WALL/ROOF JUNCTIONS AND SOFFITS

by R.G. Turenne

Efflorescence on masonry walls at roof level and damage to brick parapets from freeze-thaw action, due to excessive dampness, may result from moisture-laden air escaping from buildings because of chimney effect and wind action. Such air leakage results from a failure to make the walls and wall/roof junction airtight. Although these problems generally appear when the air is highly humid, any air leakage contributes to the total energy cost of operating a building.

While stack effect is a dominating force behind air leakage in high-rise buildings, wind action, which creates relatively high suction forces along the windward eaves, can be a major source of air leakage in low buildings. In both cases large quantities of air are drawn from inside the building unless the wall/roof junction is made airtight. Suction forces created by the wind vary with its speed, and they affect different areas of the building depending on the wind's direction.

A wind speed of 20 mph (32 km/h) exerts a velocity pressure of 0.20 in. (5 mm) of water, but the stagnant pressure acting on the walls of a building is usually less than the velocity pressure. Along the eave on the windward side, however, local suctions are created that are two to three times greater than the velocity pressure of the wind. This means that a crack 1/16 in. (1.6 mm) in width at the wall/roof junction can allow air to exfiltrate at a rate from 5.5 to 8.0 cfm (0.15 to 0.23 m^3/min) per foot (0.3 m) of crack from a 20 mph (32 km/h) wind, depending on its direction, the height of parapet, etc.

It is often said that up to 85 per cent of all roofing problems originate along the roof edges and other discontinuities of the membrane where water infiltration can saturate the insulation and find its way into the building. The lack of success in making buildings both air and watertight in these locations suggests that the quality of building enclosures should be improved by modifying the design of the wall/roof junction and other problem areas.

In the design of a building enclosure, a water vapour retardant is usually called for in the wall, but as shown in Figure 18, it may or may not extend to the roof deck, and it or some other component may perform the role of air barrier. A roofing membrane, whether conventional or inverted, is mandatory but seldom extends to the edge of the roof. Instead it is turned up a cant strip and bituminous flashings are installed on the inside face of the parapet wall. The result is that a hole is left in the building envelope which allows moist air to escape, and water vapour to condense within the wall and parapet.

A solution to this problem might consist of extending the roofing membrane to the edge of the roof where it is turned downward to overlap the air and vapour stop of the wall (as shown in Figure 19). This might involve its relocation in the wall, but the result would be a completely sealed envelope separating the building interior from the exterior. A parapet could then be added to satisfy the aesthetic and functional requirements of the wall/roof junction, with base and cap flashings installed in the usual manner, although their performance would no longer be as critical. The continuous membrane would prevent any water seeping into the parapet from gaining access to the roofing and the building.

It is important to establish in the early stages of the design which element of the roofing system is to constitute the air barrier. A deck made of cast-in-place concrete makes a good air barrier. When using a steel deck, a vapour retardant should be specified, otherwise the membrane becomes the air barrier by default. When a protected membrane system is specified, either the deck, if of cast-in-place concrete, or the membrane, can constitute the air barrier. Whatever element is chosen, however, it must be impervious to air, must be sealed at all penetrations and made airtight whenever it joins with another material, otherwise air leakage will occur.

Designers are sometimes influenced by architectural details shown in catalogues distributed by manufacturers of building components. Though details relating to the use of these products are generally correct, this does not necessarily mean that the over-all performance requirements of the enclosure will be met. Since designers have the final responsibility for the selection of materials, their arrangements and the performance of the system, they should examine these suggested details carefully and modify them when necessary.

With respect to the wall/roof junction, steel construction is frequently difficult to make airtight, especially when incorporating a steel deck. Yet steel frames are used extensively in conjunction with masonry walls in the construction of schools, low-rise office buildings, warehouses, plants and retail stores, sometimes with little thought given to achieving air tightness.

Air tightness is not readily achieved with the arrangement shown in Figure 20, a steel frame set in the same plane as the interior wythe of a cavity wall because it is not possible to install the insulation as shown with any hope that it will remain in place, much less will such a detail result in an airtight construction. In addition, masonry walls cannot be built tightly to the underside of a steel spandrel beam because of the difficulty of filling the mortar joint. Subsequent shrinkage of the wall will open a crack between the bottom flange of the beam and the top of the wall, providing a channel for air leakage. The general situation at the wall/roof junction is such that construction tolerances, the instability of construction materials and building movements all conspire to open up cracks in this area.

The details shown in Figure 20 have been modified in Figure 11 to improve air tightness and structural performance. The changes involve

(1) leaving a gap between the top of the concrete block wall and the spandrel so that the beam can deflect freely under its superimposed load and not transfer the load to the wall. The top of the wall is supported laterally if required by clip angles welded or bolted to the bottom flange of the beam.

(2) the steel beam is faced with drywall;

(3) a continuous strip of flexible membrane is installed along the edge of the steel deck, overlapping the drywall on one side and the roofing vapor retardant on the other;

(4) a continuous strip of flexible membrane is installed so as to seal the gap between the drywall and the block wall;

(5) the vapor retardant of the conventional roof is turned up the inside face of the insulation stop to act as a water stop and the membrane can be nailed along its edge to the insulation stop prior to the installation of the cant strips;

(6) the roofing is completed with the installation of bituminous flashings and metal counterflashings.

Placing the steel frame inside the masonry wall line, as shown in Figure 21, does not necessarily guarantee a successful design since the detail as shown does not attempt to incorporate an effective air seal at the wall/roof junction nor does it concern itself with the differential movement that is likely to occur between the steel structure and the masonry wall. Some of the deficiencies of the design shown in Figure 21 can be overcome by the arrangement shown in Figure 22 where

(1) steel joists are kept clear of the masonry wall so that the beam can deflect freely;

(2) the insulation and air barrier are moved outside the concrete blocks;

(3) the roof's vapor retardant is joined to the wall air stop by means of a strip of flexible membrane material which is supported by a sheet metal closure supplied and installed by the steel deck contractor.

The masonry bearing wall shown in Figure 23 provides an easy solution to the problem of achieving air tightness at the wall/roof junction, obtained by installing a strip of flexible material at that location. In this design, too, differential movements between structure and wall are not a matter of concern.

Perimeter venting of the insulation, a practice adopted by some designers, must be carried out in such a way that the opening created in the membrane prevents water from getting into the roofing. Warm moist air from inside the building must be prevented from entering the roof insulation, where it can condense, by the installation of a continuous air barrier under the insulation.

A major obstacle in achieving air tightness at the wall/roof junction stems from the fact that a number of trades are usually responsible for its construction, which involves the supply and installation of various materials, such as masonry, wood, roofing, steel. Unless their individual responsibilities are clearly defined, and a proper sequence of work established, air tightness is unlikely to be achieved. To obtain a satisfactory result the general contractor must coordinate the work of his subcontractors.

Where a wall rises above a roof, such as shown in Figures 24, 25 and 26, the continuity of the wall/roof air barrier is just as important as it is at the perimeter of the building. It has been generally considered that a base flashing extending 8 to 10 in. (200 to 250 mm) above a roof and counterflashed into a wall with sheet metal is all that is required to keep water out and warm air in. In certain areas of the country, however, snow can accumulate on multi-level roofs to depths of 3 ft (900 mm) or more and a sudden rainfall during the winter can cause water to back up against a wall to depths greater than is waterproofed by the base flashings, resulting in water infiltration. In addition, air leakage at the base of a wall can melt snow and ice in contact with the wall. Accordingly, it is a good policy to join the wall air/vapour barrier to the roof membrane with a strip of flexible flashing to ensure both the water and air tightness of the junction, and where a vapour retardant is used on the deck it should also be joined to the wall air/vapour barrier.

Expansion joints in roofs and penetrations through roofs are other areas where air tightness is difficult to achieve and problems often arise.

Canopies and soffits do not always receive the attention they deserve. Where a steel deck is cantilevered over an exterior wall to form a canopy, for example, it is difficult to seal the corrugations. Neoprene closures are sometimes used for this purpose but if the steel frame is located inside the wall line, the air can usually circumvent the closures. If the steel structure is set in the wall then the structure itself can create a problem. Where the exterior wall is erected after the steel deck is in place, the blocking of all the corrugations becomes a laborious job. It must also be remembered that wherever a steel deck is cantilevered over an outside wall, the corrugations on the top side of the deck must also be made airtight, otherwise they provide a direct path for air leakage between the inside and outside of the building. Stuffing some loose insulation into these corrugations is generally not sufficient to prevent air movement.

It may be preferable to build the canopy as a separate structure, but this may create problems of its own, such as drainage and the need to provide an independent supporting structure, but the benefits may well offset the disadvantages. If, however, the canopy is attached to the main structure, although the deck itself is not continuous, a large number of holes may have to be cut through the wall for the support of the canopy, in which case every hole must be sealed to restore the air barrier, as installing a soffit may conceal the holes but will do little more.

Insulated soffits can be a source of air infiltration in buildings unless a proper air stop is installed. An insulated metal soffit extending over an entrance is shown in Figure 27. The wall at ground level, built of steel studs faced both sides with drywall, has its inside sheet of drywall extended to the suspended ceiling, while the exterior sheet stops at the soffit. The wall is insulated with batts, which are extended over the inside face of the horizontal metal siding, and are covered by a sheet of polyethylene. It is obviously difficult to assemble an airtight barrier under such conditions since the polyethylene sheet has to be perforated by the metal braces supporting the soffit framing. Thus outside air is capable of flowing freely through the insulation and polyethylene film under stack or wind effect, reducing the thermal efficiency of the insulation.

A better solution to the soffit problem from the point of view of air tightness might consist in extending the exterior sheet of drywall along the outside face of the canopy framing (metal studs in this case); the friction fit insulation and polyethylene vapour retardant could be installed as before. Air movement between the exterior and interior of the building is prevented by the drywall, improving the efficiency of the insulation. This solution, however, raises the possibility of warm moist air, transported by convection through openings in the polyethylene vapour retardant, coming in contact with cold drywall; condensation may then form on the inside face of the drywall and be absorbed by the gypsum, causing it to deteriorate.

A superior solution to the above canopy problem is shown in Figure 28 where the vapour retardant and the insulation are placed on the outside of the drywall, thus properly controlling air, vapour and heat flows through the assembly.

In conclusion, air tightness is difficult to achieve at a wall/roof junction unless it is carefully considered in the design of the wall, the structure and the roof deck or slab. It is at the wall/roof junction that cracks and openings frequently form as a result of the differential movements of materials and components, thus requiring the use of adequately flexible air and vapour barriers. An additional problem in achieving air tightness arises because the wall/roof construction usually proceeds in stages and involves various trades, each of which contributes to its success or failure. The potential for air movement through stack effect and wind action is always present in buildings; only good design can hold in check the driving force for air leakage.

LEGEND

1 Asbestos-Cement Board
2 Brick
3 Concrete Block
4 Concrete Block Lintel
5 Concrete Column
6 Concrete Curb
7 Concrete Foundation Wall
8 Concrete Slab
9 Aluminum Sill
10 Dovetail Anchor
11 Flashing
12 Furring Channel
13 Hollow Metal Frame
14 Metal Anchor
15 Steel Deck
16 Metal Counter Flashing
17 Metal Siding
18 Metal Sheet
19 Sheet Steel Closure
20 Metal Stud
21 Metal Tie
22 Metal Up-Stand
23 Metal Z Bar
24 Nesting Channels
25 Shelf Angle
26 Sill
27 Soffit Closure
28 Spacer
29 Spandrel Beam
30 Steel Column
31 Open-Web Steel Joist
32 Wedge Insert
33 Batt Insulation
34 Rigid Insulation
35 Semi-Rigid Insulation
36 Bituminous Flashing
37 Flexible Membrane Flashing
38 Window Frame
39 Caulking
40 Compressible Mastic
41 Foam Plastic Rope
42 Built-Up Roofing Membrane
43 Air-Vapour Barrier
44 Gypsum Board
45 Plywood
46 Gravel
47 Wood Frame or Brick
48 Wall Cladding
49 Sealed Double-Glazed Window
50 Clip Angle

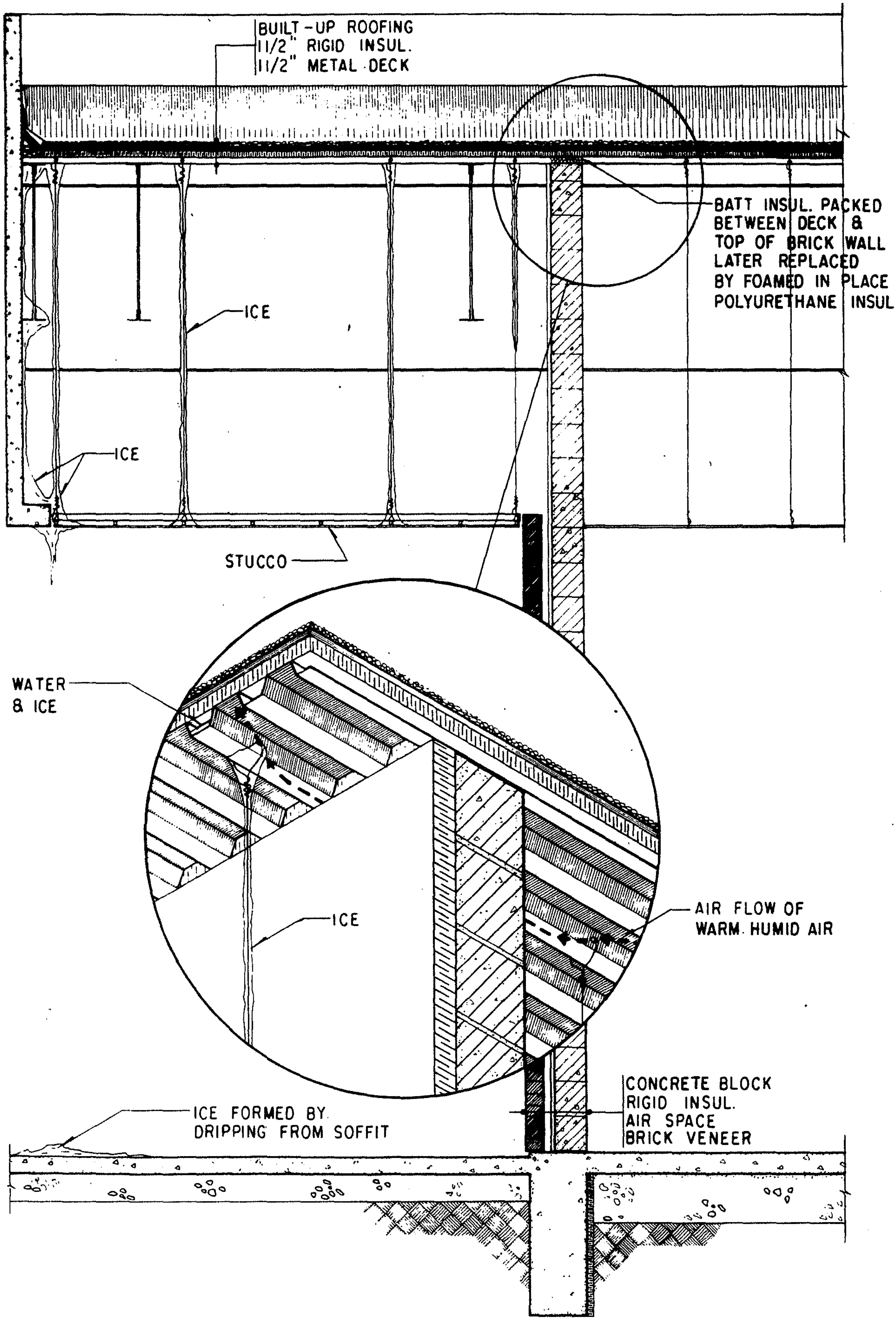

BUILT-UP ROOFING
11/2" RIGID INSUL.
11/2" METAL DECK
BATT INSUL. PACKED BETWEEN DECK & TOP OF BRICK WALL LATER REPLACED BY FOAMED IN PLACE POLYURETHANE INSUL.
ICE
ICE
STUCCO
WATER & ICE
ICE
AIR FLOW OF WARM HUMID AIR
CONCRETE BLOCK
RIGID INSUL.
AIR SPACE
BRICK VENEER
ICE FORMED BY DRIPPING FROM SOFFIT

FIGURE 1

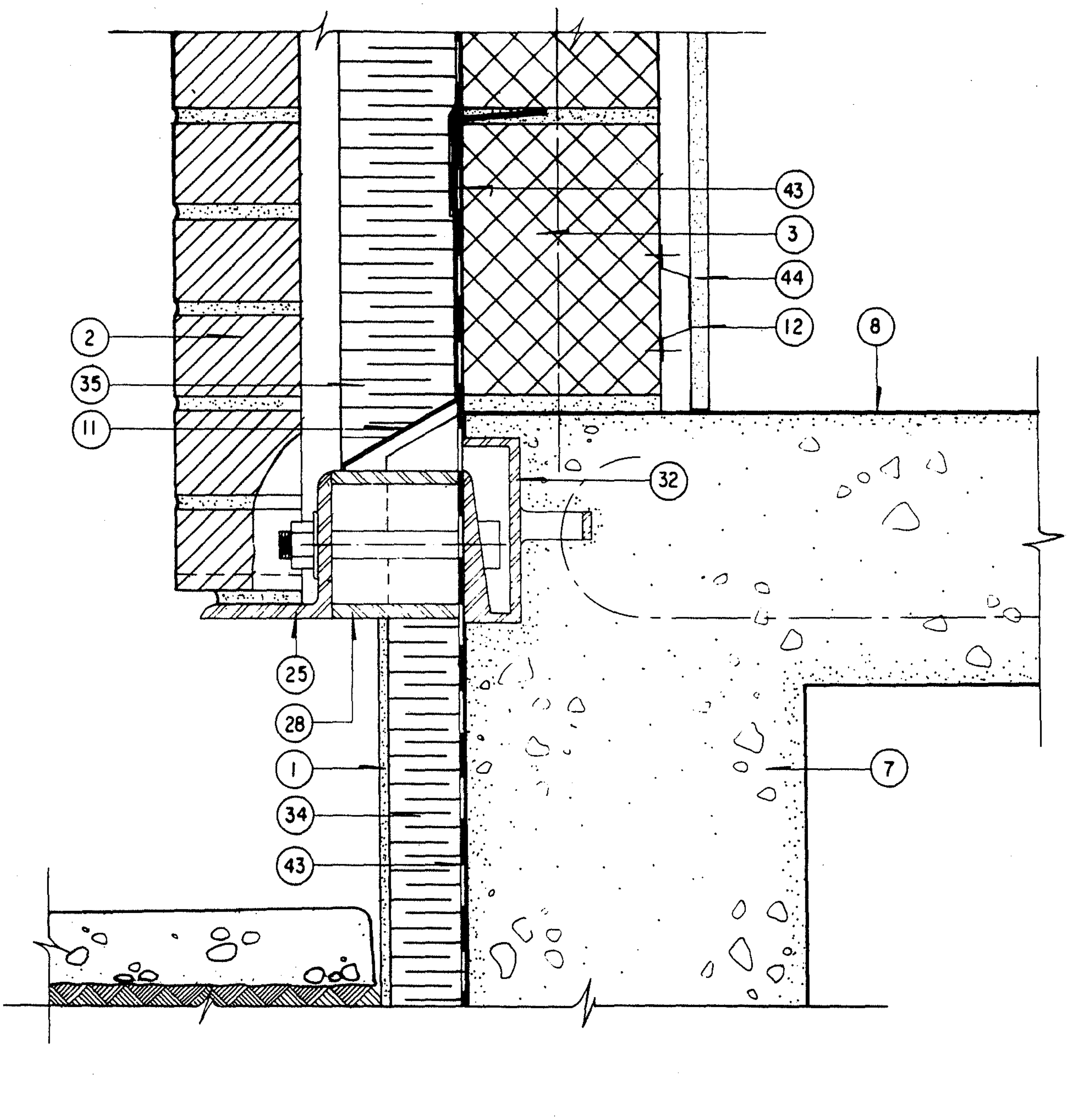


FIGURE 2

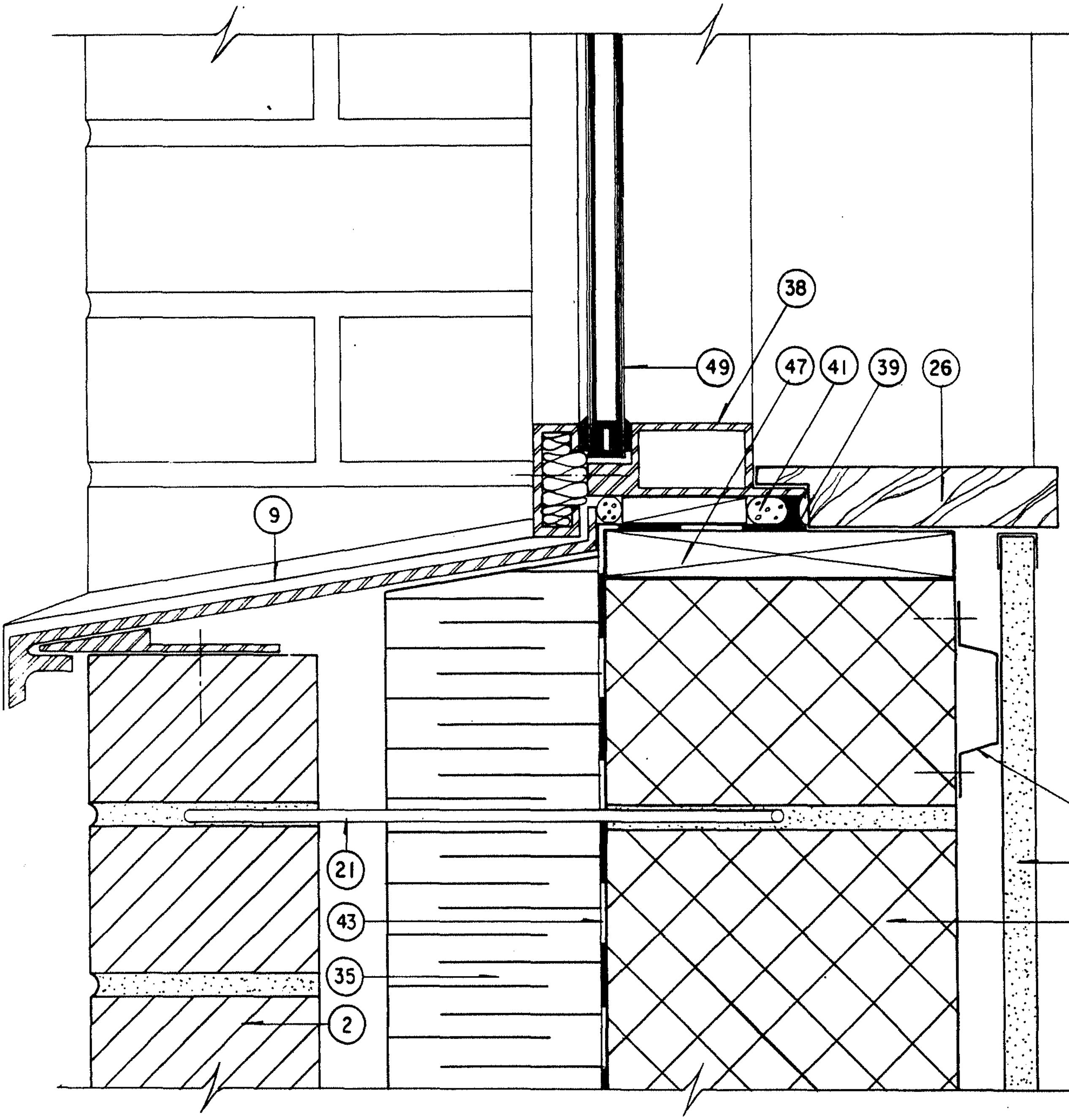


FIGURE 3

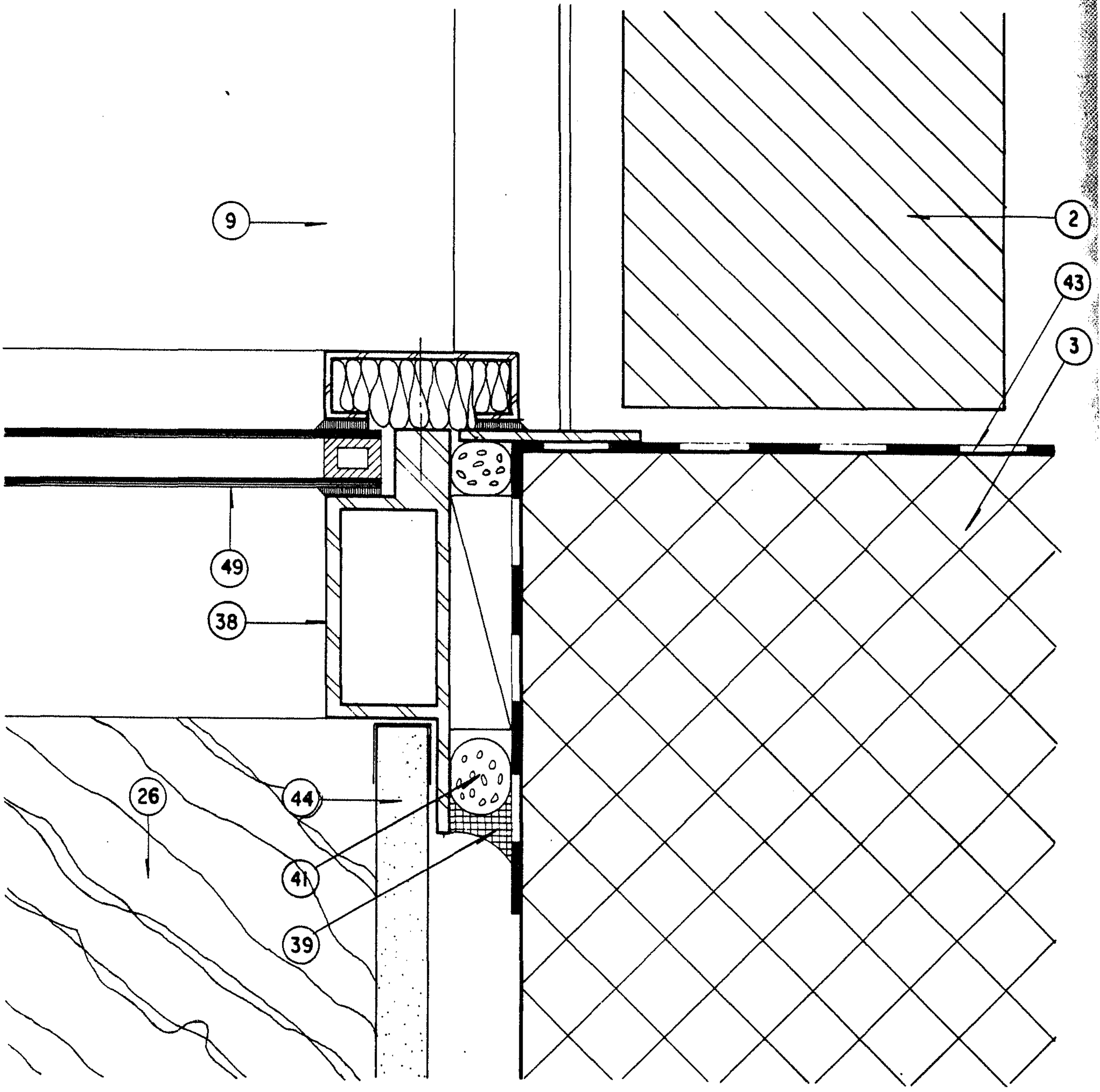


FIGURE 4

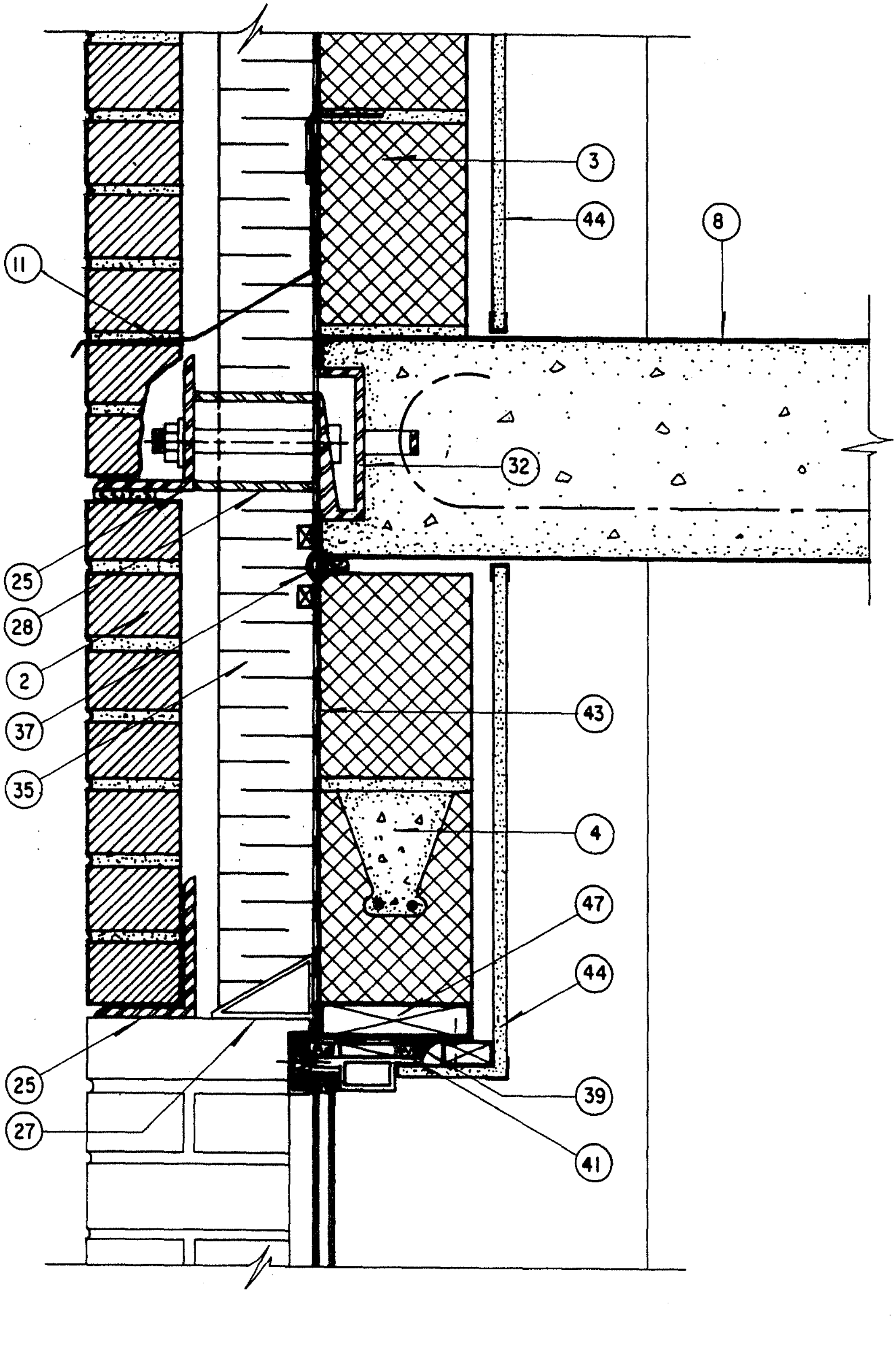


FIGURE 5

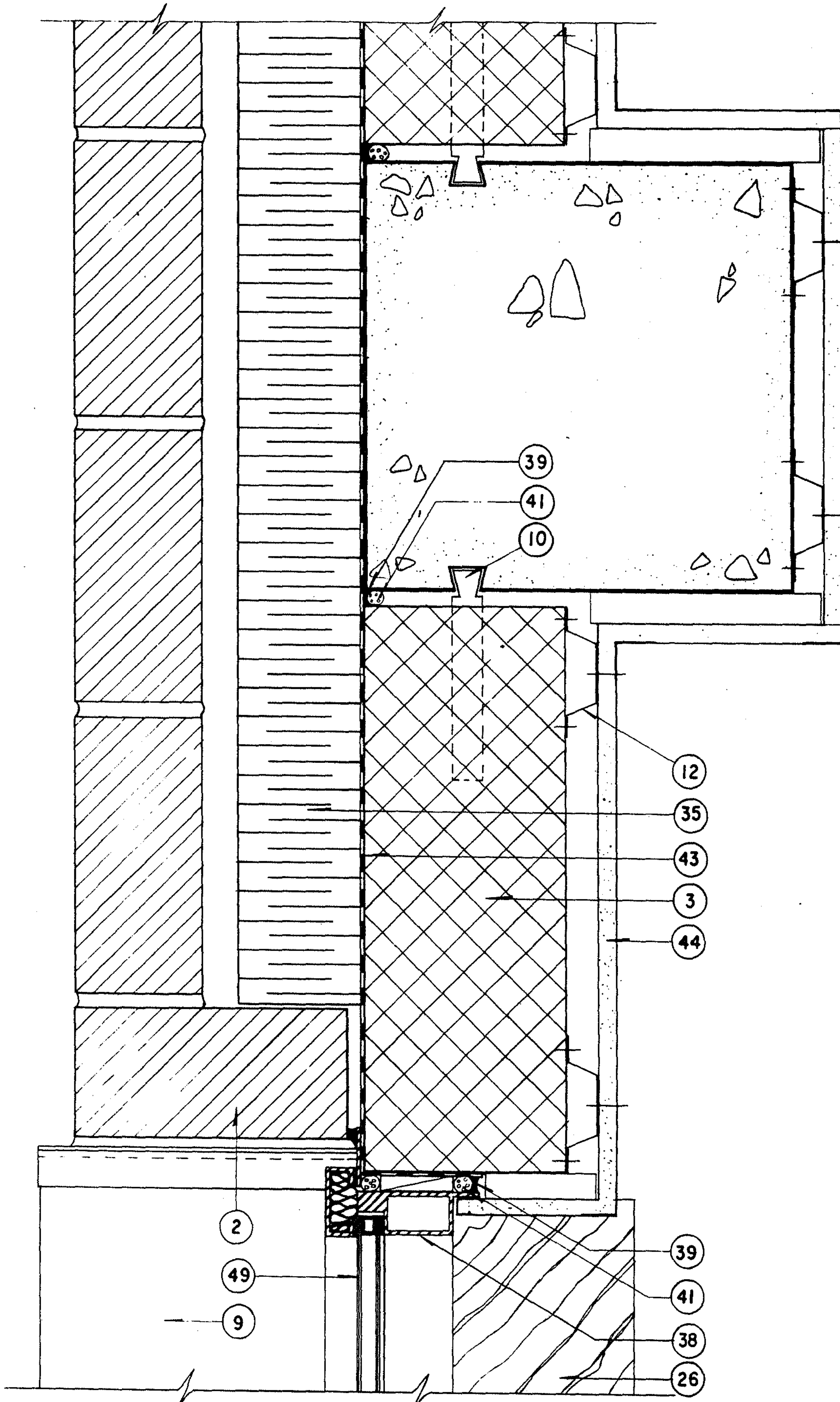


FIGURE 6

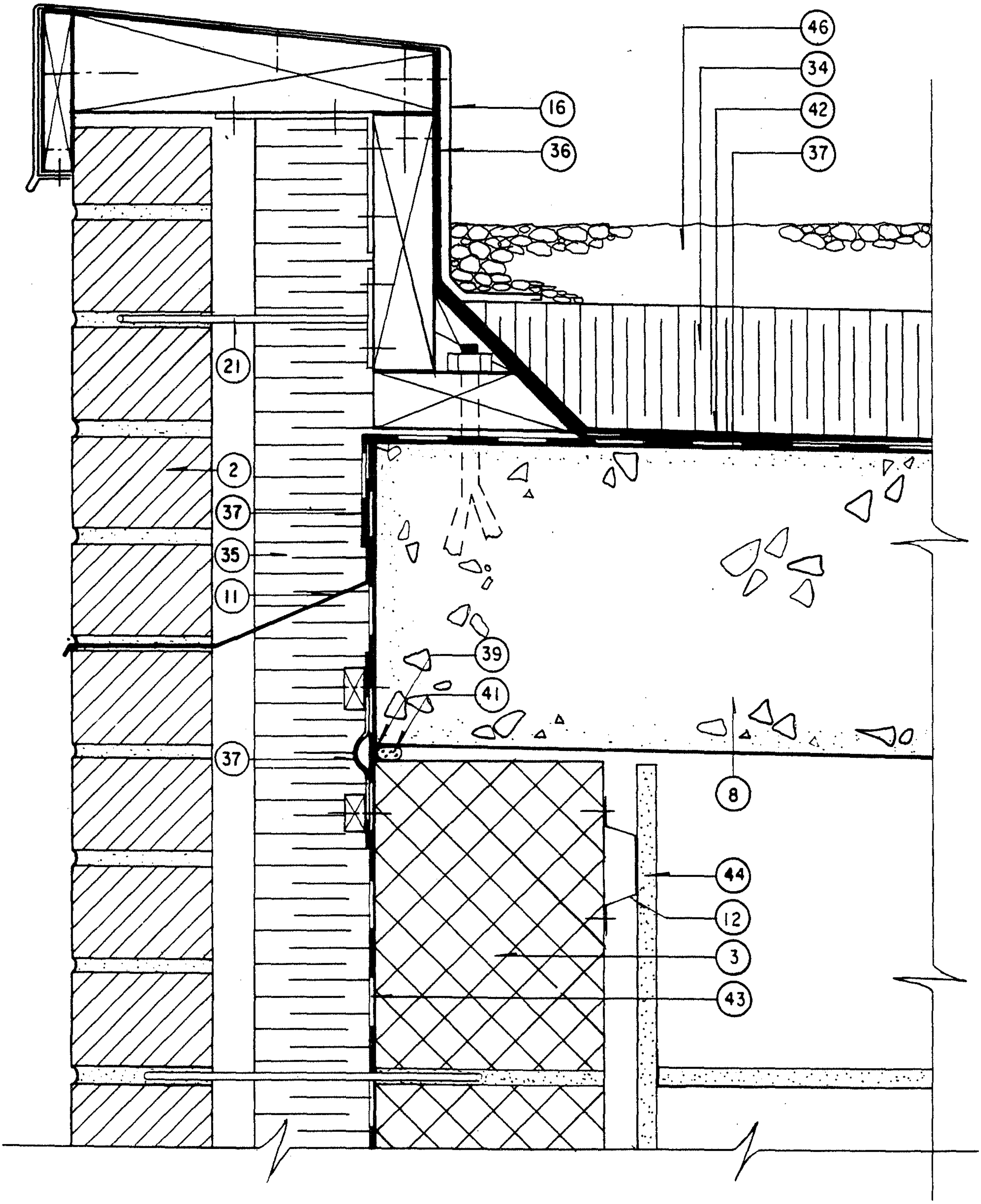


FIGURE 7

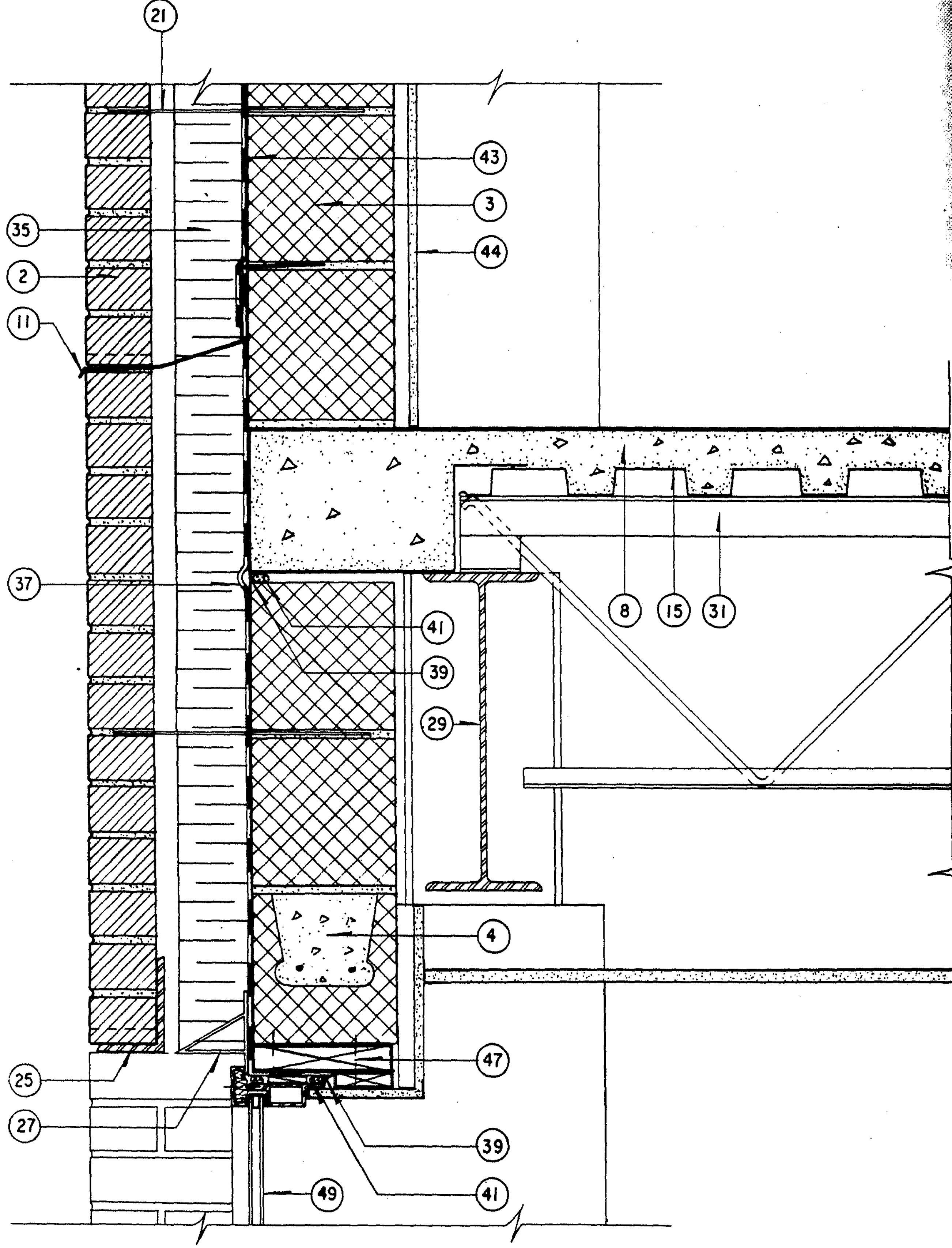


FIGURE 8

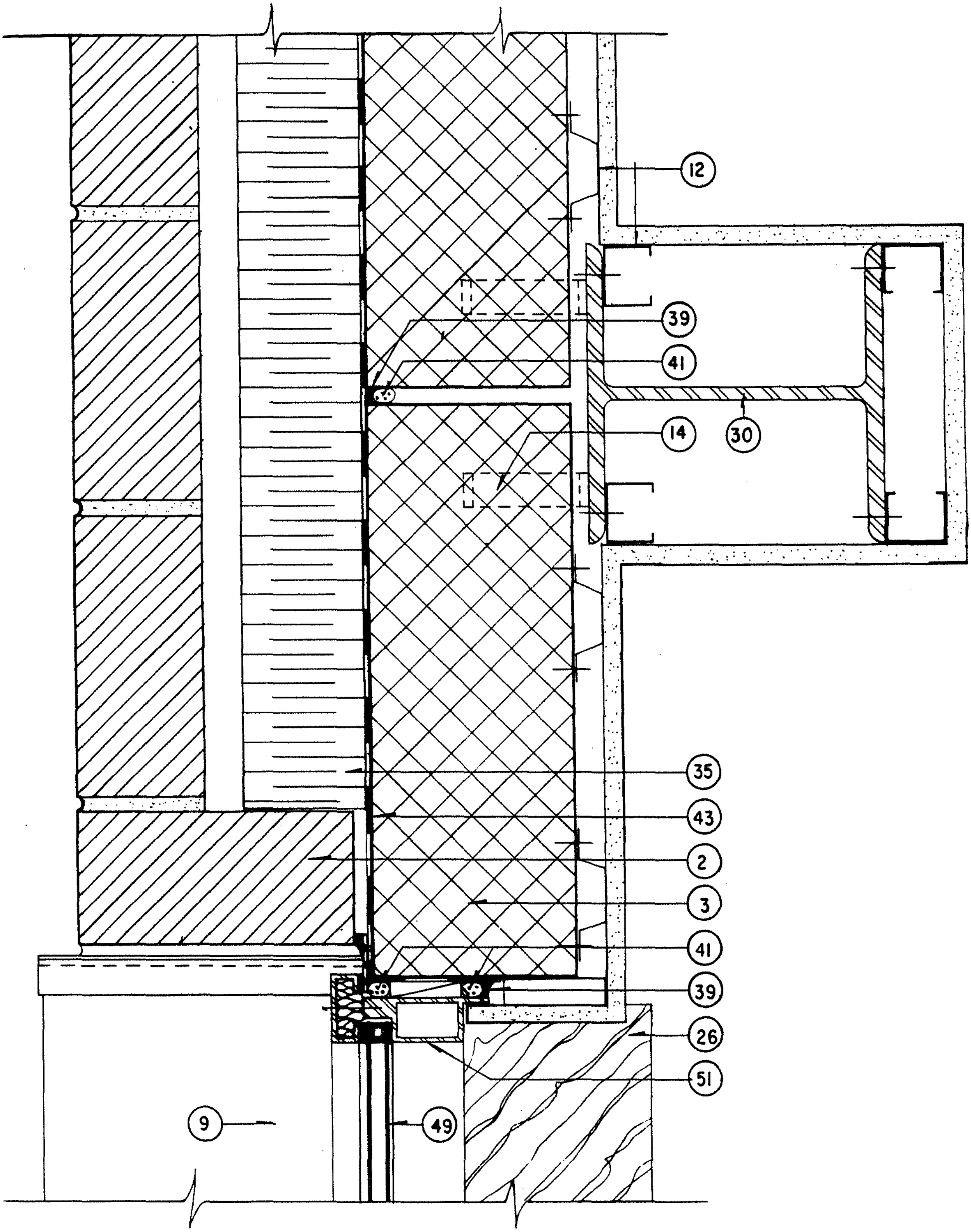


FIGURE 9

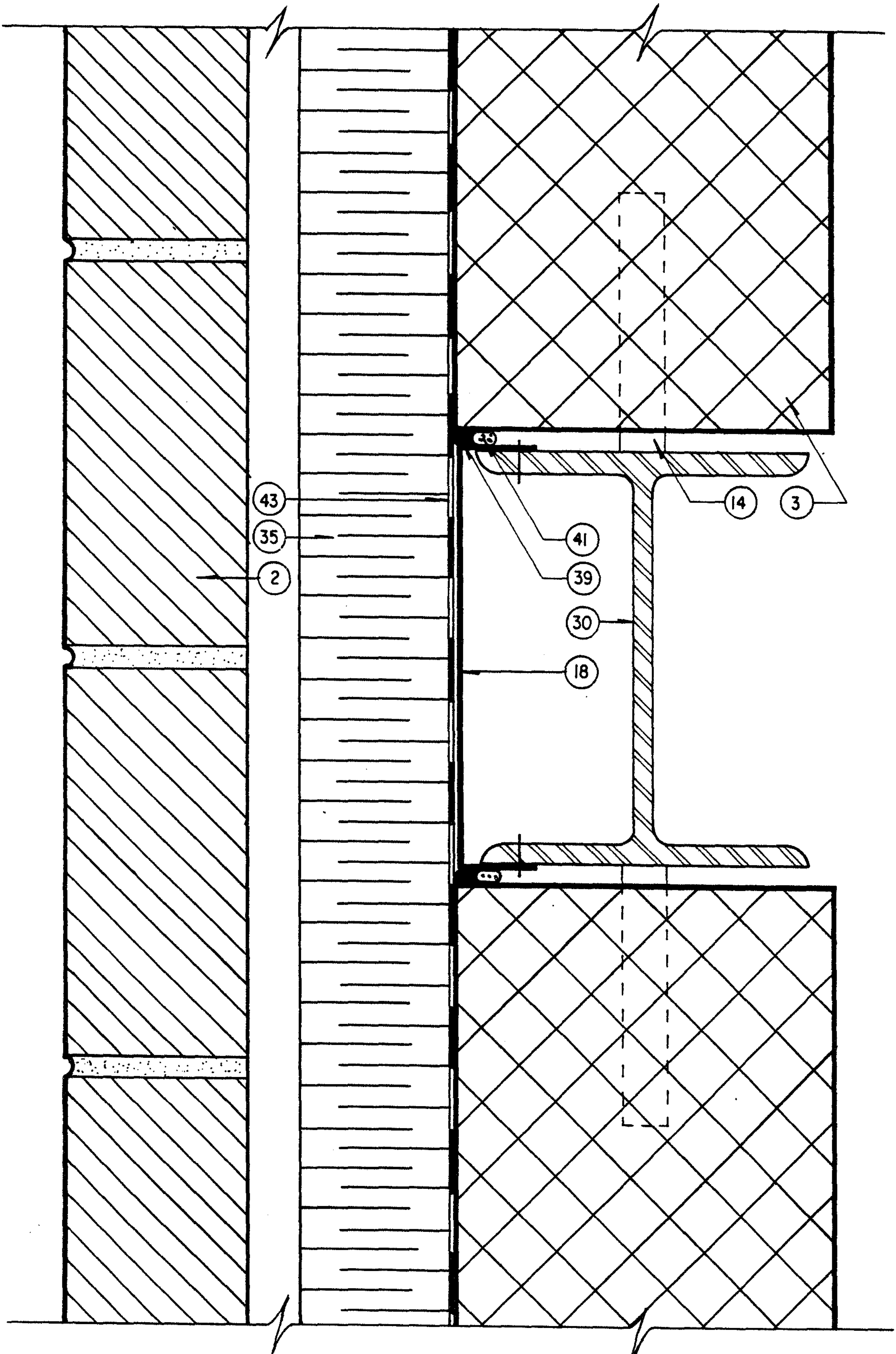


FIGURE 10

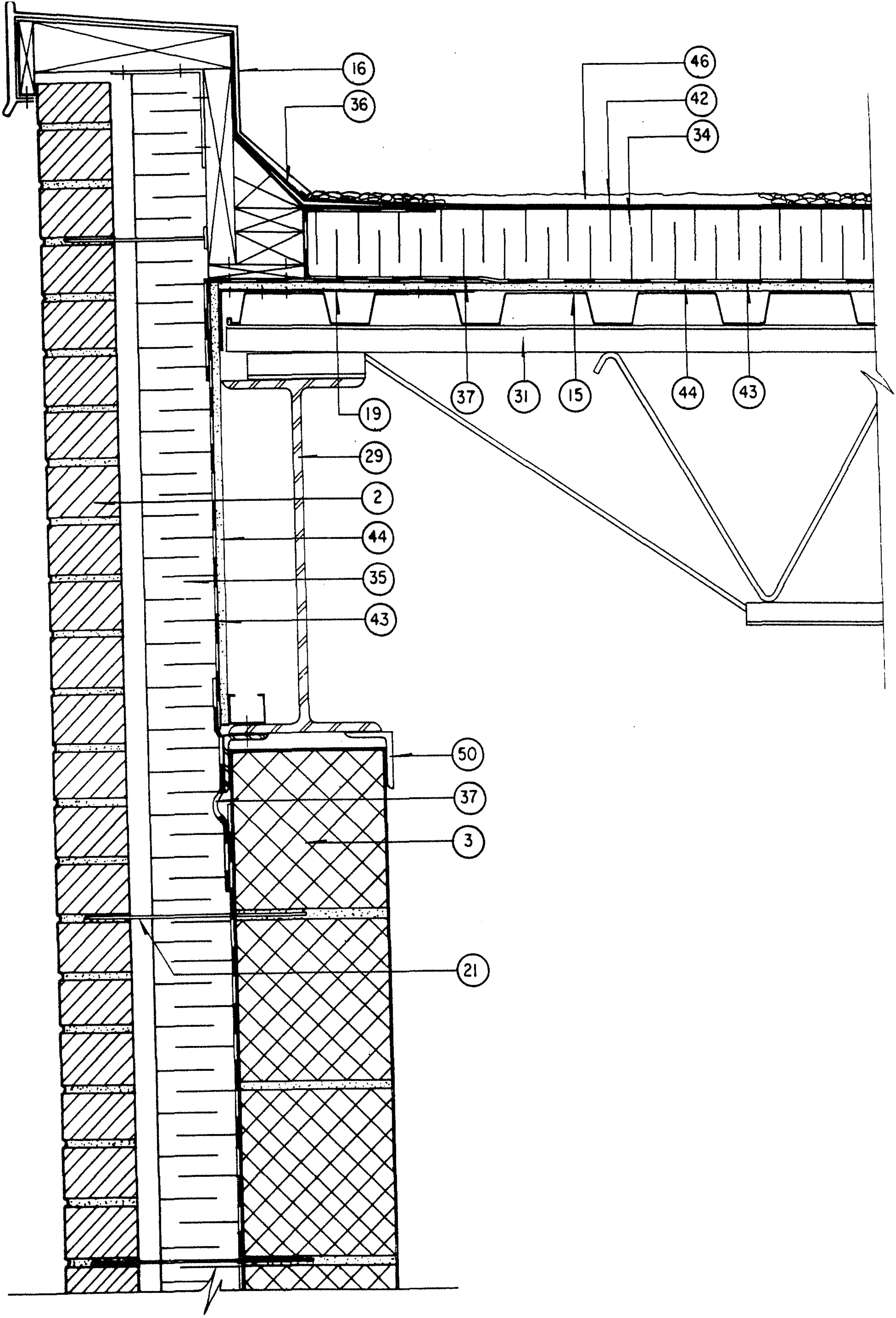


FIGURE 11

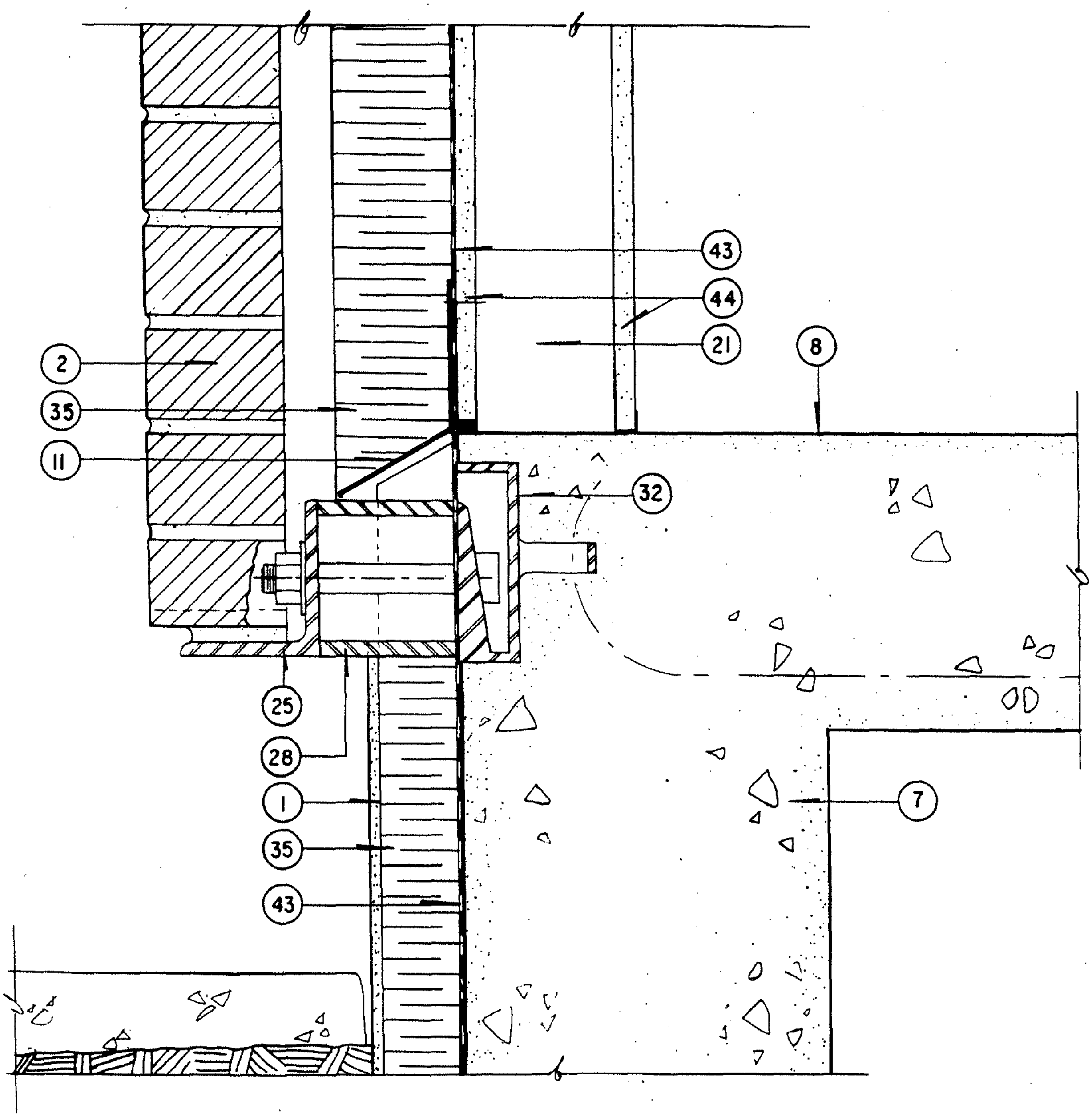


FIGURE 12

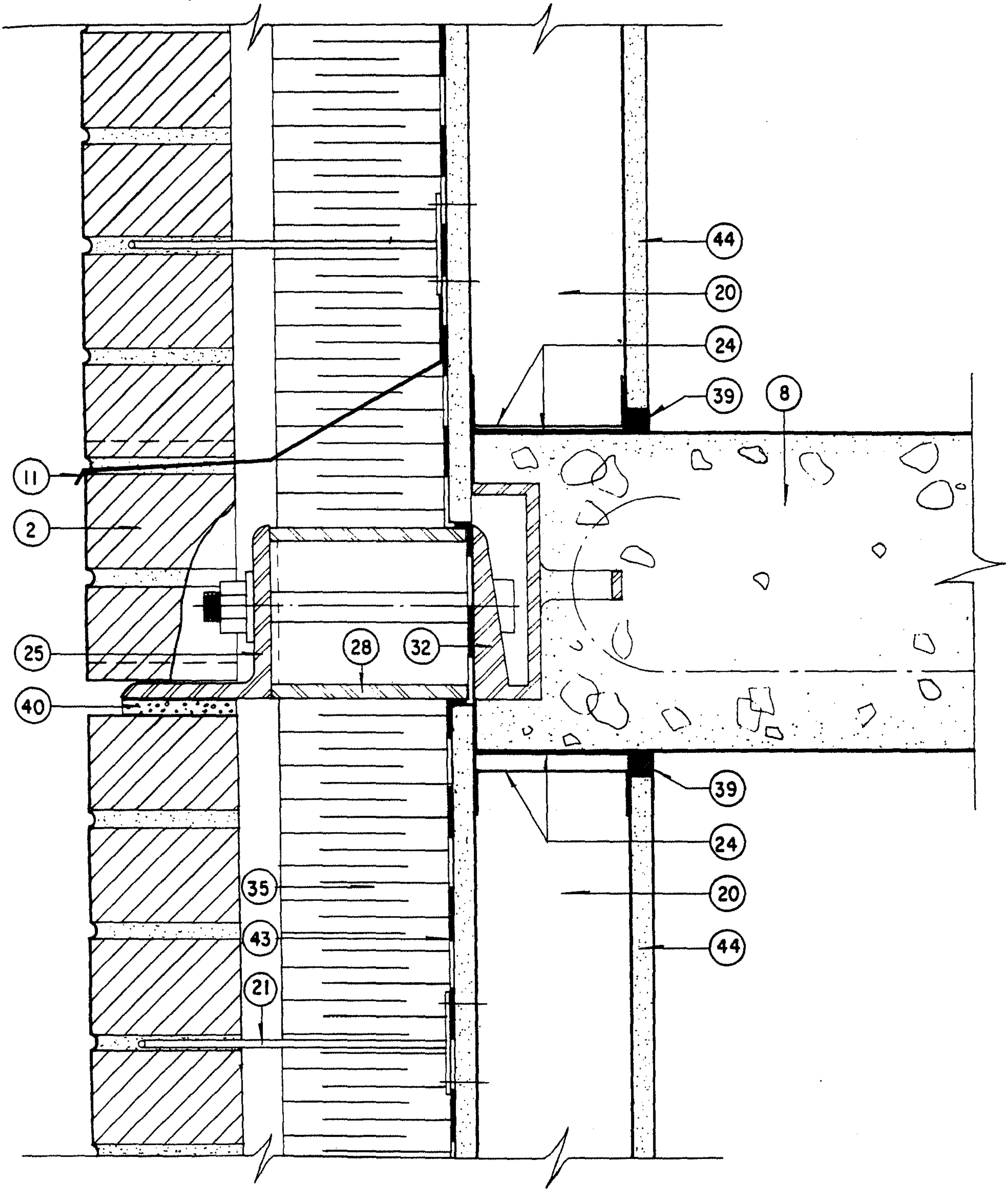


FIGURE 13

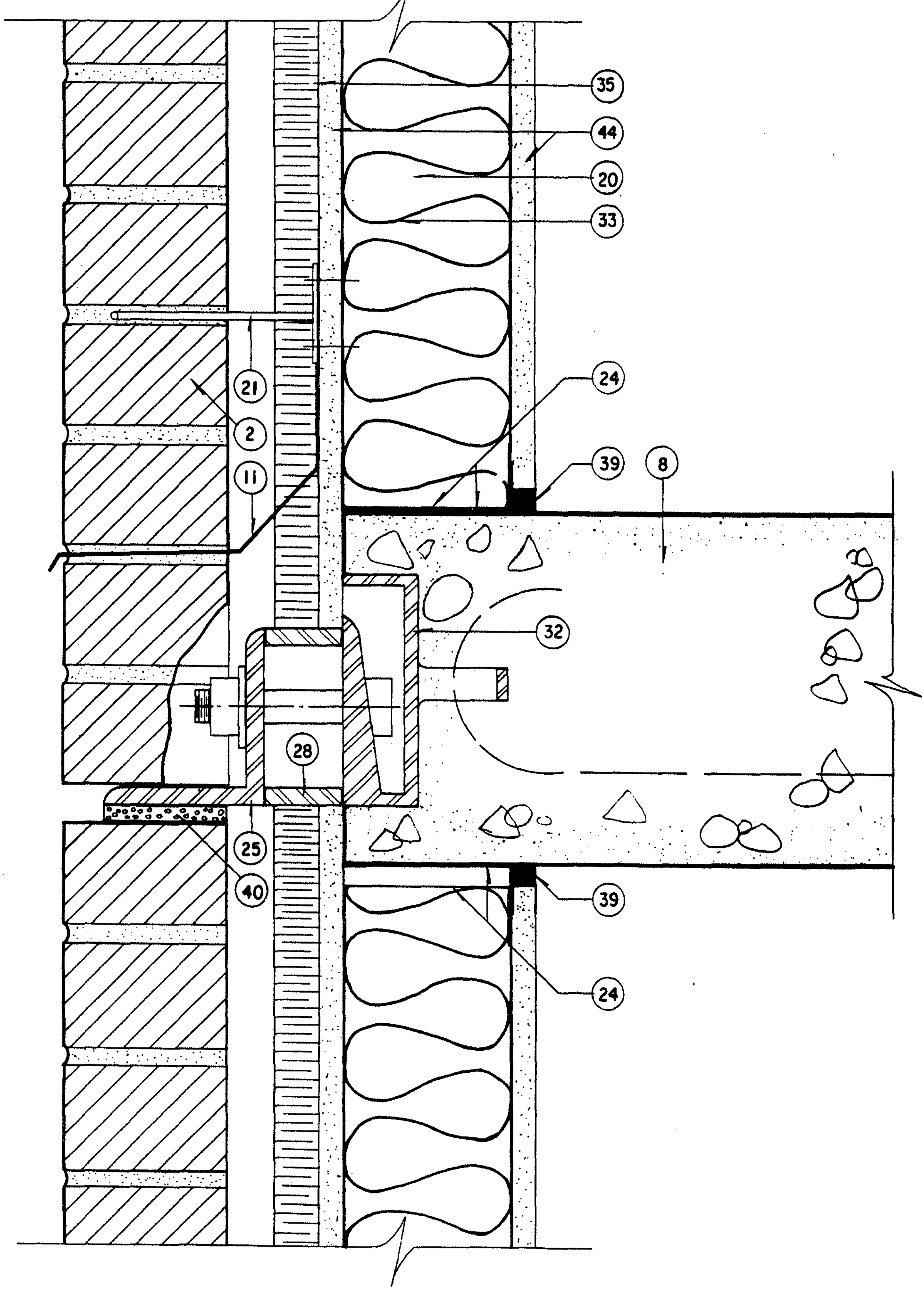


FIGURE 14

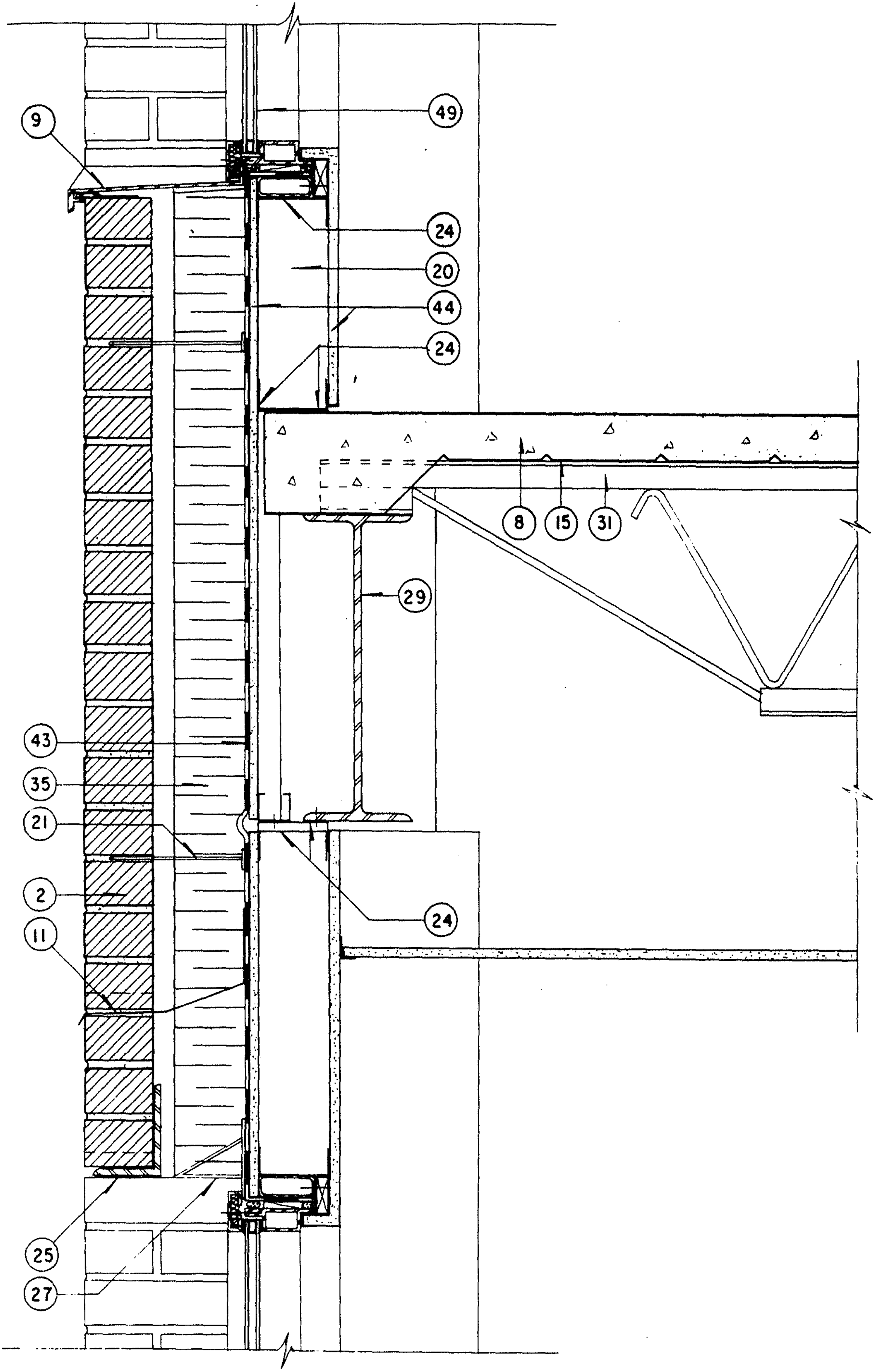


FIGURE 15

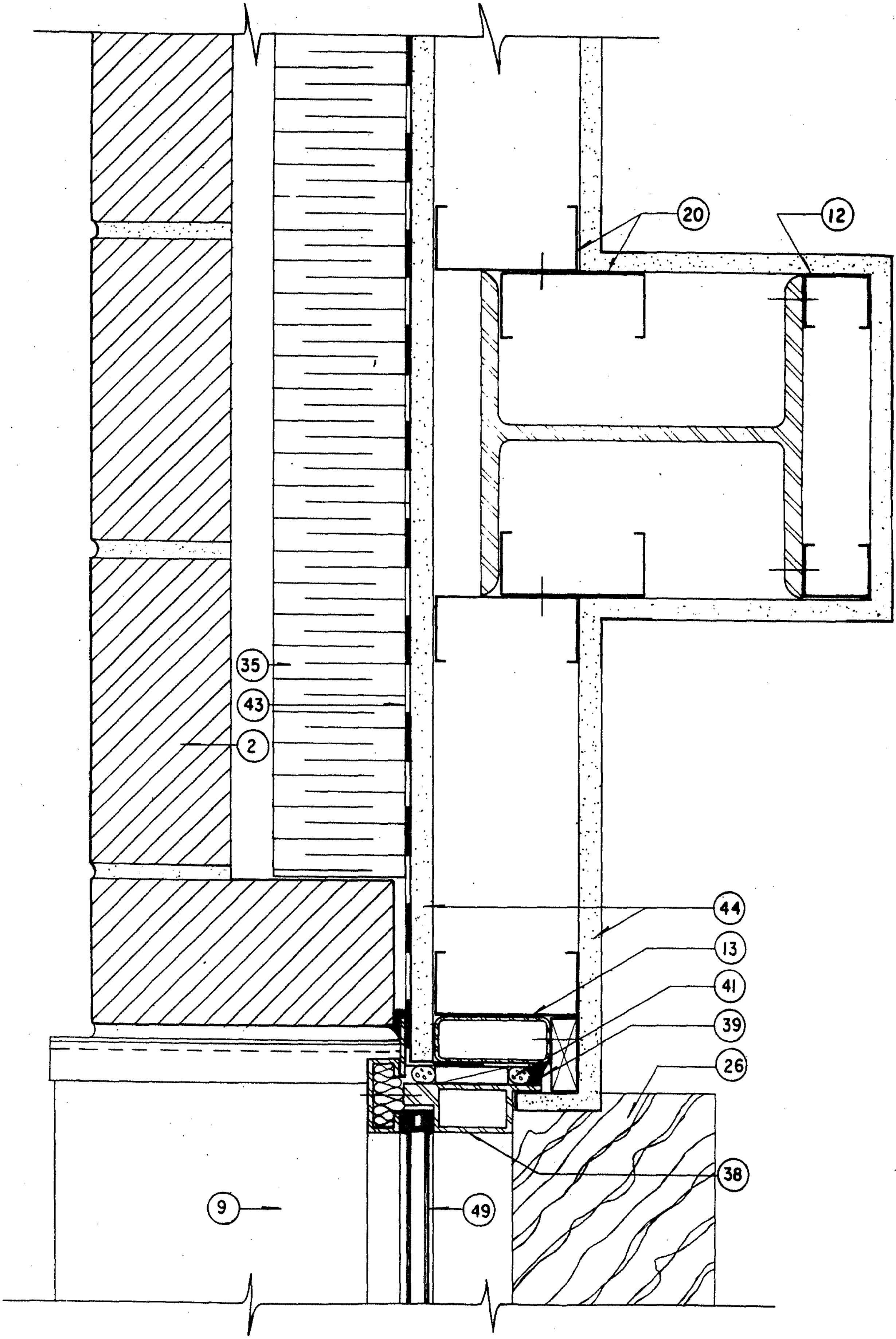
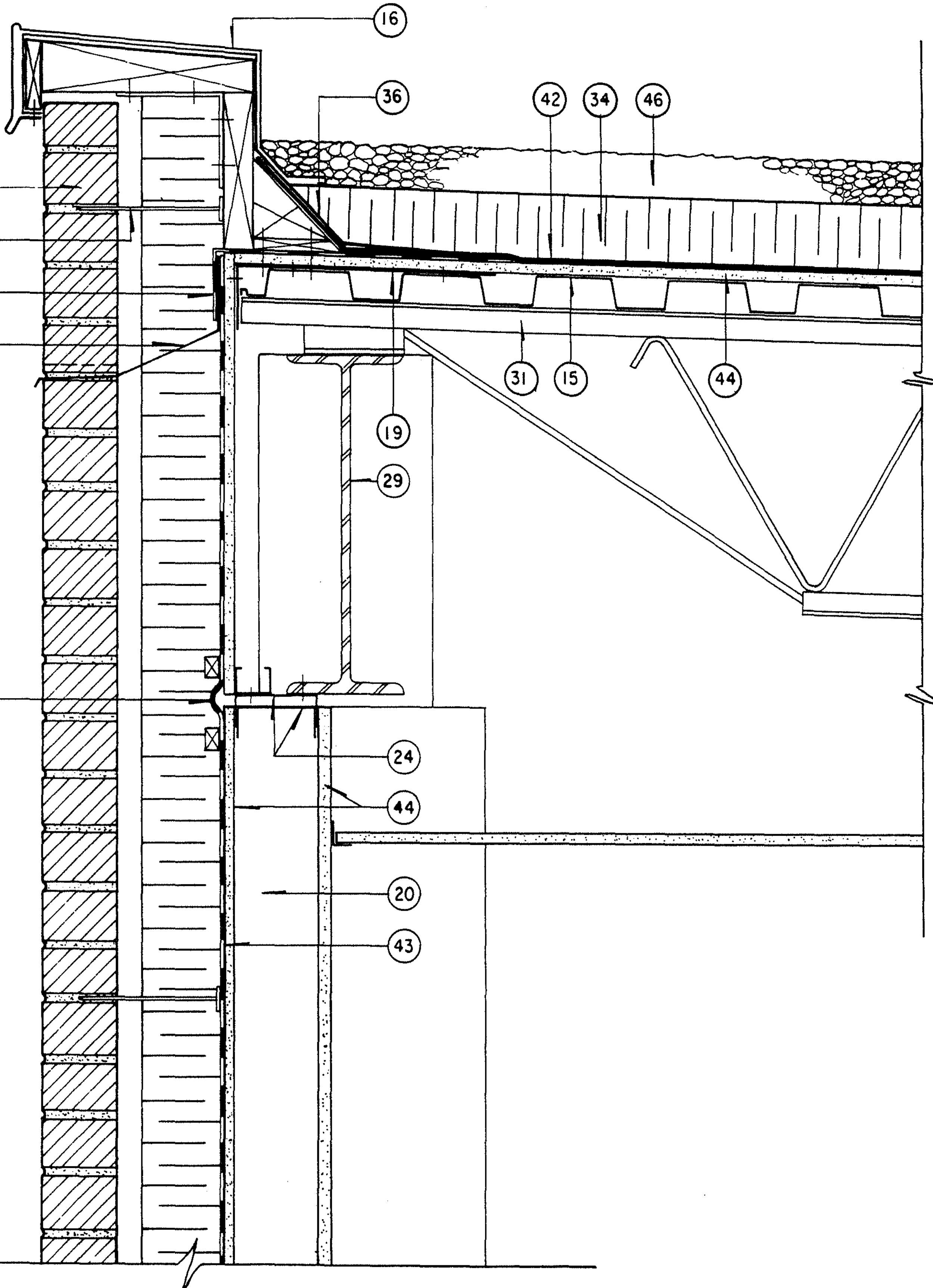


FIGURE 16



IGURE 17

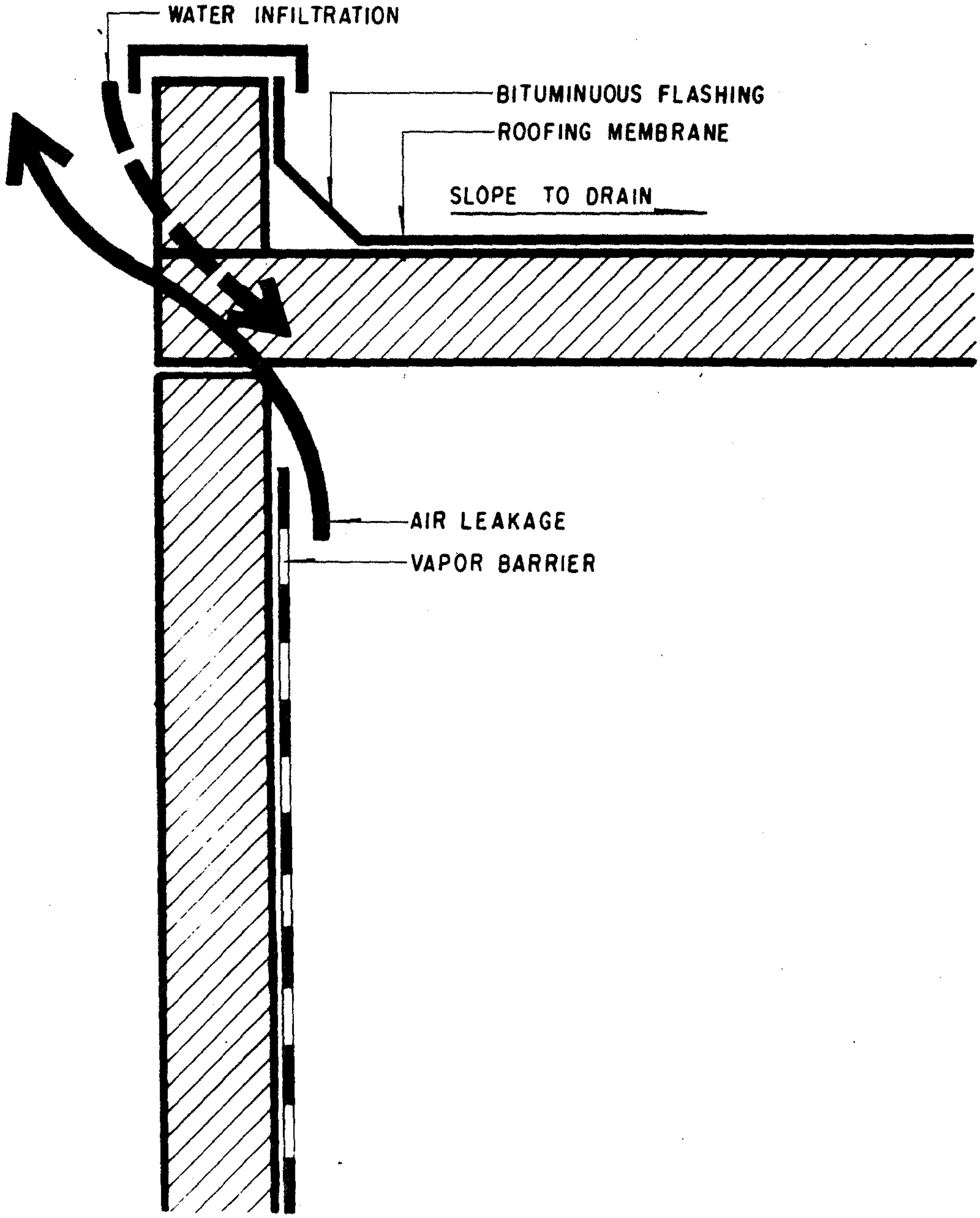

WATER INFILTRATION
BITUMINUOUS FLASHING
ROOFING MEMBRANE
SLOPE TO DRAIN
AIR LEAKAGE
VAPOR BARRIER

FIGURE 18

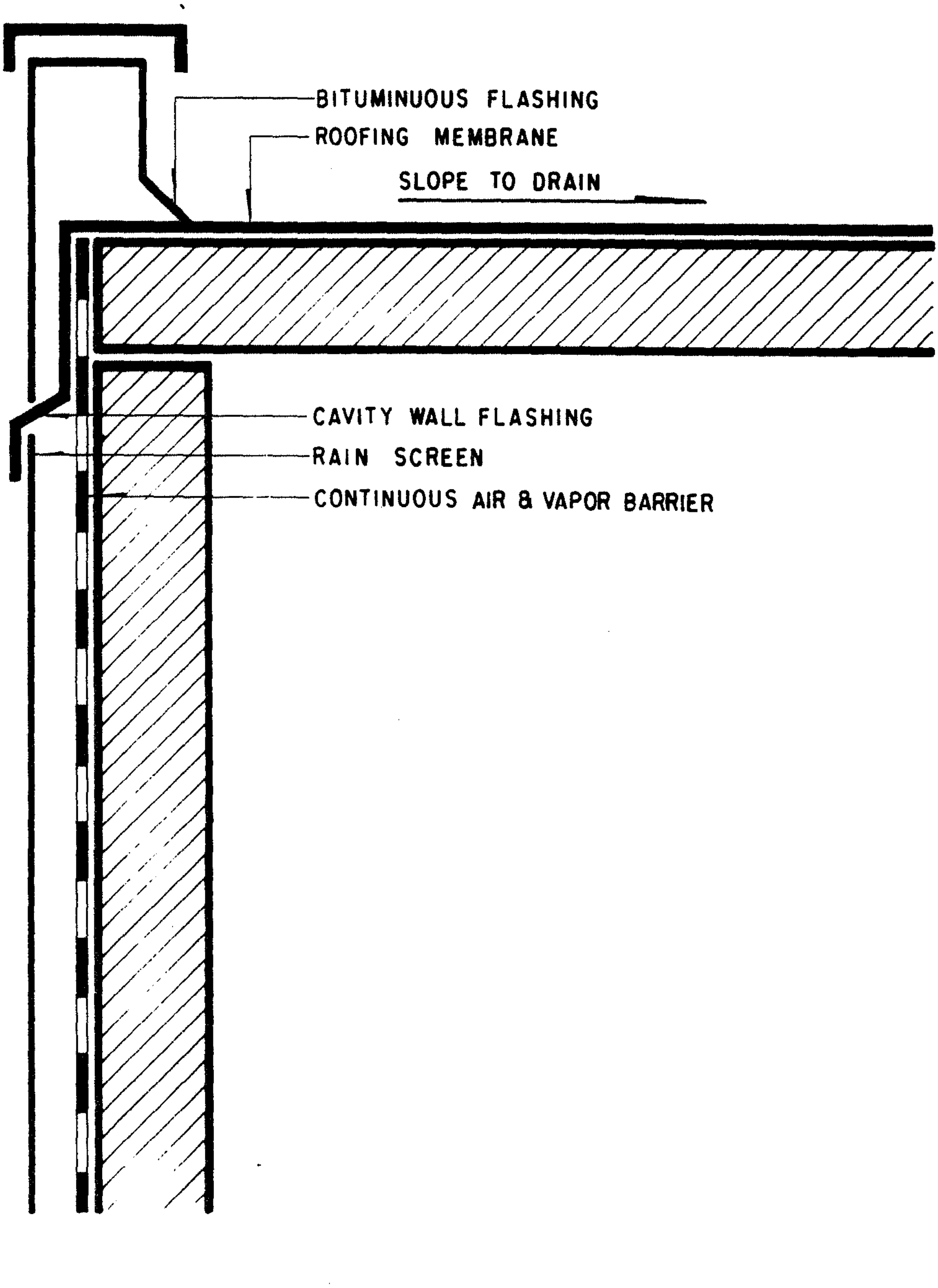

BITUMINOUS FLASHING
ROOFING MEMBRANE
SLOPE TO DRAIN
CAVITY WALL FLASHING
RAIN SCREEN
CONTINUOUS AIR & VAPOR BARRIER

FIGURE 19

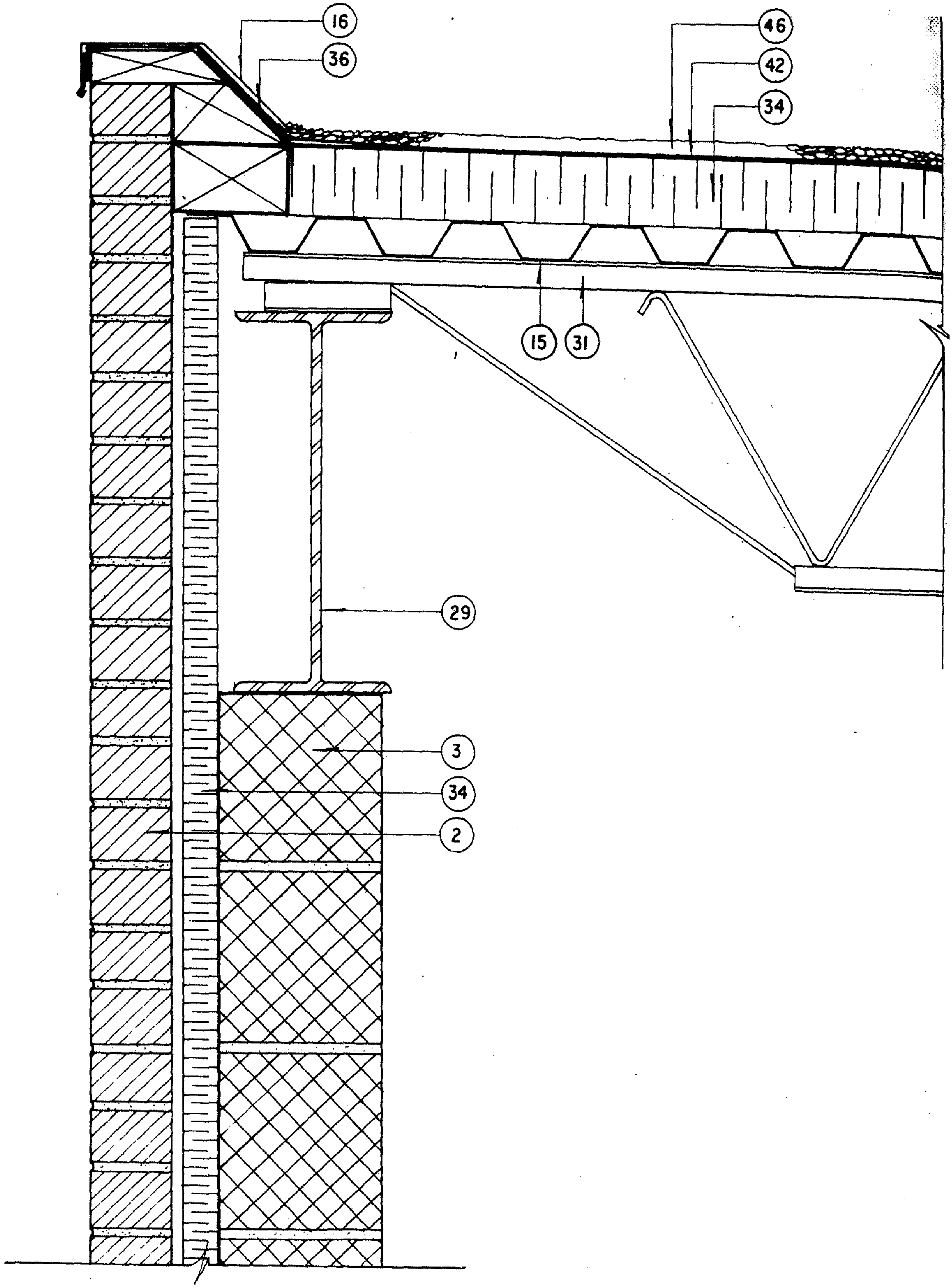


FIGURE 20

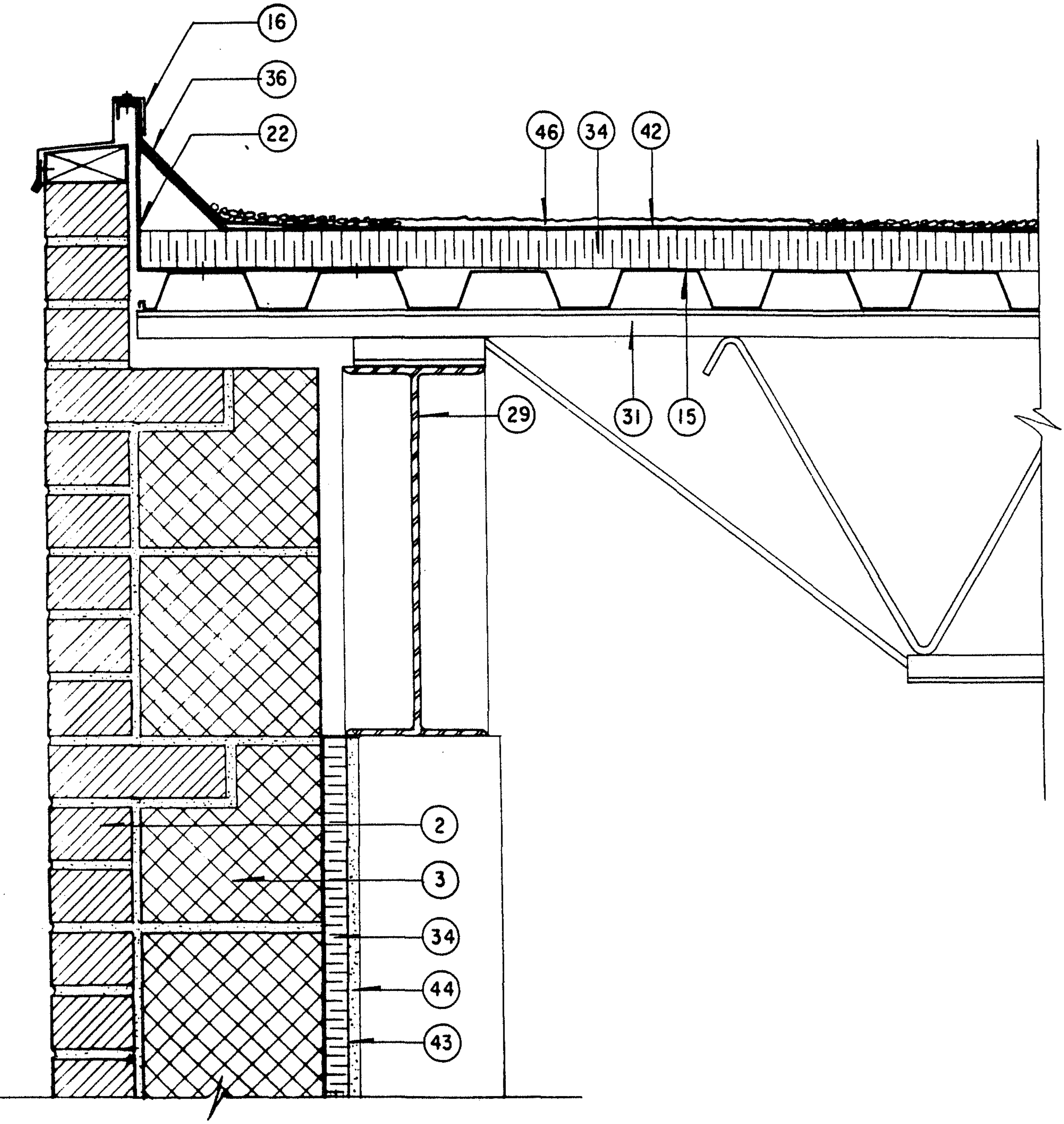


FIGURE 21

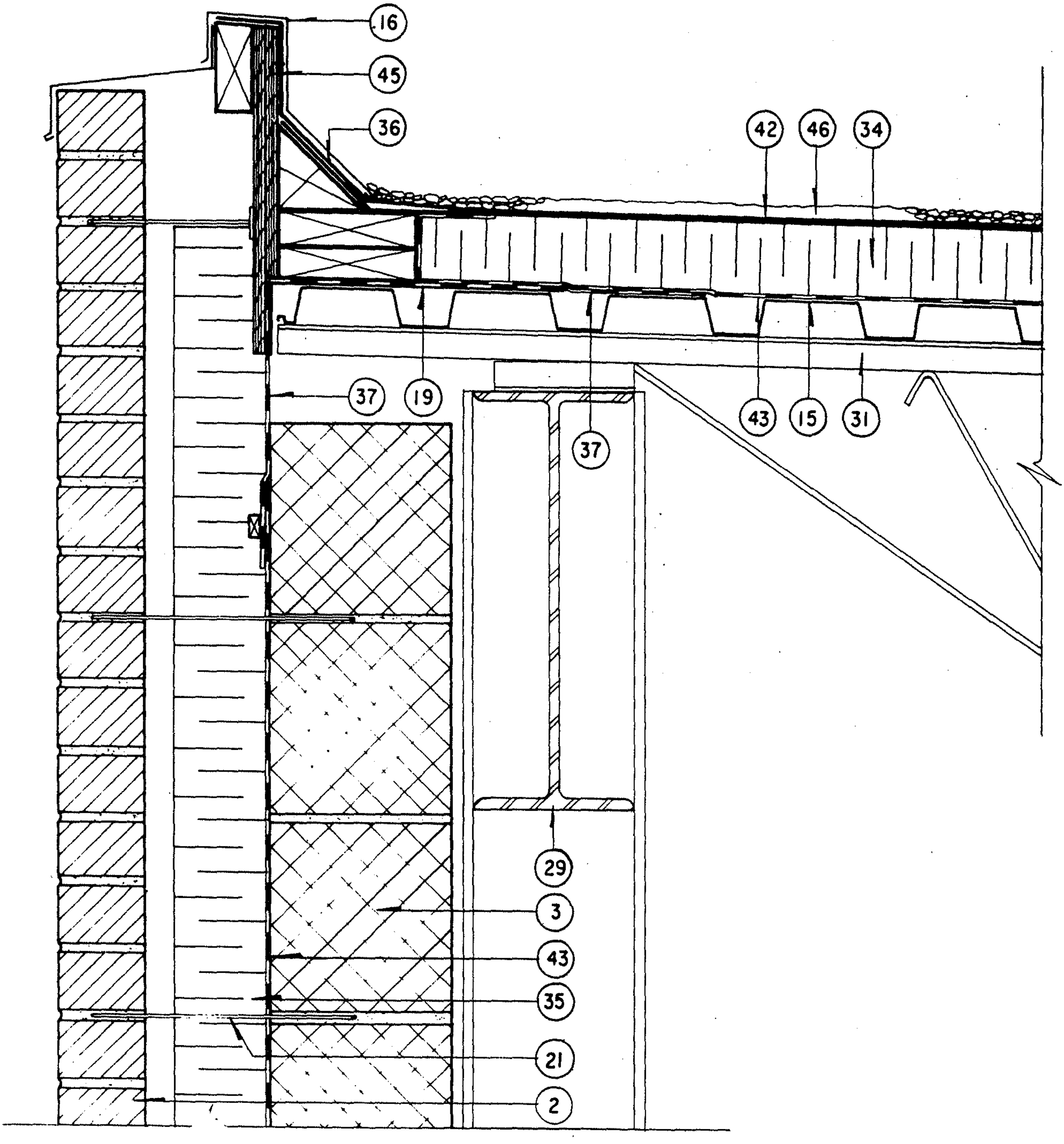


FIGURE 22

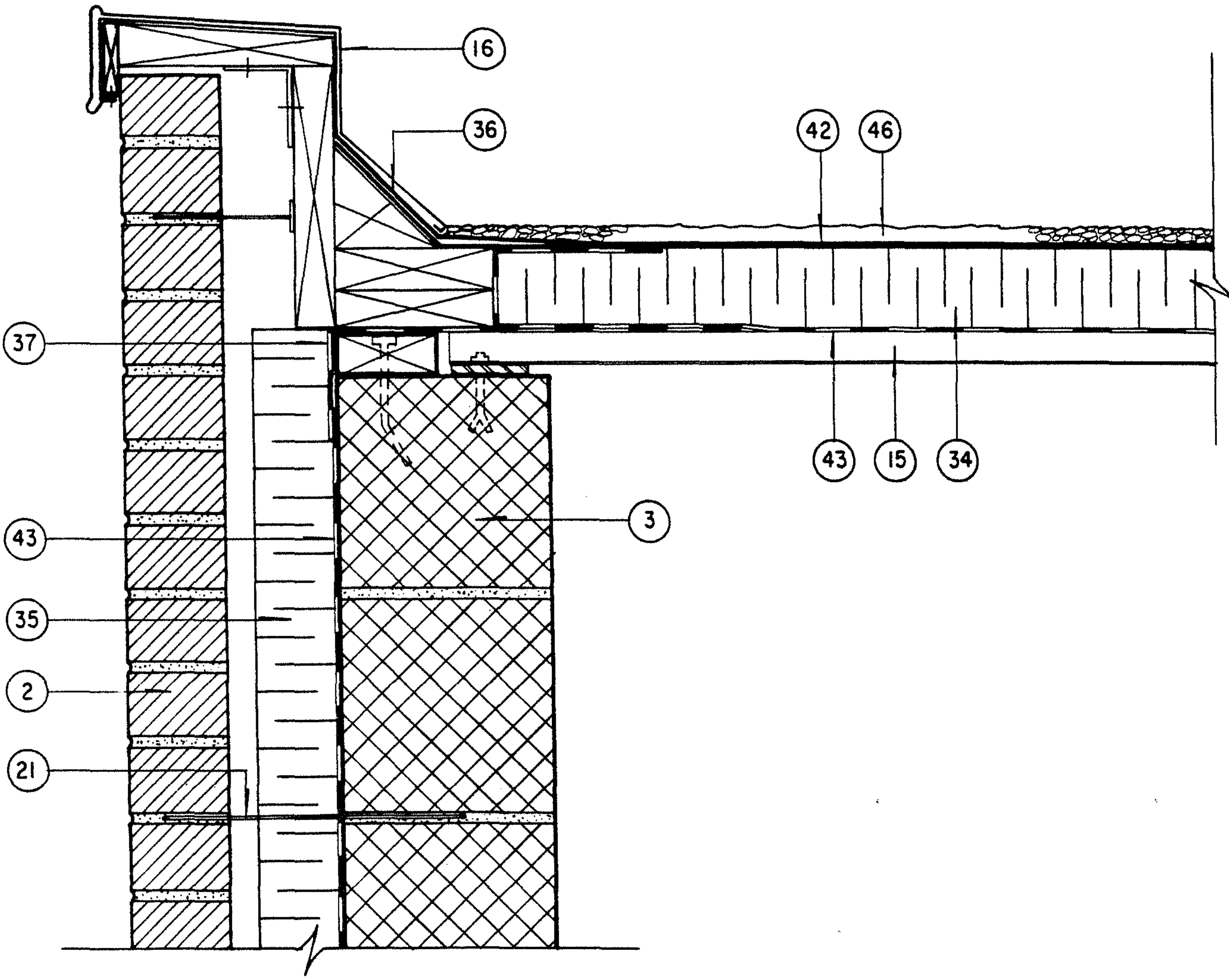


FIGURE 23

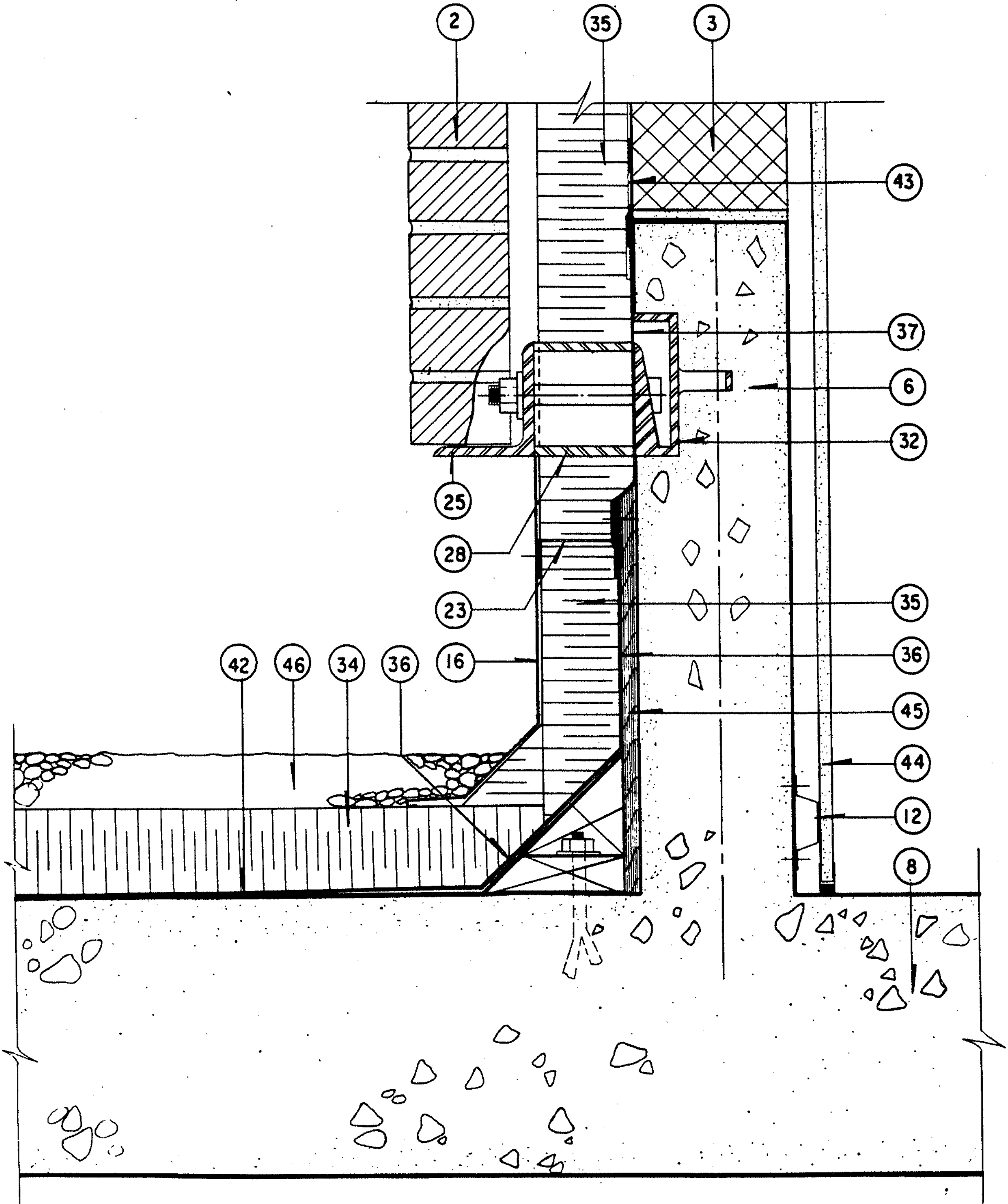


FIGURE 24

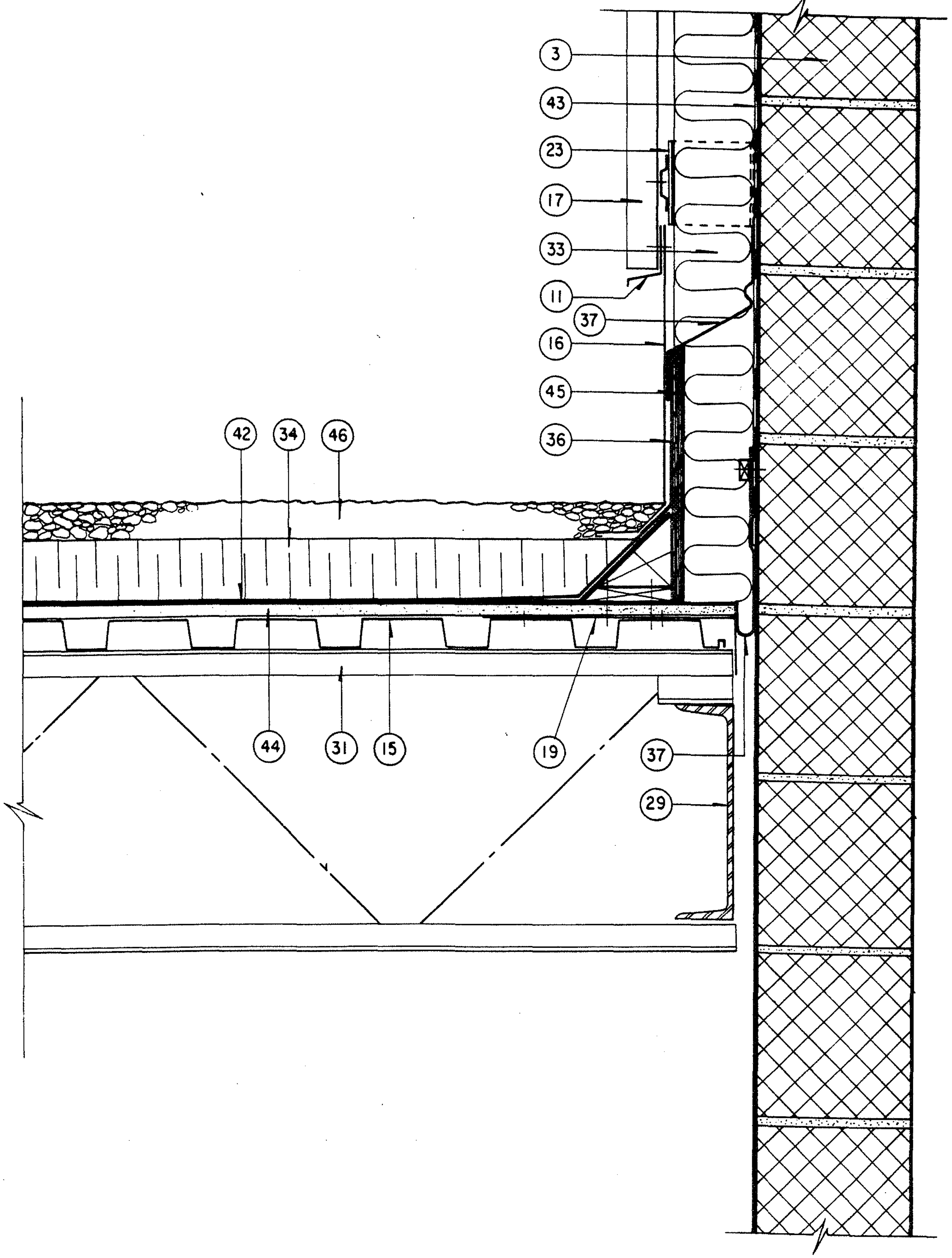


FIGURE 25

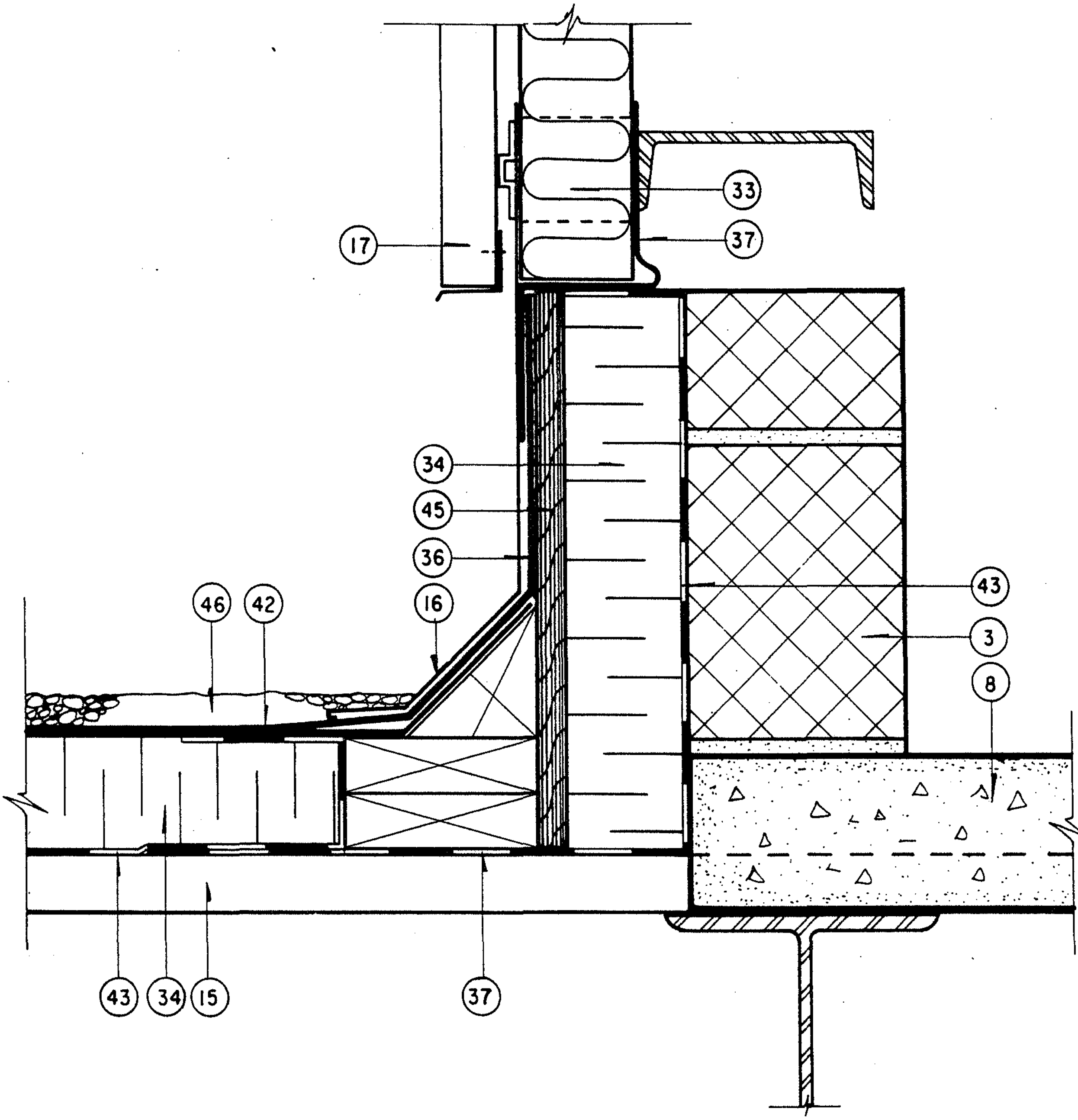


FIGURE 26

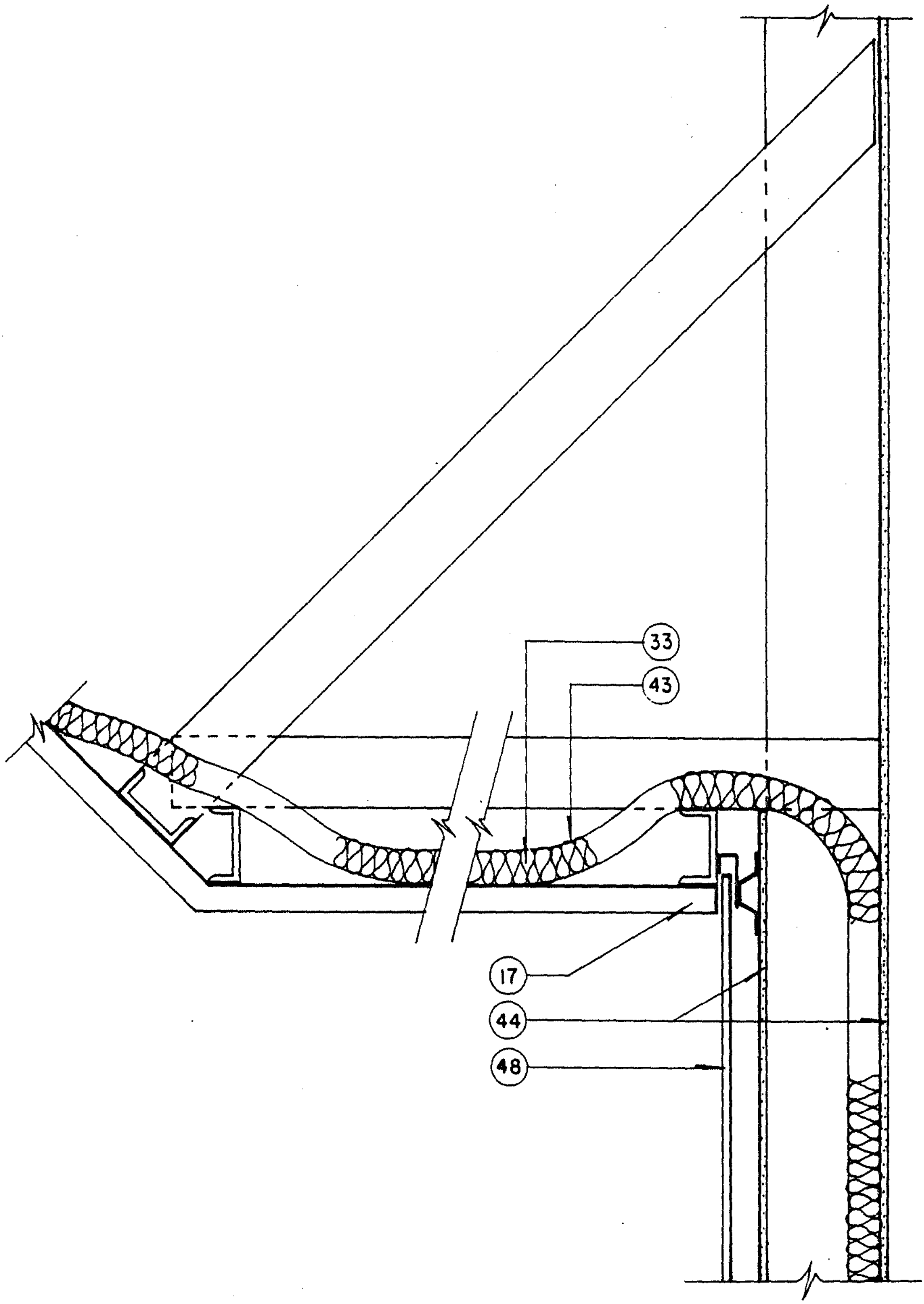


FIGURE 27

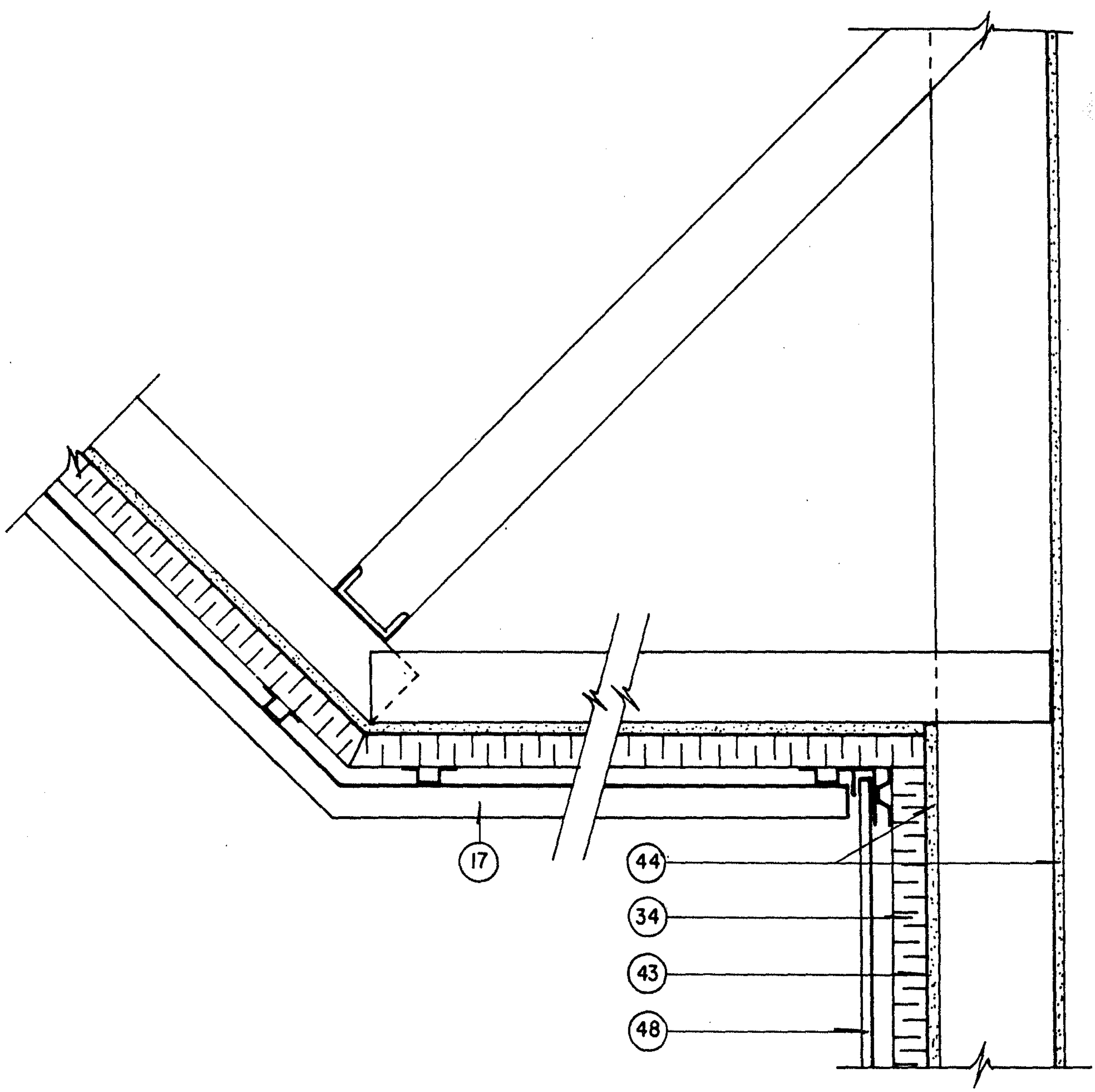


FIGURE 28