Fig. 2.
Fig. 3.
LINING OF PASSAGES WITH CONCRETE

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This invention relates to the lining of passages, more particularly, but not solely, steeply inclined passages such as penstocks, with concrete.

The invention consists in apparatus for lining a passage with concrete, comprising a shutter drum adapted to act as a support for concrete over the complete circumference of a length of the passage, a frame tube, or other supporting member (hereinafter referred to as a frame) suitably received within the drum, supporting means for the frame beyond each end of the drum adapted to support and align the frame and the drum suitably received thereon, and means for anchoring the drum to a previously cast ring of concrete.

The invention further consists in a method of lining a passage with concrete using apparatus as set forth above, comprising supporting and aligning the frame, moving the drum forwardly thereon until in a position to support a ring of concrete, clamping the drum into position, and pouring fresh concrete between the drum and the passage wall.

While the concrete is setting the drum remains clamped in position but the frame may be moved forwardly there-through and aligned and clamped in position, being supported during movement by the clamping of the drum.

There is thus a saving of several hours per ring over a method in which the shuttering can only be set up after the concrete of the previous ring has hardened.

In steeply inclined or vertical shafts the apparatus climbs up the shaft using the previous rings of concrete, and it is in this type of work that the apparatus and method according to the invention are most advantageously employed.

Working in an inclined shaft the plane of the upper or forward surface of the drum is preferably inclined to a plane normal to the axis of the frame and drum so as to be horizontal in operation. By using a frame having a clear centre, access can be had between the ends of the shaft even while lining is in progress.

The invention will be further described with reference to the accompanying drawings of a preferred embodiment.

In the drawings:

FIGURE 1 is a section through a preferred form of apparatus according to the invention in position in a steeply inclined shaft;

FIGURE 2 is a section on the line II—II of FIGURE 1;

FIGURE 3 is a view on the line III—III of FIGURE 1; and,

FIGURE 4 is a section on the line IV—IV of FIGURE 1.

The apparatus illustrated comprises a main tube frame, or truss 11, a shutter drum 12 more particularly illustrated in FIGURE 2, a rear support or anchoring unit 13 more particularly illustrated in FIGURE 3, and a forward support or centering ring 14 more particularly illustrated in FIGURE 4. FIGURE 1 illustrates the apparatus in position in a steeply inclined passage in course of being lined. The rock line of the passage is designated by reference numeral 16. An upper or latest ring 17 of concrete is shown together with one complete previous ring 18 and parts of two further previous rings 19 and 21. Each ring of concrete has four sets of six female anchor screws 22 set therein during pouring of the concrete and these are used during use of the passage for mounting various services, and during lining for aiding in anchoring the anchor unit 13 and the shutter drum 12. It is not essential that they are used in all applications.

The anchor screws 21 are attached to the drum 12 by studs projecting through apertures in the drum apertures.

Referring first to FIGURES 1 and 2, it will be seen that the main truss 11 is of substantially square section and is provided at its corners with bright steel rubbing strips 23 extending over substantially its whole length. The main truss 11 is substantially clear through the centre so that access may be had through the passage even while lining is in progress.

The shutter drum 12 itself is mounted on a carriage 24 surrounding the truss 11 and having bronze pads 26 secured thereto, two at each corner at each end, for co-operation with the strips 23 to allow relative sliding between the truss 11 and the carriage 24.

The shutter 12 is in four portions which combine to complete the whole outer cylindrical surface. Of these portions, a crown portion 27 is supported by screw jacks 28 or turnbuckles mounted on the carriage 24 and two side wall portions 29 are hinged at 31 to the crown portion 27 and are moveable by turnbuckles 30. An invert portion 32 is supported on further screw jacks 33 or turnbuckles mounted on the carriage 24, and co-operate with the side wall portions 29 by means of striking joints 34.

The leading and trailing edges of the cylindrical surface of the shutter 12 are inclined to planes normal to the axis so that they are horizontal in operation. Mounted on the leading edge are a plurality of safety beams 35 which project beyond the cylindrical surface of the shutter so that if the support for the shutter should fail then the fall of the shutter would be slowed or stopped by the beams co-operating with the concrete.

A supporting beam 37 co-operates with supporting balls 35 mounted in the ends of the side wall portions 29 to take the weight of the crown and side wall portions during striking and setting of the shutter.

When in the casing position illustrated each of the portions of the shutter is further supported by thrust struts 38 secured between outriggers 39 on the carriage 24 and rigid parts of the respective portions. Some of these struts have been omitted from the drawings for clarity of illustration.

A long stroke, double acting, hydraulic jack 41 is pivoted on a trunnion 42 on the carriage 24 and is also pivoted to the truss 11 at 43. A pump and motor assembly 44 and a reservoir 45 for the jack 41 are mounted on the truss 11.

Mounted on the lower side of the carriage 24 beneath the shutter 12 is a support pad 46 for engaging the ring 18 to obtain a frictional grip to maintain the shutter 12 and carriage 24 in position when the anchoring unit is released, i.e. to inhibit movement towards the vertical position. The pad 46 is mounted on a pair of links 47 and its position is adjusted by a turnbuckle or screw jack 48 linked to a cross member 49 between the links 47.

Referring now to FIGURES 1 and 3, it will be seen that the anchoring unit 13 comprises a square frame 51 surrounding a lower end portion of the truss 11 with longitudinal movement relative thereto limited by engagement of anchor rings 52 and 53 on the frame with a retainer yoke 54 and a member 55 on the truss 11. The frame 51 is mounted on the truss 11 by means of rockers 56 which allow slight rocking movement about an axis perpendicular to the plane of FIGURE 1.

A central section of each side of the square frame 51 is anchored to the rings 19 and 21 by means of anchor pads 57, two of which, with their associated linkage, are omitted from FIGURE 1. Each anchor pad 57 is sup-
ported by a pair of links 58 pivoted to the ring 53 and joined by a cross member 59 to which is pivoted a turnbuckle 61. The opposite end of the turnbuckle 61 is pivoted to the ring 52. The anchor pads 57 are arranged to be stressed against the concrete by the turnbuckles 61 to obtain a frictional group and can also be attached to the adjacent female anchor screws 22 by insertion of suitable nuts.

Referring now to FIGURES 1 and 4 it will be seen that at the forward or upper end of the truss 11 the centering ring 14 has its longitudinal movement on the truss limited by means of yokes 62 and 63. Centering jacks 64, 65, and 66 and 67 are mounted on supporting frames attached to the centering ring. These jacks engage the underlying rock above the line of the shutter drum. The lowermost or invert position jack 64 is a hydraulic jack which is used to adjust the position of the centering ring itself relative to the rock line. This jack is provided with threaded collar 68 which may be run down to prevent collapse of the jacks under the weight of the structure should the hydraulic pressure fail for any reason. The jack 64 is operated by a hand pump. The remaining jacks 65, 66 and 67 are screw jacks operated by hand wheels 69. Each of the jacks 64, 65, 66 and 67 is provided with an extension tube to increase the maximum extension length when necessary.

A lateral adjustment along an axis 71, parallel with the rocking axis of the truss 11 relative to the anchoring ring 13, is provided by screws jacks 72 connecting the truss 11 and the anchoring ring 14.

The liquid concrete for the lining can be supplied through a pipe extending down the shaft and provided at its end with a flexible connection arrangement to aid in distributing the concrete round the circumference of the shutter 12.

A preferred mode of procedure, starting with the shutter centered, is as follows:

1. Check that anchor screws and bolts in the shutter 12 are tight and thrust struts 38 are connected in the shutter.
2. Retract top and side jacks 65, 66 and 67 on centering ring 14.
3. "Take up" the load on the centering ring lower hydraulic jack 64 just sufficiently to enable the threaded collar 68 on its ram to be screwed back then retract the jack 64 by opening a return screw on the hand pump body.
4. Check that shutter carriage support pad 46 is firmly pressed against the concrete lining by its turnbuckle 48.
5. Release and retract top side anchor pads 57 on anchor ring 13.
6. Re-check that shutter carriage support pad 46 is in firm contact with concrete lining.

7. Check that the suction valve for the pump 45 is open, then start hydraulic pump.
8. Check that the shutter drum is firmly held by the studs screwed into the anchor screws 22, and that the thrust struts 38 are tight.
9. Release and slowly retract lower anchor pad on anchor ring 13, transferring the load onto the shutter drum 12 and its support pad 46.
10. Ensure that the leading edges of the anchor pads 57 at the rear of the truss 11 cannot pivot and foul the lining as the truss 11 moves forward (it may be necessary to add chain-link ties at the leading edges to ensure this).
11. Admit pressure to the jack 41 to push the truss forward through the shutter carriage.

12. As soon as the truss is in the forward position, extend the lower hydraulic jack 64 of the centering ring 14 to take the weight and lock it; then extend the anchor pads 57 at the lower end of the truss 11 and the remaining centering ring screw jacks 65, 66 and 67.

13. Assuming that the truss is correctly aligned it should be locked by exerting thrust on the screw jacks 65, 66 and 67 and turnbuckles 61 of the centering and anchor rings and bolting the anchor pads 57 to the anchor screws at the position shown dotted.

14. Should it be necessary to correct elevation or alignment this can be done a small amount at each new shutter setting by means of the inner centering ring stud jacks 72, the vertical centering ring jacks 64 and 66, and the anchor pad turnbuckles 61. The shutter drum can now be moved as follows:

15. Release thrust struts 38 remove studs from anchor screws 22, remove all bolts and drifts from the striking plates between the portions 29 and 32 and all drifts from the hinges 51.
16. Retract side wall turnbuckles 30 striking the side wall portions 29. During this operation the side wall support ball 35 should be running on the supporting frame 37; if not the ball support 37 should be shimmed out to ensure that it is under load.
17. After this operation the crown and side wall portions 27 and 29 may be lowered, using the top four vertical screw jacks 28. These should be operated together in order to eliminate binding on the jacks or racking of the portions or forms.

18. When the crown and side walls have been lowered the invert portion 32 may be struck and lifted in a similar way, using the lower four vertical screw jacks 33. The invert unit also rides on ball units which should bear on their support frame.

19. The shutter carriage support pad 46 can now be retracted and the collapsed drum moved forward along the truss 11, using the jack 41, after which the drum is re-set, reversing the order of operations to that given above for striking.

It might be found useful to paint register marks on the truss and shutter carriage to maintain regularity of centres of anchor screws from lift to lift.

20. After the shutter drum is in position a new set of anchor screws should be attached to the drum before concreting starts.

Various modifications may be made within the scope of the invention. For example the jacks 41 may be replaced by a pair of single acting jacks.

I claim:

1. Apparatus for lining a passage by consecutively casting rings of concrete, comprising a shutter drum adapted to act as a support for casting rings of concrete over the complete circumference of a length of the passage, frame means passing through the drum, mutually co-operating means within the drum and on the frame means for supporting the drum and frame means for relative sliding movement axially of the drum, supporting means for the frame means beyond each end of the drum adapted to support the assembling of drum and frame means and align the same within the passage, and means for anchoring the drum to a previously cast ring of concrete.

2. Apparatus as claimed in claim 1, in which the shutter comprises a plurality of relatively movable arcuate portions completing between them the whole outer surface of the drum, and means for inwardly retracting and outwardly advancing the said portions.

3. Apparatus as claimed in claim 2, in which the drum comprises a rigid drum carriage supported on and supporting the frame means by said mutually cooperating means, and supporting dendents mounted on the carriage for supporting the arcuate portions during movement.

4. Apparatus as claimed in claim 3, in which releasable thrust struts are provided for attachment to the drum carriage and the said arcuate portions.

5. Apparatus as claimed in claim 1, in which the drum includes apertures through which anchor screws may be set in the concrete.

6. Apparatus as claimed in claim 1, primarily for use in a passage inclined to the vertical, in which the plans of the upper surface of the drum is inclined to a plane normal to the axis of the drum.
7. Apparatus as claimed in claim 1, particularly for use in a passage inclined to the vertical, comprising retractable means movable with the drum and located therebelow to engage a preceding ring of concrete and support the drum against movement towards the vertical.

8. Apparatus as claimed in claim 1, wherein the drum comprises at its upper or forward end a plurality of projections beyond the surface of the drum to prevent the drum falling in uncontrolled manner down a passage in the event of failure of the supporting or anchoring means.

9. Apparatus as claimed in claim 1, wherein the supporting means comprises a sub-frame mounted on the frame means to the rear of the drum, and free to rock about a rocking axis with respect thereto, and means for anchoring the sub-frame to a preceding ring of concrete.

10. Apparatus as claimed in claim 9, in which the supporting means further comprises a forward sub-frame mounted on the frame means so as to allow lateral adjustment in a direction parallel to the said rocking axis, and means for anchoring the forward sub-frame to the passage wall ahead of the concrete.

11. Apparatus as claimed in claim 1, comprising hydraulic jack means for advancing the drum along the frame means and for advancing the frame means through the drum.

12. Apparatus as claimed in claim 11, in which the jack means is pivotally mounted on the frame means to allow for adjustment of alignment.

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