Feb. 25, 1969

A. FEINER ET AL

3,429,130

DAM CONSTRUCTION

Original Filed May 3, 1963

Sheet 1 of 2

FIG. 3

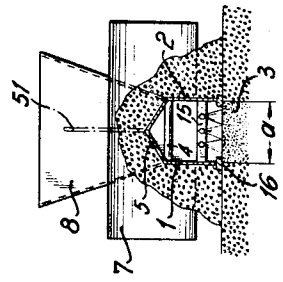


FIG. 1

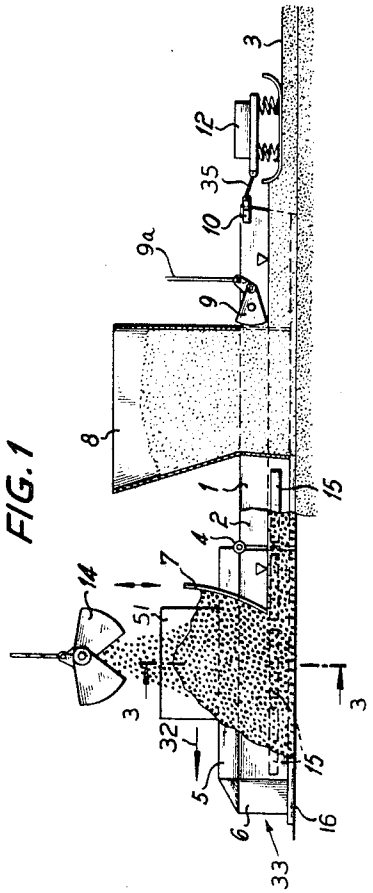
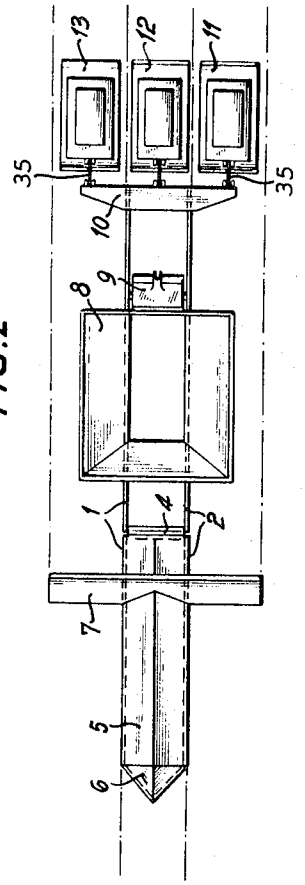


FIG. 2



INVENTOR
ALFRED FEINER
RUDOLF HAMANN
CLEMENS SCHOPF
BY
Burgess, Dinklage & Sprung
ATTORNEYS.

Feb. 25, 1969 A. FEINER ET AL 3,429,130

DAM CONSTRUCTION

Original Filed May 3, 1963 Sheet 2 of 2

FIG. 4

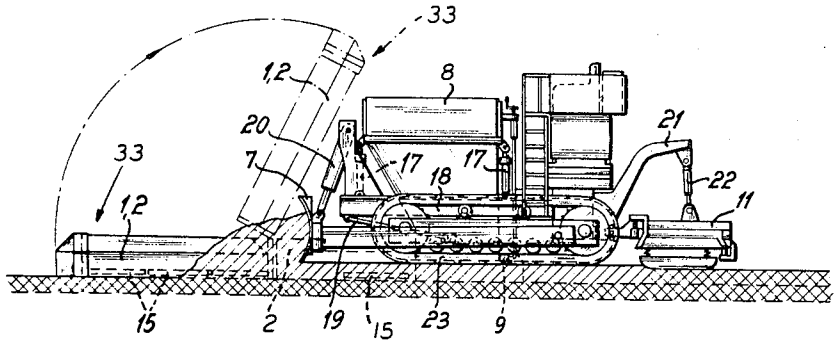


FIG. 5

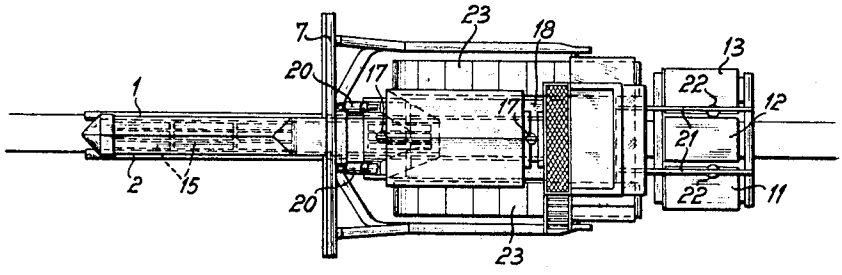
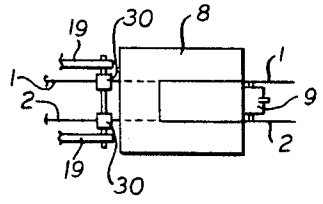


FIG. 4a.



INVENTOR
ALFRED FEINER
RUDOLF HAMANN
CLEMENS SCHOPF
BY
Burgess, Dinklage & Sprung
ATTORNEYS.

United States Patent Office 3,429,130
Patented Feb. 25, 1969

3,429,130

DAM CONSTRUCTION

Alfred Feiner, Porz-Westhofen, and Rudolf Hamann and Clemens Schopf, Cologne-Poll, Germany, assignors to Strabag Bau-A.G., Cologne-Deutz, Germany

Original application May 3, 1963, Ser. No. 277,809, now Patent No. 3,299,642, dated Jan. 24, 1967. Divided and this application Oct. 12, 1966, Ser. No. 586,250
Claims priority, application Germany, Nov. 14, 1962, St 19,964
U.S. Cl. 61—63 13 Claims
Int. Cl. E02b 7/06, 8/00; E01c 19/12

ABSTRACT OF THE DISCLOSURE

Apparatus for erection of dams having an internal sealing apron. Spaced partition walls are moved over the ground, and during such movement, the apron material is deposited between the partition walls and fill material is deposited outwardly of each of the partition walls. Compactors are provided for compacting the deposited materials. The desired height can be built up by depositing of successive levels, one atop the other, of the materials.

This application is a division of application Ser. No. 277,809, filed May 3, 1963 now Patent No. 3,299,642, which claims the process hereof.

The invention relates to a method and an apparatus for the installation of narrow, impermeable, internal barriers known as "sealing aprons" in dams which are to include a water barrier. The invention finds application in earth dams such as those extending over the entire cross-section of a valley.

Hitherto, concrete forms have been used in the construction of impermeable internal barriers. The dam fill material or finely granular filter material is dumped against the outside of the form, while the material for the impermeable barrier is placed between the walls of the form. The form must then be stripped off in order to be able to lay the next layer on the dam. This process, however, is very time consuming, and when it is used for the construction of bituminous barriers, it has considerable disadvantages.

The apron can be formed of any suitable material, such as, for example, material which can be compacted to a stable impermeable condition. Bituminous material (asphalt or asphalt cement) is a preferred material. Bituminous internal barriers, due to their greater density and uniform composition, may have a substantially slighter thickness than barriers made of such natural impermeabilizing materials as clay, loam or clay concrete and loam concrete. Whereas in the case of the latter a thickness of one-third to one-sixth of the height of the dam is required, thickness of one-twentieth to one-fiftieth of the dam height may suffice in the case of bituminous materials. The separations that occur due to the coning of the material as it is poured, however, are of much greater consequence in the case of thin barriers, of course, than in the case of thick ones. A great deal depends, therefore, upon the care exercised by the personnel when placing the material in the forms, especially when the bituminous barrier material is, on the basis of German Federal Patent 1,108,620, composed of a greater proportion of coarse-grained material.

With the prior art method, the form cannot be stripped off until after a considerable length of time, namely, not until all of the impermeable material has been placed between the walls of the form, and the pouring of the fill laterally of the form has been completed, and the layers of material have been leveled off. Bituminous concrete hardens during this time, so that an intimate interlocking of the concrete with the grit of the adjacent fill material can no longer take place, and even the necessary tamping of the bituminous material can be performed but imperfectly.

According to the invention, the procedure is such that the materials of the sealing apron and of the adjacent (upstream and downstream) fill are poured and graded to about the same level simultaneously and continuously along the course of the dam, while being separated from one another by parallel vertical or inclined partitions moving along the work surface, whereupon the materials left directly in contact with one another after the partitions have passed are simultaneously tamped down.

The new method makes it possible to build up the dam in the vicinity of the waterproof barrier continuously, layer by layer, while at the same time achieving a sharp separation (without overflow into one another) between the material of the impermeable barrier and the lateral fill. In this manner, the assurance is obtained that the impermeable barrier has a uniform thickness and contains no foreign matter from the adjacent earth fill that might adversely influence its impermeability and permanence.

Owing to the continuous method of operation, although the materials are separated by the moving partitions while they are being laid in place, they can come into direct contact with one another within a few seconds. The bituminous material is then still fully plastic and it can easily be intimately interlocked with the grit of the adjacent fill by the tamping which immediately follows, and it can be intensely compacted. In this manner, an impermeable internal barrier is developed of accurate thickness which can be strongly compacted, and which is so intimately interlocked with the load-bearing grit of the adjacent fill based on the method of German Federal Patent 1,108,620, that the load-bearing mineral skeleton of the dam is also continued through the impermeable barrier and thus gives the dam a stability never before achieved.

The apparatus for the practice of the new method consists, according to the invention, of two parallel partitions standing on edge, whose distance apart is equal to the thickness of the impermeable barrier, means for advancing the partitions along the work surface of the dam, means for pouring and leveling the fill material outside of the parallel partitions on the upstream and downstream sides of the dam, means for pouring and leveling the impermeable barrier material between the parallel partitions, and vibrating tampers disposed rearwardly in the line of movement, behind the parallel partitions, for the simultaneous compaction of the separately poured and leveled materials.

The parallel partitions permit the simultaneous but spatially separate pouring and leveling of the materials of the impermeable barrier and the adjacent fill, so that it will be impossible for them to spill over into one another. Consequently, they give an absolute assurance that the structure of the impermeable barrier will have the necessary homogeneity and a uniform thickness.

In further improvement of the invention, a hopper to contain the impermeable barrier material is placed on the parallel partitions, the bottom opening of said hopper being located between said partitions. In this manner, it is brought about that the impermeable barrier materials pour from the hopper into the space between the partitions at a rate dependent upon the movement of the latter. This method of pouring the impermeable barrier material entirely prevents the formation of cones and hence the separation of the material. It assures that the structure

of the impermeable barrier will be entirely homogeneous.

Thus, the invention provides a method for erection of dams with an internal sealing apron, the method involving: (a) advancing over the course on which apron is to be laid a pair of vertically extending partition walls spaced to provide a form for the transverse cross-section of the apron, the partition walls being shorter in length than the dam, and progressively and simultaneously depositing material for forming the apron between the forms, and depositing fill material adjacent and on the outer side of each of the forms, whereby as the forms advance over the course, the apron material and the fill are laid up side by side behind the forms; and compacting the apron material and the fill laid up side by side as aforesaid. In this manner, increments of the height of the dam can be formed and the procedure can be repeated to form the successive height increments of the dam.

The invention is further described in reference to the accompanying drawings, wherein embodiments thereof are set forth.

FIG. 1 is an elevation view partially in cross-section of apparatus according to the invention;

FIG. 2 is a plan view of the apparatus shown in FIG. 1;

FIG. 3 is a cross-sectional view taken along line 3—3 in FIG. 1;

FIG. 4 is an elevation view of apparatus according to the invention, the apparatus including a vehicle for movement thereof over the area to be worked;

FIG. 4*a* is a plan view of a portion of the apparatus shown in FIG. 4; and

FIG. 5 is a plan view of the apparatus shown in FIG. 4.

In the various views, like reference characters indicate corresponding parts.

The apparatus of FIGS. 1 to 3 comprises two parallel partitions **1** and **2**, made of sheet steel and standing on edge vertically or aslant, and separated by a distance *a* (FIG. 3) which is equal to the thickness of the impermeable barrier **3**. The partitions are rigidly fastened to one another by cross members to assure their parallelism. Their bottom edges lie flush with the wok surface and are driven over the work surface along the length of the dam in the direction indicated by the arrow **32** and at the necessary working speed. The partitions may consist of a plurality of sections coupled together by articulation hinge connections such as hinge **4**. In this manner, they adapt themselves better to slight unevenness in the work surface without losing contact therewith at portions of their bottom edges.

The forward portion of the parallel partitions forms a shelter member **33** having a peaked roof **5** covering the space between the forward part of the partitions, and at the front a nose plate **6** on the order of the bow of a ship is provided. Further, the shelter member is provided with earth bearing plates **16** to prevent the walls from digging into the material over which the apparatus travels. A leveling blade **7**, which can be raised and lowered, is provided for depositing of the fill material alongside the impermeable barrier **3**. It projects laterally of and beyond the partitions **1** and **2** and sweeps the areas outside of the partitions.

On the rear portion of the parallel partition walls is provided a hopper **8** for the impermeable barrier material, the bottom outlet of which empties into the area between the parallel partitions. Behind the hopper **8** between the partitions, there is provided a regulating gate **9**, which is adjustable vertically by operation of the suspension rod **9***a* and determines the level at which the impermeable barrier material is spread.

A lateral traction bar **10** is fastened to the end of the parallel partitions **1** and **2**, and to it are hitched three vibrating compactors **11**, **12** and **13** of any known design. The outer two compactors, **11** and **13**, operate in the area of the material graded by the leveling blade **7**, while the middle one **12**, compacts the material that is leveled off by the regulating gate **9**. The middle compactor **12** can have a bottom plate that is heated by gas or oil burners (not shown) so as to prevent the adhesion to same of the bituminous materials it is compacting.

The plane of the vibrations of the compactors **11** to **13** is preferably inclined towards the horizontal, so that a component of motion will be imparted to the compactors in the direction of movement of the parallel partitions. In this manner, accumulations of material at the forward edges of the compactors will be prevented, such accumulations which could result in undesired lateral displacement of the material, especially in the surface area. The desired plane of vibration can be obtained by joining the vibrators to the body of the apparatus by short connecting rods **35** in the manner that the points of connection at the compactors is at a level below the points of connection to the body of the apparatus.

In operation of the device as thus far described, while the parallel partitions **1** and **2** are being moved longitudinally in the direction of the arrow, the material being used as fill on the upstream and downstream side of the dam, which is generally coarsely crushed stone, is dumped by a clamshell bucket **14**, for example, in front of leveling blade **7** on the roofed portion of the parallel partitions. As shown in FIG. 3, the material slopes down towards both sides of the parallel partitions in the area of the leveling blade **7**, and is scraped level by same to a certain depth of, say, 20 to 25 centimeters. The shelter member **33** is disposed on the front end of the apparatus and is formed so that it overlies the course along which the apron material is to be laid. The roof **5** of the shelter member prevents fill material from falling along the course on which the apron material is to be laid. See FIG. 3. Simultaneously with the depositing of fill material impermeable barrier material, preferably bituminous material composed according to German Federal Patent 1,108,620, passes from the hopper **8** into the area between the parallel partitions at a rate determined by the speed of movement of the latter, and is there leveled by the regulating gate **9** to about the same depth as the fill material outside of the parallel partitions. As the partition walls move forward, the trailing end of the partition walls are pulled out from the material leaving the apron and fill material laid up side by side behind the walls. Since they have been graded to about the same depth, there can be no overflow from the one to the other. The compactors are mounted on the body of the apparatus and as close to the partition walls as is convenient so that the compacting can be performed substantially as soon as the partition walls have been pulled through the material laying the apron and fill up side by side. The compactors are spaced from the rear end of the partition walls in the order of several feet. Thus, after a few seconds, the materials come within the reach of the vibrating compactors **11** to **13** and are simultaneously and uniformly compacted by them, while the dividing lines between the adjacent materials fall between two adjacent compactors in each case. The load-bearing mineral grits of the adjacent materials are therefore tightly pressed together in the area of the dividing line and are perfectly interlocked with one another, so that, according to the teaching of German Federal Patent 1,108,620, a single load-bearing skeleton develops throughout the entire dam that provides the latter with outstanding static characteristics. The dam is built up layer by layer to form successive height increments in the manner described above.

As previously mentioned, it is primarily bituminous materials that are being contemplated for the impermeable barrier, and they, of course, must be laid in the hot state. The hopper **8**, therefore, is equipped with thermal insulation. In order to achieve a good bond between the layer of materials put down in the preceding pass, which have already become cold and have been compacted, and the next layer, heating means **15**, such as infrared radiators, are installed between the parallel

partitions 1 and 2, and their radiation is directed against the bituminous layer compacted in the preceding pass so as to soften it to a depth of 2 to 3 centimeters. Thus, it is brought about that the two layers will bond intimately to one another and at the same time their load-bearing mineral grains will completely interlock with one another, so that a seamless impermeable barrier results.

Instead of using the same material for both the upstream and downstream fill, as shown and described, it is possible when the circumstances require it, for a different composition of material to be used for the downstream side than for the upstream side of the dam. The clamshell bucket 14 then has to drop the one material on the right side and the other material on the left side, next to the parallel partitions 1 and 2. In this case, the spillage of one material over into the other is prevented by mounting a vertical partition 51 on the peak of the roof 5.

The apparatus represented in FIGS. 4 and 5 is self-propelled and otherwise is the same as that represented in FIGS. 1 to 3. The reference numbers of this schematic representation are therefore the same where the same components are concerned.

The parallel partitions 1 and 2 are rigidly affixed to the hopper 8 for the impermeable barrier materials, and they are suspended so as to be able to be raised and lowered together with the regulating gate 9 by means of the hydraulic cylinder 17 on the vehicle frame 18. The force required for the forward movement of the partitions is transmitted from the vehicle frame through special pull rods 19, which are articulated to the vehicle frame and to the partitions 1 and 2. The leveling blade 7 is also articulated to the vehicle frame 18, and is raised and lowered by means of the hydraulic cylinder 20 in order to adjust the grade level.

The vibrating compactors 11, 12 and 13 are articulated to the transporting vehicle and can be raised and lowered by means of the boom 21 fastened to frame 18 and the hydraulic cylinder 22.

As represented in FIG. 4 in phantom, the shelter member 33 can be folded upwardly so as to be in an out of the way position when not being used. The transporting vehicle travels on its crawler treads 23 or pneumatic tires on the work surface created by the leveling blade 7 on the fill being deposited on both sides, and it is self-propelled by a diesel engine which is also the source of energy for the hydraulic pump for the operation of the hydraulic cylinders 17, 20 and 22, and is the source, through an electric current generator which it drives, of the electrical power for the infrared radiators 15.

The position of the self-propelled apparatus when in operation, is as represented in FIGS. 4 and 5, and the manner of operation is the same as described with reference to the schematic representation in FIGS. 1 to 3. When traveling to another place of operation, and when turning at the ends of the courses, the front portion of the parallel partitions 1 and 2 is elevated as indicated in phantom in FIG. 4*a*. Then the partitions 1 and 2 are elevated by the hydraulic cylinder 17 and the vibratory compactors 11 to 13 are elevated by hydraulic cylinder 22 to such an extent that the vehicle will have the necessary ground clearance to travel even at greater speeds.

Apparatus according to the invention was utilized to construct a dam 16 m. in height and 130 m. in length. An internal sealing apron was composed of asphalt concrete containing mineral aggregate 0–25 mm. and was applied at a temperature of 160–180° C. The height of material (asphalt concrete and fill) poured during each pass or course, was 0.25 m., and this height of material was compacted to 0.20 m. by the trailing compactors. The speed of the equipment was at an average of about 0.7 m. per minute and, for the work described here, can vary from 0.1–2 m. per minute. About 5 m.^{3} per hour of compacted asphalt concrete was applied. The drive capacity for the equipment was about 8.5 H.P. The vibrating compactors were excited by eccentrically mounted rotating weights at a frenquency of about 27 Hz. The centrifugal force of the eccentric weights was 2000 kg. each, and the drive capacity of each vibrator was about 7.5 H.P.

While the invention has been described with respect to particular embodiments thereof, various alterations and modifications will occur to those skilled in the art, and it is intended to secure by these Letters Patent all such embodiments.

What is claimed is:

1. Apparatus suitable for use in erection of dams with an internal sealing apron comprising:
   (a) a pair of movable, vertically extending partition walls fixedly joined together in spaced relation to provide a form for the transverse cross-section of the apron, said wall being longitudinally movable;
   (b) means for depositing apron material between said walls as the walls are moved longitudinally so that the apron material extends upwardly from the level of the bottom edges of the walls;
   (c) means for depositing fill material adjacent and on the outer side of each of the forms as the walls are moved longitudinally so that the fill material extends upwardly from the level of the bottom edges of the walls;

whereby the apron material and the fill material can be laid up side by side behind the forms, and

   (d) means for compacting the apron and fill material laid up side by side as aforesaid.

2. Apparatus according to claim 1, said means for compacting comprising compactors joined with the partition walls for travel therewith, and being disposed for progressively compacting the apron and fill material substantially as said material is laid up side by side as aforesaid.

3. Apparatus according to claim 1, and comprising a shelter member, said shelter member extending longitudinally outwardly of said partition walls for travel in advance of the partition wall over the course to be traversed by the partition walls, said shelter member including a roof portion for preventing deposit of material on the course of the partition walls in advance of the partition walls, said means for depositing fill material being positioned to deposit such material in advance of the partition walls and laterally of said shelter member, said shelter member preventing the fill material from falling onto the course for the apron.

4. Apparatus according to claim 3, and including a partition extending vertically upward from the roof of said shelter member, whereby the apparatus is accommodated for depositing different kinds of fill material on the respective sides of the sealing apron.

5. Apparatus according to claim 1, each of said partition wall being formed of at least two longitudinally extending sections, said sections being joined together for articulation, whereby unevenness of the course over which the partition walls are moved can be accommodated.

6. Apparatus according to claim 1, said means for depositing apron material between the partition walls including a hopper disposed for delivery of apron material to between the partition walls.

7. Apparatus according to claim 3, said means for depositing apron material between the partition walls including a hopper positioned for delivery of apron material to between the partition walls.

8. Apparatus according to claim 1, and including means for heating the course along which apron material is to be deposited between said partition walls, is advance of the deposit of apron material between the partition walls by the said means for depositing apron material.

9. Apparatus according to claim 1, and including a transporting vehicle, said partition walls being mounted on the vehicle.

10. Apparatus according to claim 9, the means for depositing apron material between the partition walls

being a hopper, said hopper being mounted on said vehicle, the means for depositing fill material being a plow mounted on said vehicle, said partition walls being joined to said vehicle frame by articulation rods permitting movement of the partition walls to compensate for unevenness of the course along which the apron is to be laid.

11. Apparatus according to claim **10**, wherein said means for compacting comprises a compactor mounted on the vehicle and positioned for compacting material substantially as it is laid up side by side behind the partition walls as aforesaid.

12. Apparatus according to claim **11**, said vehicle having a front end and a rear end, said compactor being mounted on the rear end of said vehicle, the partition wall being disposed under said vehicle and extending longitudinally thereof for movement along a course over which apron is to be laid upon advance of the vehicle, a shelter member extending longitudinally of the vehicle in advance of the front end thereof for travel over the course along which apron is to be laid in advance of the partition walls, said shelter member including a roof portion for covering the apron course and preventing material from dropping onto said course prior to the positioning therealong of the partition walls, the means

front end of the vehicle and for working fill material for depositing fill material being disposed adjacent the over the said shelter member to the outwardly disposed sides of the shelter member, mounting means for the shelter member for permitting selective movement of the shelter member to an inoperative position to facilitate running of the vehicle when the shelter member is not being utilized.

13. Apparatus according to claim **1**, and including means for leveling the apron material deposited between the walls.

References Cited

UNITED STATES PATENTS

2,351,593	6/1944	Barber	94—46
2,539,063	1/1951	Ekenstam	61—63
2,551,110	5/1951	Fuller	61—63
2,589,634	3/1952	Shook	61—63
2,885,861	5/1959	Jackson	61—63

DAVID J. WILLIAMOWSKI, *Primary Examiner.*

J. KARL BELL, *Assistant Examiner.*

U.S. Cl. X.R.

61—31; 94—46

Teuterberg 202.1 Div.
FMM/na

PO-1050
(5/69)

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,429,130 Dated February 25, 1969

Inventor(s) Alfred Feiner, et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

1. Col. 8, lines 1 and 2, interchange these two lines.

SIGNED AND
SEALED
AUG 4 - 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents