March 5, 1963 L. ZETLIN 3,079,662

METHOD OF CONCRETE CONSTRUCTION

Filed Oct. 9, 1958 3 Sheets-Sheet 1

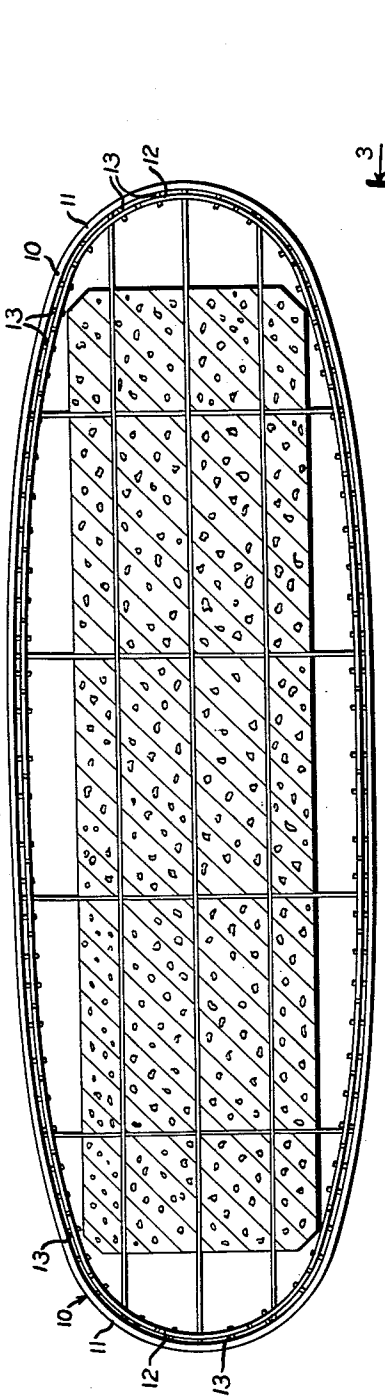


FIG. 1.

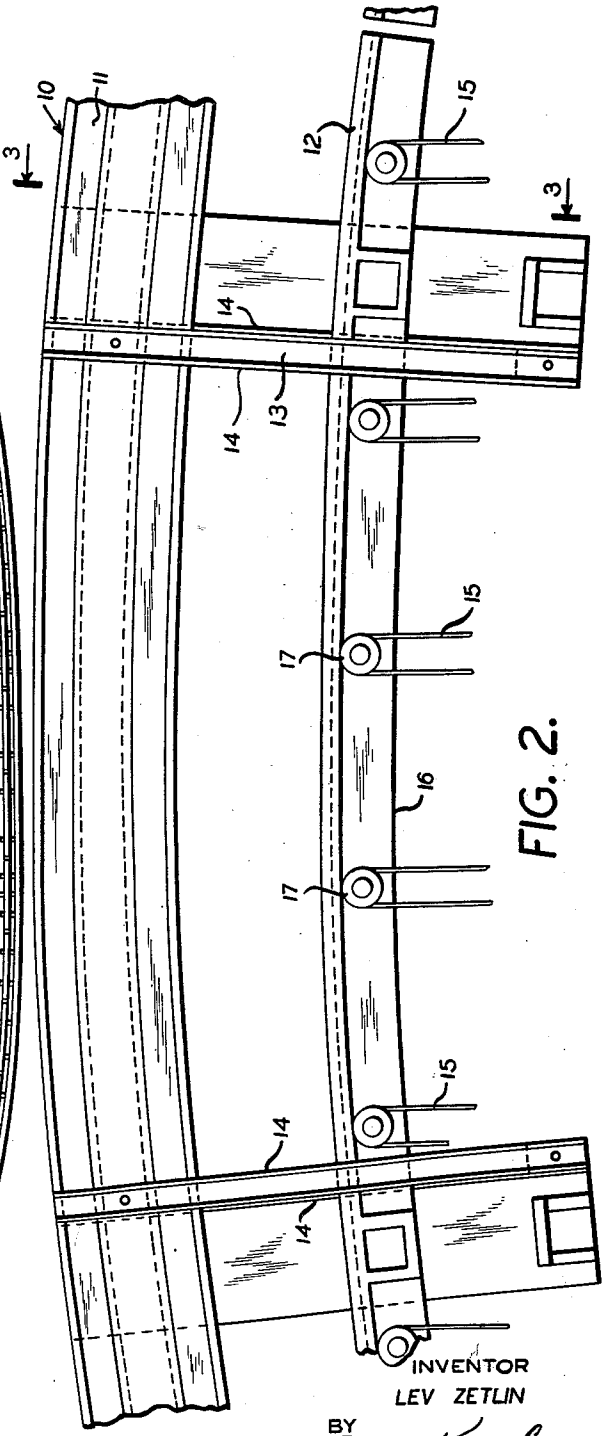


FIG. 2.

INVENTOR
LEV ZETLIN
BY Sawyer & Kennedy
ATTORNEYS

March 5, 1963 L. ZETLIN 3,079,662

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Filed Oct. 9, 1958 3 Sheets-Sheet 2

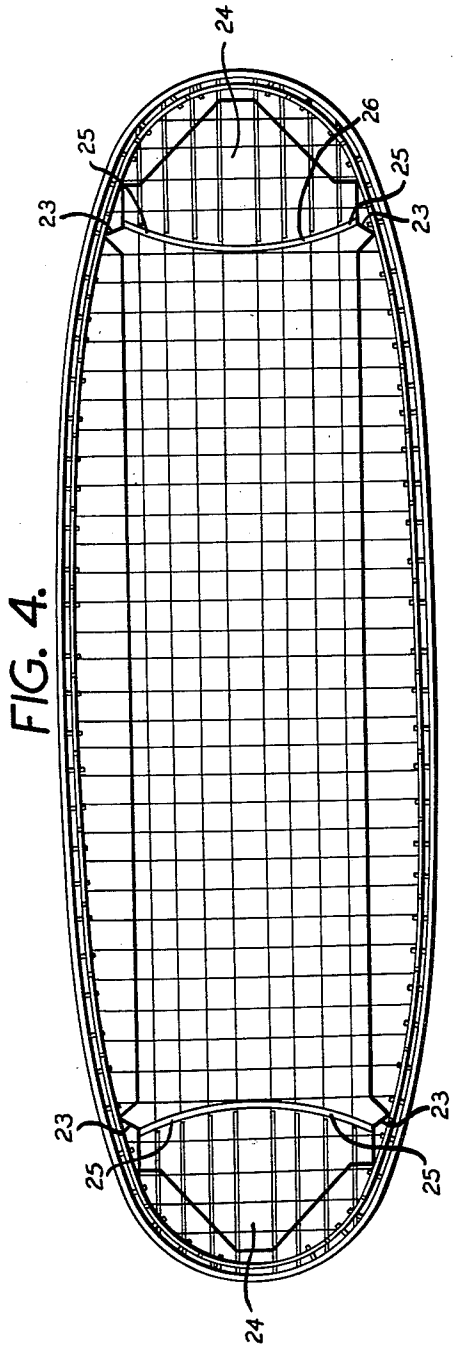


FIG. 4.

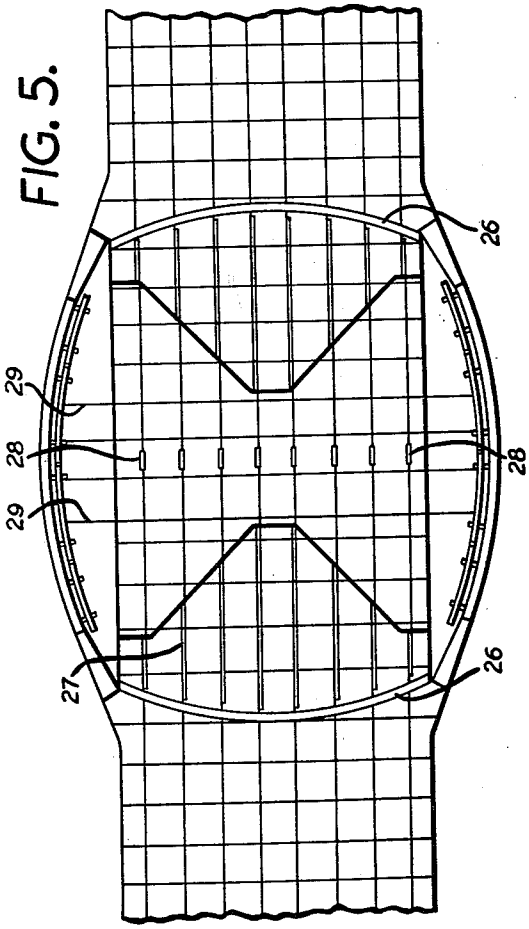


FIG. 5.

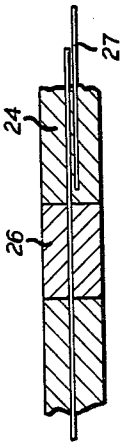


FIG. 6.

INVENTOR
LEV ZETLIN
BY Sawyer & Kennedy
ATTORNEYS

March 5, 1963 L. ZETLIN 3,079,662

METHOD OF CONCRETE CONSTRUCTION

Filed Oct. 9, 1958 3 Sheets-Sheet 3

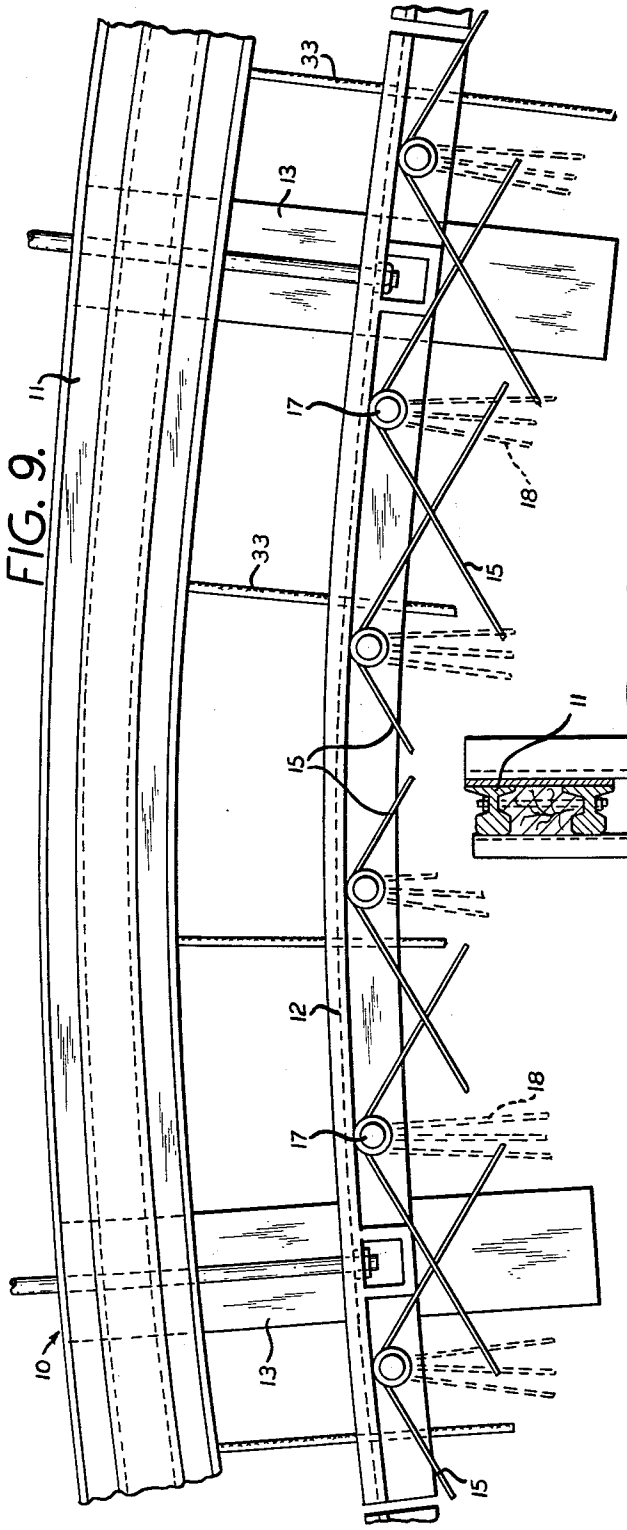


FIG. 9.

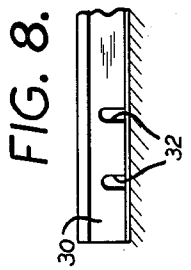


FIG. 8.

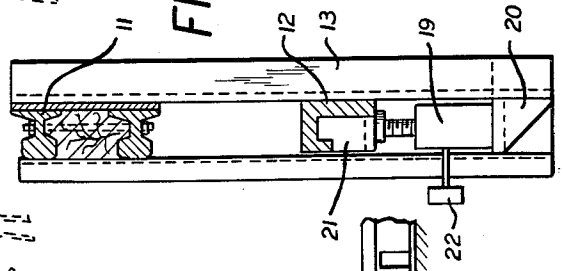


FIG. 3.

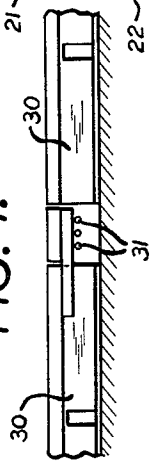


FIG. 7.

INVENTOR
LEV ZETLIN

BY Sawyer & Kennedy
ATTORNEYS

United States Patent Office

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3,079,662

METHOD OF CONCRETE CONSTRUCTION

Lev Zetlin, 83—75 118th St., Kew Gardens, N.Y.

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1 Claim. (Cl. 25—154)

This invention is concerned with concrete construction and is more particularly concerned with a method for pre-stressing the reinforcements in the concrete.

In concrete construction, especially in the construction of highways and runways for airfields and similar types of concrete work, the pre-stressing of concrete has always presented a difficult problem. In order to properly pre-stress the strands used in pre-stressed concrete construction, various methods have been tried, none of which have been successful for large projects such as highway or runway construction.

One of the chief reasons behind this problem is that the use of abutments to pre-tension the strands of the reinforcement material have been either too cumbersome, too expensive or insufficient in size to provide a means for pre-tensioning of large blocks of concrete. For this reason, in ordinary pavement construction, it has been necessary to cast concrete highways or runways in small sections and to fill in the interstices between the sections with plastic material to withstand the expansions and contractions of the separate slabs. In casting runways or highways, it has been the practice to pour the concrete into forms in small blocks, so that there has been little or no pre-stressing or stressing of the concrete, and there have been no means of pre-stressing large sections or slabs of the runways or highways. This type of construction is both expensive and inefficient, since it requires a great deal of manual labor in filling the space between the slab, and because it requires that the concrete slab be much heavier and thicker than would otherwise be necessary, were pre-stressed concrete employed. In addition, even though the separate slabs poured under present construction methods were pre-stressed by the methods and devices now being used, the pre-stressing would be limited to the separate small slabs as poured, and would not provide pre-stressing of a continuous slab of concrete roadway or runway.

In the pre-stressing of concrete slabs, it is known that pre-tensioning of the reinforcing strands, wires or cables has many advantages. However, it has never been possible from a physical or economic standpoint to provide means for properly pre-tensioning the strands employed for reinforcing because of the size of the abutments and because of lack of means of anchoring the abutments, that would be required. It is known that there have been developments and methods for the use of jacks, etc., but no developments have been made where a means or method of providing an abutment for pre-tensioning which may be used for large size slabs of concrete, such as continuous slabs for highway construction or runways. One of the problems that had not been solved in this type of construction is for a continuity of pre-stressing in large slabs of concrete.

It is recognized that concrete is comparatively weak in tensile strength, while having great strength in compression. Attempts were made to obtain a suitable method of pre-stressing of the concrete by means of post-tensioning of the reinforcement materials. In the use of the method of post-tensioning of the reinforcing strands, it was found difficult to ascertain the true tension, since in such a method friction is a major factor, and it is difficult to determine the friction factor in this type of construction. In the second place, post-tensioning is more expensive in material since there is need of extra pipes or tubing to carry the reinforcement strands

in such a manner that they can be tightened to cause the post-tensioning action.

It is an object of this invention to provide a method for pre-tensioning the reinforcements for concrete slabs, in which the pre-tensioning can be effective in the slab both lengthwise and across the width of the slab.

It is a further object to provide a method whereby a portable abutment may be employed upon which and from which the strands of reinforcement material may be pre-tensioned in both directions and which abutment will not require any means of anchoring.

It is an additional object to provide a method for pre-tensioning of the reinforcement in the concrete slab so that there is a minimum of waste of material, and whereby not only each of the strands may be separately tensioned, but also whereby a pre-determined tension may be maintained in all directions in the reinforcement members.

Other objects and advantages of the method of this invention will be obvious as the description unfolds.

For the purposes of illustrating one form of the apparatus which may be used in my invention, reference is made to the drawings in which:

FIGURE 1 is a plan view of a pre-stressed concrete slab of highway or airport runway showing the portable abutment surrounding the slab.

FIGURE 2 is a plan view of a detail of the portable abutment also showing a form of pre-tensioned reinforcement strands.

FIGURE 3 is a section of a detail on the lines 3—3 of FIGURE 2.

FIGURE 4 is a plan view of the slab and portable abutment of FIGURE 1 with modifications in the shape of the slab.

FIGURE 5 is a plan view of the portable abutment in modified form where used to join two slabs as shown in FIGURE 4.

FIGURE 6 is a section through pre-cast concrete blocks shown in FIGURE 5.

FIGURE 7 is a side view of a detail of the forms for the concrete slab.

FIGURE 8 is a side view of a modification of the forms for concrete slab; and

FIGURE 9 is a detail view in plan of a portion of the portable abutment showing modifications in the arrangement of the transverse reinforcement strands.

Referring to the drawings, 10 represents generally a portable abutment. This abutment in the form as shown has an outer ring 11 which is preferably of heavy solid construction and in the form of a closed circle. This outer ring 11 is preferably constructed in portable sections which may be fitted together at the location of the construction project, and for the purpose of providing means for varying the size of the outer ring to form a large or small abutment as the project may require. Since the portable abutment is in the form of a ring or closed curve, such as a circle, elipse or other type of closed curve in plan, made up of a series of segments attached together, it may be varied in size and shape in accordance with the size or shape of the building project. The portable abutment as shown on FIGURE 1 also has an inner ring 12 which is connected to the outer ring by a plurality of ribs 13. In the form as shown, the inner ring 12 is movable in relation to the outer ring, and moves on the ribs which are in the form of a single or plurality of tracks 14 as are shown in FIGURE 3. The inner ring 12 is also preferably built in segments corresponding to the segments of the outer ring for ease of movement and also to allow for changes in size of the abutment ring.

The use of the outer ring and the inner rings as de-

scribed herein are for illustration and it should be understood that a single ring of the portable abutment may be employed to accomplish the necessary pre-tensioning of the reinforcing strands.

Steel reinforcing strands **15**, which serve as reinforcement means or strands are fixed to the moving segment **16** of the inner ring by any conventional means, such as by nut and bolt **17**, so that movement of the inner ring will cause the strand to be under tension. The steel strands **15** are attached to the inner ring at required intervals to provide the reinforcement required in the concrete slab to be poured within the circumference of the inner ring. The reinforcing strands as shown in FIGURE 1 are preferably placed at right angles to the length of the slab for transverse tensioning to be poured and also run lengthwise of the slab so that pre-tensioning is obtained in both directions. The reinforcing strands extend from the portion of the inner ring on one side of the slab to that portion of the inner ring on the opposite side of the slab, and similarly from the inner ring on one end to the inner ring on the other end of the slab. In some cases, it has been found advantageous to have a cluster **18** of strands for the reinforcement of the slab, and the clusters to be attached to the inner ring at specified points as shown in FIGURE 3 of the drawings.

In order to pre-tension the reinforcing strands, the inner ring is pulled toward the outer ring, thus tightening the strands **15** attached to the inner ring and causing the strands to become under tension. In FIGURE 3 one of the methods employed to obtain this tension on the reinforcing strands is shown. In that form, a jack **19** is placed against a jack support **20** mounted on the ribs **13** and at the other side bears against the moving segment **21** of the inner ring to which the reinforcing strand is attached. When the jack is operated it pushes the moving segment of the inner ring away from the jack support and toward the outer ring thus causing the reinforcing strands attached to the moving segment to come under tension. In the same way, where a cluster of strands are fixed to the moving segment **21**, all of the strands are tensioned by the force of the jack moving the moving segment toward the outer ring.

The reinforcing strands which run lengthwise the slab to be poured are tensioned in the same manner as those running cross-wise as described above. To pre-tension all of the reinforcement strands, the desired and required tension can be obtained on each of the strands separately, but at the same time, the tension on each or all of the strands can be regulated to the desired tension. For this purpose, I provide a gauge **22** mounted on each of the jacks which will show the amount of the tension on the strand or strands obtained by each of the jacks. In this way, the pre-tensioning may be controlled before pouring the concrete slab on the reinforcement strands, to any desired tension force. Since the portable abutment is a ring in the form of a closed circle, elipse or curve, the use of extra tension at specific points will only cause the curve of the abutment to be deformed to a small extent, and such deformation may be cured by proper adjustment of the tension on the other strands.

The portable abutment derives its strength from the pre-tensioning of the reinforcing strands as required in the pre-stressing of the concrete pavement. Thus with an abutment in the form of a closed curve, any change of distance of one diagonal induces changes in length of the other diagonals. Thus when all strands in the portable abutment are in tension to the desired force, the closed ring of the abutment are in compression.

While the above description illustrates the method of pre-tensioning the reinforcement strands in a concrete slab to be poured, the size of the slab to be poured and the size of the abutment may not be sufficient for the size of the pre-stressed slab desired. Such would be the case in highway or runway construction, where it is desirable and advantageous to provide a continuous slab having a substantial length, I employ the same type of portable abutment to provide the pre-tensioning for the reinforcing strands. To provide for a lengthy slab as mentioned above, the forms are made to provide a pair of shoulders **23** at each end and on each side of the main slab as shown in FIGURE 4.

At each end of the main slab forms are prepared for a wedge-shaped slab **24** as shown in FIGURE 4 of the drawing. A space **25** is also provided in the forms, which space is approximately eight inches in width, which is curved in shape and extends from one side of the main slab to the other. Pre-cast concrete blocks **26**, preferably tapered in shape and lined with waxed or oiled paper, are then placed in space **25** prior to the pouring of the concrete slab for the main slab and for the wedge-shaped slab **24**. The pre-cast concrete blocks are shaped to provide a hollow section on the bottom so that they fit over the reinforcing strands extending lengthwise the main slab and into the wedge-shaped slab **24**.

Embedded in the wedge-shaped slab **24** are the longitudinal strands which are used in pre-stressing the main slab, and another series of reinforcing strands **27** leading to the gap are embedded in the slab **24**. These strands **27** will be later employed for longitudinal pre-stressing of the strands in the gap and provide for continuity of pre-stressing for the entire pavement.

When the main slab and the wedge-shaped slabs have been poured and the concrete has hardened, the pre-tensioned strands are cut from the abutment and pre-stressing has been imparted to the main slab, the pre-cast blocks and the wedge-shaped slabs. The strands **27** not having been under tension at the time of the pouring of the slabs are loose and have no effect on the slab at this point.

The strands **27** extending from each end of the adjacent slabs and into the gaps are then joined to the corresponding strands **27** extending from the adjacent slab, as shown in FIGURE 5 and jacks **28** or other means for tensioning the strands **27** are employed. Segments of the portable abutment **10**, having the outer ring **11** and inner ring **12**, are then placed in position to form an arch around and across the gap between the adjacent slabs, and bear against the shoulders **23** on the same side of the adjacent main slabs. The segments of the abutment and the main slab thus form a closed circle around the gap and the wedge-shaped slabs **27**. Reinforcing strands **29** extending transversely across the gap between the adjacent ends of the main slab are fixed to the inner ring **12** of the portable abutment segment. These reinforcing strands **29** are then pre-tensioned to the same tension as the reinforcing strands had been tensioned in the main slab. At the same time the longitudinal strands **27**, which have been joined together are tensioned, so that the compressive forces bearing against the pre-cast blocks placed in the space **25** are released, whereas the compressive forces in the main slab remain constant. The pre-cast blocks are then removed leaving the space **25** empty. This space is then cleaned and the concrete is poured into the space **25** and the gap between the adjacent blocks. When the concrete has hardened the transverse strands **29** connected to the abutment are cut and the abutments are then removed. This creates continuous prestressing between consecutive main slabs both longitudinally and transversely, and may be continued to produce long continuous slabs, pre-stressed in both directions as may be desired.

In preparing the forms for pouring the concrete where portable abutments as above described are employed, and the reinforcing strands extend across the slab to the abutment, it is preferable to provide for the passage of the strands through the sides of the forms **29**. For this purpose, a special device has been employed, as shown in FIGURE 7, whereby at specific intervals in the sides of the form a plate **30** having an opening for the passage of the pretensioned strands is provided. This plate is mov-

able and may be attached to the sides of the form by bolts 31.

Where a large piece of concrete construction is to be poured in a slab of this type, special concrete forms may be prepared whereby openings 32 are provided in the lower portion of the sides of the forms 29 as shown in FIGURE 8. The cross-wise reinforcing strands would then pass under the openings, thus leaving the strands under the desired tension, without interfering with the forms themselves.

In the use of the portable abutment, especially where large abutments are to be employed, it is preferable to provide lower levelling cables 33 as shown in FIGURE 9. These cables extend across from the bottom of the outer ring 11 on one side to the outer ring on the other side. These cables are preferably below the inner ring and the reinforcing strands, and are for the purpose of preventing any buckling of the abutment when the reinforcing strands are brought under tension by the movement of the inner ring.

The method of pre-stressing slabs of concrete or other types of moldable materials in accordance with this invention are especially useful in the construction of pavement for highways or runways of airports where the protection of the pavement against high load shock is important. Such shocks may be caused during the take-off or landing of heavily laden jet planes for example. By pre-stressing the slab of the pavement as described herein, there are additional advantages since the thickness of the pavement may be reduced, since the pre-stressed pavement is much stronger and able to withstand shocks.

In addition, the pre-stressing obtained through pre-tensioning is very economical in comparison with the methods and for post-tensioning of the slab, since the apparatus employed in the pre-tensioning may be recovered and used again, whereas in post-tensioning there are many unrecoverable items, such as anchorages, tubing, etc.

In the construction of long concrete runways at airports for example, by the use of the method of this invention, main sections could be poured in any convenient lengths, with gaps between the main sections of 20 to 30 feet. Each of the main sections and the sections for the gaps would be pre-stressed by pre-tensioning from the portable abutments as previously described. The gaps are pre-stressed in such a manner as to create a continuously pre-stressed pavement when the slab is poured in the gaps between the previously poured main sections.

Having described my invention, I claim:

In concrete construction, the method of pre-stressing continuous concrete slabs which comprises providing abutments encircling the area of adjacent slabs of concrete, attaching reinforcing strands running lengthwise and across the area of the slabs within the abutments, providing a plurality of longitudinal reinforcing strands having one of the ends within the area of the slab and the other ends of said longitudinal reinforcing strands extending under the abutments and into the spaces between the adjacent concrete slabs, providing forms within said abutments to define the area of the concrete slabs, pre-tensioning the reinforcing strands within the abutments and attached thereto by means bearing against said abutments, pouring concrete into said forms and over said pre-tensioned strands, cutting the ends of the pre-tensioned strands extending from the slabs when the concrete has hardened, fitting abutments against the concrete slabs and around the spaces between the adjacent concrete slabs, attaching together the ends of the longitudinal srands exending into the spaces between the adjacent slabs, providing transverse reinforcing strands attached to the abutments around the spaces between the concrete slabs, providing forms within said abutments to define the area of the concrete slabs between the adjacent slabs, pre-tensioning the longitudinal and transverse reinforcing strands within said spaces until the tension on said strands within said spaces has been equalized with the tension of the reinforcing strands in the poured slabs, pouring concrete into the forms within the adjacent slabs and over the pre-tensioned reinforcing strands and cutting the ends of the pre-tensioned transverse strands extending from the slab when the concrete has hardened.

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