. of trinitrotoluene comprising a rigid shell constructed above ground having sufficient strength to support earth mounded thereover and against the walls of said shell, the interior of said shell constituting an explosives working space substantially square in plan and with a floor-to-ceiling height varying from about one-half to about one length dimension of said working space in extent, a vertically disposed open vent shaft communicating with said working space, at least one portal opening from inside said working space to the outside in a direction clear for blast venting and out of direct line with explosives disposed within said working space, and a minimum of about 8 ft. of earth, substantially uncompacted except under the load of its inherent weight, mounted over the roof and around the walls of said shell part from the outside openings of said vent shaft and said portal, the mass of said earth being sufficient to absorb by substantially static self-compaction all of the forces of an explosion occurring within said working space not dissipated by venting within a time interval of about 0.1 second while arresting any missiles originating within said working space having flight paths out of direct line with any openings into said working space and preventing penetration of said missiles through said earth, at the same time constraining the projection of all other missiles to paths in substantial prolongation with said openings.

4. An explosives processing building according to claim 3 wherein the communication of said open vent shaft with said working space is coextensive with the area of substantially one entire side of said working space as regards the substantially unimpeded venting of gases generated by an explosion occurring within said working space.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,062,158

Clyde O. Davis et al.

November 6, 1962

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 18, for "mounted" read -- mounded --;
column 5, line 5, for "tunneled" read -- tunnel --; line 64,
for "gasses" read -- gases --; column 7, line 42, for
"explosive" read -- explosive --; column 8, line 3, for
"vening" read -- venting --; line 5, for "sime" read
-- same --; line 26, for "part" read -- apart --.

Signed and sealed this 9th day of April 1963.

(SEAL)
Attest:

ESTON G. JOHNSON
Attesting Officer

DAVID L. LADD
Commissioner of Patents