

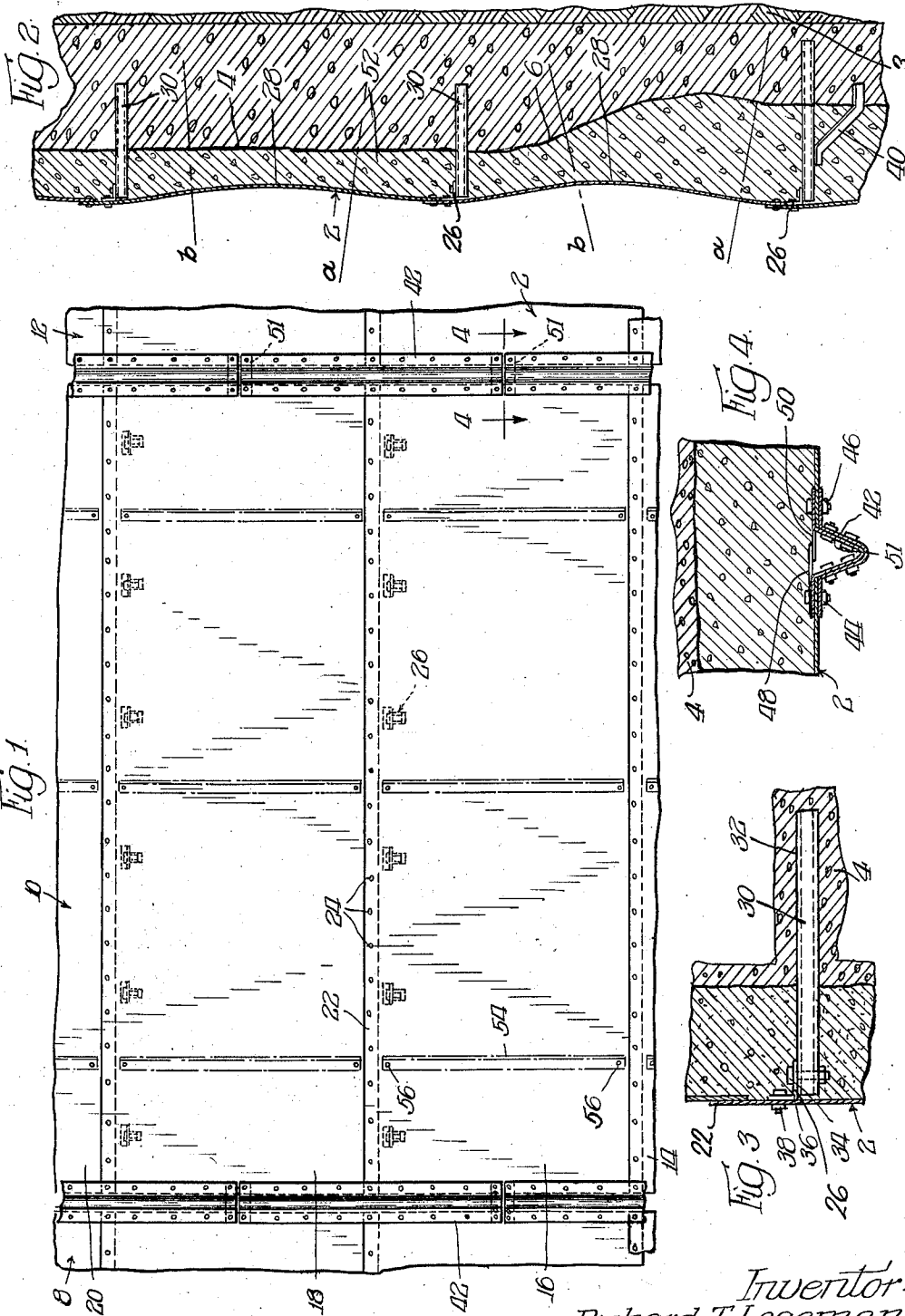
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FACING FOR RETAINING STRUCTURES AND METHOD OF FORMING SAME.

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FACING FOR RETAINING STRUCTURES AND
METHOD OF FORMING SAME

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The present invention relates to sheeting structures and method of forming the same, and more in particular to metal facings for retaining structures, such as dams of the earth or rock fill type, or concrete or masonry type, and the method of forming such metal facings.

Engineers for years have appreciated the distinct advantages inherently characteristic of metal sheeting as a facing for retaining structures. Where metal sheeting can be used, it has certain qualities which make it particularly adapted for the facing of retaining structures, as for example, dams of the earth fill type, as compared to a facing of concrete, rubble masonry, or the like, which has been used in the past. One of the main advantages of a metal sheeting is that the same is not subject to deterioration due to the wearing processes of water, and has the desired resiliency and ability to flex in all directions so that should there be any settling or movement of any kind in the fill, such metal sheeting is adapted to accommodate itself to such settling or movement.

However, metal sheeting, where assembled in association with retaining structures such as dams of the earth fill type, in order to provide a water-tight membrane on the upstream surface of the dam, had to be connected together in such a rigid condition that when subjected to variations in temperature the same buckled and warped, and because of this expansion and contraction satisfactory use with a very few exceptions has never been made of such material for rendering said retaining structures impervious to water, and for providing a suitable facing therefor.

Therefore, one of the objects of the present invention is to provide a sheeting structure formed of a plurality of assembled relatively thin elements of contractible and expansible material so constructed and arranged as to provide for expansion and contraction in two directions, thereby making such an assembled sheeting structure particularly adapted as a facing for retaining structures.

Still another object of the present invention is to provide novel methods of assembling and erecting the present sheeting structure in position on the face of the retaining structures.

The present invention has to do more specifically with metal sheeting structures comprising a plurality of relatively thin elements which are erected and connected together in the field and which, when assembled, provide a substantially continuous uninterrupted surface adapted to be applied to or form the upstream face of retaining structures such as dams of the earth fill type and which, even though assembled as a unit, nevertheless is provided with such means as to permit expansion and contraction in two

directions without causing buckling or warping of such sheeting structure to any extent but one in which the elements are sufficiently flexible and so constructed, arranged and assembled as to accommodate certain settling and movement of the fill without in any way affecting the imperviousness of the entire sheeting.

The present invention also lends itself admirably for reconstructing or repairing old retaining structures such as dams of the earth fill type which may have the upstream face thereof of rubble masonry or concrete which has become so damaged because of settling and buckling of the fill as to permit a large amount of water to seep from the reservoir through the fill to the downstream face of the retaining structure and to such an extent that damage has been caused and unless repaired would so undermine the structure as to result in a complete failure of the same. The sheeting structure made in accordance with the present invention is particularly adapted for refinishing the upstream face of such an old dam construction and may be easily and readily applied thereto and when finished is fully capable of providing imperviousness of the entire structure, yet admirably adapted to withstand further settling or other movement of the dam which might take place because of the damage already done due to the seepage of water through the fill.

The present invention also relates to various methods whereby the sheeting structure made in accordance with the present disclosure may be readily and easily fabricated in the shop, shipped to the site of the retaining structure and erected in place on the face thereof.

Other objects, features, capabilities and advantages are comprehended by the invention, as will later appear and as are inherently possessed thereby.

Referring to the drawing:

Figure 1 is a fragmentary view in elevation of a sheeting structure made in accordance with the present invention;

Figure 2 is an enlarged view in vertical cross section taken through the structure shown in Figure 1 of the drawing;

Figure 3 is an enlarged fragmentary view in vertical cross section taken through a part of the structure shown in Figures 1 and 2 of the drawing; and

Figure 4 is an enlarged fragmentary view in horizontal cross section taken in the plane represented by line 4—4 of Figure 1 of the drawing.

As hereinbefore indicated, the present invention particularly relates to metal sheeting structures provided as facings for retaining structures, such as dams of the earth or rock fill type, or concrete or masonry type. However, it is to be clearly understood that such sheeting structures

may be used whenever and wherever the advantages of such a facing are desired, whether for retaining structures or not, although in the illustrative embodiment selected to disclose the present invention such sheeting, which is generally represented as 2, is shown as forming the face of a dam of the earth fill type 3 having a concrete facing 4 which has become so damaged as at 6 that said concrete facing is no longer capable of rendering the desired service, namely, to properly retain the fill and provide an impervious sheet or wall preventing the seepage of water through the dam, and has become worn to such an extent that the concrete wall either has to be replaced or repaired in some way to fulfill the requirements of such a structure.

In accordance with this invention, such a wall can be readily and easily repaired by applying the sheeting structure of the present disclosure, which sheeting structure, because of its assembly and formation, provides a water-tight facing adapted to withstand extreme changes in temperature without buckling, warping or becoming displaced in any manner which would affect its imperviousness. This sheeting structure 2 comprises a plurality of sections, such as 8, 10 and 12 as shown in the drawing, to cover the face of the dam, each of said sections comprising a plurality of flexible metal sheets, such as 14, 16, 18 and 20, which are of such a size as to be easily fabricated, handled and assembled in the field. As an illustrative example, these sheets when in assembled condition, are substantially eight feet in a vertical direction or in the direction of width of the dam or sheeting structure and substantially twenty-five feet in a horizontal direction, or in the direction of the length of the dam or sheeting structure. In a vertical direction the sheets are assembled in overlapping relation, as at 22, and are secured together by bolts or rivets as at 24, a sufficient number of such bolts or rivets being provided to secure a water-tight joint between said plates.

In order to retain the sheeting structure in position, the same is assembled in spaced relation to the face 6 of the retaining structure and held in place by a plurality of anchoring means 26 spaced apart horizontally and disposed adjacent each of the joints formed by the overlapping of the plates as at 22. As will be clearly understood from Figure 2 of the drawing, each of the plates is bent to cause a bow at the center thereof as at 28 so that the sheeting structure, when assembled and secured in position by anchoring means 26, has an undulating form from top to bottom. These plates are so bent that the bow or offset therein will accommodate maximum changes in width in a vertical direction due to maximum changes in temperature. The offset disclosed in the illustrative embodiment for the plates which are substantially eight feet in width vertically amounts to approximately two and one-half inches, which provides for maximum changes due to expansion and contraction in width of the plate for temperature changes of 150 degrees, which is the design data used in a good many localities where such temperature changes may take place. More particularly, each of the sheets at the central portion between tangent lines *a* and *b* is formed as the arc of a circle whereby the adjacent end portions of adjacent sheets in the direction of the width of the sheeting structure provide a curved formation opposite to that at the central portion of the sheets, thus producing the undulating form above re-

ferred to and which sheeting structure as a whole or the individual sheets thereof may be referred to as being of reverse curve formation.

The anchoring means 26 as more particularly disclosed in Figures 2 and 3 of the drawing, comprises a structural element or anchoring member 30 which is anchored within a hole 32 drilled in the face of the concrete 4, these anchoring members projecting from the face of said concrete a sufficient and calculated amount so that when the sheet structure is finally assembled the same will be in a substantially vertical position. Connected to the outer end of these anchoring members, as by means of bolts 34, are angle brackets 36 which are connected, as by means of bolts 38, to the plates of the sheeting structure. Where the face of the concrete has disintegrated to such an extent as indicated in the lower portion of Figure 2 of the drawing, these anchoring members may have to be supported during the erection of the sheeting structure by means of the brackets 40. The angle members 36 are provided with horizontally slotted holes in the horizontal leg thereof, which slotted holes receive bolts 34 and permit expansion and contraction of the sheeting structure in a horizontal direction, it being understood that even though the sheeting is fixed against vertical movement of the same relative to the facing 4, nevertheless expansion and contraction are provided for by the undulating formation of the same. In this connection, it should be observed that the sheets at the anchoring points 26 are substantially fixed. Therefore contraction in the individual sheets is accommodated by the sheet between said points moving away from the face of the dam or retaining structure. This movement does not in any way affect the anchoring means for the plate. When the individual sheets expand, elongation takes place between the anchoring points gradually moving the sheet into intimate contact with the face of the dam or retaining structure until such time as further movement is prevented thereby. Internal stresses are gradually built up but are quickly relieved by slight buckling of the sheets substantially at the tangent points of the curves. It will therefore be seen that expansion and contraction are provided for in the direction of the width of the sheeting structure. Furthermore, slight buckling takes place to relieve the sheets of internal stress, thus preventing any damage to the anchoring means.

The edges of the plates of the adjacent sections are connected together by vertically extending expansion joints such as 42, each of which is constructed in accordance with the disclosure in Figure 4 of the drawing of substantially V-formation in cross section; the same being connected to the adjacent plates by means of the rivets or bolts 44 and 46, the expansion joints also being formed with the overlapping plates 48 and 50 which are included to prevent entrance of concrete or the like into the V-shaped trough formation of said expansion joints. These expansion joints comprise sections disposed in end to end relation and connected together by splices 51 which provide water-tight joints between these sections. These joints, because of their resilient character and the material of which the same are formed, accommodate expansion and contraction of each of the plates of the sheeting structure in a horizontal direction without in any way affecting the imperviousness of the said sheeting structure to water or the like.

After a portion or the whole of the sheeting

structure has been assembled as indicated, the space between the same and the concrete 6 or slab 4 is filled with a sealing material such as grout or concrete 52, which filler fixes the anchoring means 26 in place for securely holding the sheeting structure in place and to form a backing for the individual sheets or panels thereof.

It will be clearly understood that by providing the expansion joints 42 in combination with the undulating formation of the sheeting structure in a vertical direction, that provision has been made to accommodate expansion in two directions, thus preventing buckling and warping of the sheeting structure due to changes in temperature and to settling or other movement of the retaining structure to which the same may be applied. By means of the present structure the advantages of a metal sheeting structure are secured without incorporating any of the disadvantages which have been characteristics of the same in years past. The completed sheeting structure may be viewed as comprising a plurality of zones each bounded by expansion joints in one direction and defined in the other direction by securing means spaced apart a distance conforming substantially to the distance between crests and connected adjacent the crests of the undulations between which is the offset portion or trough which provides for movement of the individual zones in said other direction.

The present invention also contemplates novel methods of assembling and erecting sheeting structures as above described in the field. As an illustrative example, in the embodiment disclosed in the figures of the drawing, the individual plates such as 16, 18 and 20 are formed in the fabricating shop as flat plates of the required dimensions for the particular job. These plates are shipped in a flat condition to the side of the retaining structure to which the sheeting assembly is to be applied. To assist in assembling the sheeting structure, a plurality of assembling members 54 are used, these members in the present instance comprising angle irons which have been pre-formed to provide a bend therein corresponding to the bend which is to be placed in the individual sheet members. The openings or holes represented as 56 adjacent the ends of these angle irons 54 are spaced apart the theoretical distance that similar openings which are formed in the plate at the time of fabrication will be spaced apart when said plate has been bent to the required amount to provide the desired offset. In the erection of these plates in the field, the members 54 are secured to the flat plates which, in the particular embodiment disclosed herein, have a thickness of substantially one-quarter inch and can therefore be rather easily bent so that there is proper alignment of the holes 56 of members 54 with the holes provided in said sheets, this securing being effected by using bolts or the like whereby these assembling members may be readily removed upon erection of the sheeting structure.

With the plates bent as explained, the same are successively placed in position in overlapping relation and the horizontal edges thereof secured together by means of the bolts or rivets 24. As each additional plate is placed in position vertically, the same is secured to the anchoring means which have been placed in the concrete wall 4 as described by means of openings or holes which are burned in the plates in the field in alignment with openings provided in the angle

brackets 36 of said retaining means. Each successive plate is securely connected to said anchoring means by bolts 38, after which, as successive plates are erected in position from the bottom to the top of the retaining structure, the expansion joints 42 are connected to the adjacent plates of the structure in the manner above indicated. After a part or the whole of the entire sheeting structure has been erected as described, concrete or other material 52 is poured to complete the finished job. After the concrete 52 has matured so as to hold the assembled structure in place, the assembling members 54 may be removed for use on another section of the job or on another job entirely.

Where a sheeting structure as described is to be used for the face of a retaining structure under construction, the plates or sheeting elements may be erected into place as the filling for the retaining structure progresses. In this instance the bend in the sheets is maintained by using assembling members such as 54, and the method varies from the preceding described method only in that the anchoring means 26 are secured in place to the individual sheets and project inwardly therefrom. In such a position concrete or some other equivalent anchoring substance is poured into the space between the fill and the sheeting structure, after maturing of which the anchoring means provide a suitable anchor for holding the plates in proper position.

While I have herein described and upon the drawing shown an illustrative embodiment of the invention, it is to be understood that the invention is not limited thereto but may comprehend other constructions, arrangements of parts, details, features and method steps without departing from the spirit of the invention.

I claim:

1. A facing for retaining structures comprising a sheet of relatively thin flexible material having a plurality of zones each provided with means substantially normal to one another for the movement of said zones individually in a plurality of directions due to expansion and contraction.

2. In combination, a retaining structure, a sheeting assembly therefor comprising a sheet of relatively thin flexible material having a plurality of zones, means for securing said sheeting assembly at each of said zones to said retaining structure, said sheeting assembly at said zones being provided with means for the movement of said sheeting assembly within the zones between the securing means due to expansion and contraction, and means between each of said zones providing for movement of said sheeting assembly within each of said zones in another direction.

3. In combination, a retaining structure, a sheeting assembly therefor comprising a sheet of relatively thin flexible material having a plurality of zones, means for securing said sheeting assembly at each of said zones to said retaining structure, said sheeting assembly being of undulating formation with the crests thereof at said securing means to provide for movement of said sheeting assembly at each of said zones and between said securing means due to expansion and contraction, and means between each of said zones providing for movement of said sheeting assembly within each of said zones in another direction.

4. In combination, a retaining structure, a sheeting assembly therefor comprising a sheet of relatively thin flexible material having a plurality

of zones, means for securing said sheeting assembly at each of said zones to said retaining structure, said sheeting assembly being of undulating formation in the direction of the width of said retaining structure with the crests thereof at said securing means to provide for movement of said sheeting assembly at each of said zones and between said securing means due to expansion and contraction, and means between each of said zones providing for movement of said sheeting assembly within each of said zones in another direction.

5. In combination, a retaining structure, a sheeting assembly therefor comprising a sheet of relatively thin flexible material having an undulating formation in the direction of one of its dimensions, and means for securing said sheeting assembly to said retaining structure at spaced intervals in the direction of its undulations to provide zones therebetween providing for substantially non-cumulative movement of the sheeting assembly within each of said zones in the direction of said undulations due to expansion and contraction.

6. In combination, a retaining structure, a sheeting assembly therefor comprising a sheet of relatively thin flexible material having an undulating formation in the direction of one of its dimensions, and means for securing said sheeting assembly to said retaining structure at points in the direction of its undulations spaced apart at distances substantially equal to the distance between the crests of said undulations to provide zones therebetween providing for substantially non-cumulative movement of the sheeting assembly within each of said zones in the direction of said undulations due to expansion and contraction.

7. In combination, a retaining structure, a sheeting assembly therefor comprising a sheet of relatively thin flexible material having an undulating formation in the direction of one of its dimensions, and means for securing said sheeting assembly to said retaining structure adjacent the crests to provide zones therebetween providing for substantially non-cumulative movement of the sheeting assembly within each of said zones in the direction of said undulations due to expansion and contraction.

8. In a method of erecting a sheeting structure comprising a plurality of relatively thin expandable and contractible metallic structural elements in position at the face of a retaining structure, the steps of connecting a plurality of pre-formed assembly members to said elements to bend the same to conform to the formation of said members, successively anchoring said elements in said bent condition in position on the face of said retaining structure, connecting adjacent elements together, and removing said assembly members therefrom.

9. The method of erecting a sheeting structure comprising a plurality of relatively thin expandable and contractible metallic structural elements in position at the face of a retaining structure, comprising the steps of connecting a plurality of pre-formed assembly members to said elements to bend the same to provide an offset therein to conform to the formation of said members, anchoring said elements in said bent condition in position on the face of said retaining structure, connecting the edges of adjacent elements with an expansion joint, and removing said assembly members therefrom.

10. The method of assembling a metal facing

comprising a plurality of relatively thin structural elements to the face of a retaining structure, comprising the steps of connecting in situ a plurality of pre-formed bent assembly members to said elements to bend the same to conform to the formation of said members, securing said elements together in the direction of the bends whereby said bent elements provide a sheeting assembly of undulating formation, anchoring said elements on said retaining structure to maintain said undulating formation but to provide for expansion and contraction in a direction normal to said bends, connecting said elements together to provide for expansion and contraction of said elements in said last-named direction, and removing said assembly members therefrom.

11. The method of assembling a metal facing comprising a plurality of relatively thin structural elements to the face of an earth fill retaining structure, comprising the steps of connecting in situ a plurality of pre-formed bent assembly members to said elements to bend the same to conform to the formation of said members, erecting a plurality of said bent elements in spaced relation to said earth fill at the face thereof, fixedly connecting adjacent elements in the direction of the bends, securing anchoring members to said elements for holding said elements substantially rigid at said anchoring means but permitting movement of said elements in a direction substantially normal thereto due to expansion and contraction in that direction, connecting said elements together to provide for expansion and contraction of said elements in said last-named direction, filling in said space between the erected facing and said earth fill with material capable when matured of securely holding said anchoring members in place, and removing said assembly members upon maturing of said material.

12. The method of assembling a metal facing comprising a plurality of relatively thin structural elements to the rock-like material forming the face of a retaining structure, comprising the steps of anchoring a plurality of anchoring members to said face in projecting relation thereto, connecting in situ a plurality of pre-formed bent assembly members to said elements to bend the same to conform to the formation of said members, successively erecting said elements in the direction of said expansion and contraction by securing the same together and to said anchoring members to hold the same in place yet permitting movement due to expansion and contraction normal to the direction of the bends, connecting said elements together to provide for expansion and contraction of said elements in said last-named direction, filling in said space between the erected facing and said retaining structure with material capable when matured of holding said anchoring members and facing in position, and removing said assembly members upon maturing of said material.

13. In combination, a retaining structure, a sheeting assembly therefor comprising a sheet of relatively thin flexible material secured to said retaining structure and provided with a plurality of zones, and said sheeting assembly at each of said zones being provided with means to provide for non-cumulative localized movement of said sheet within each of said zones due to contraction and expansion.