Feb. 4, 1969 U. FINSTERWALDER 3,425,076

CONCRETE HIGHWAY FORMED IN THE FASHION OF A BRIDGE AND METHOD OF CONSTRUCTING SAME

Filed Dec. 18, 1967 Sheet 1 of 4

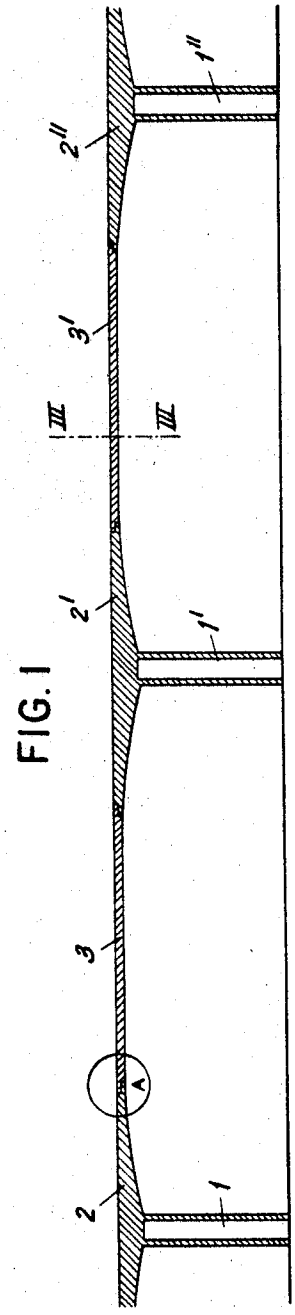


FIG. 1

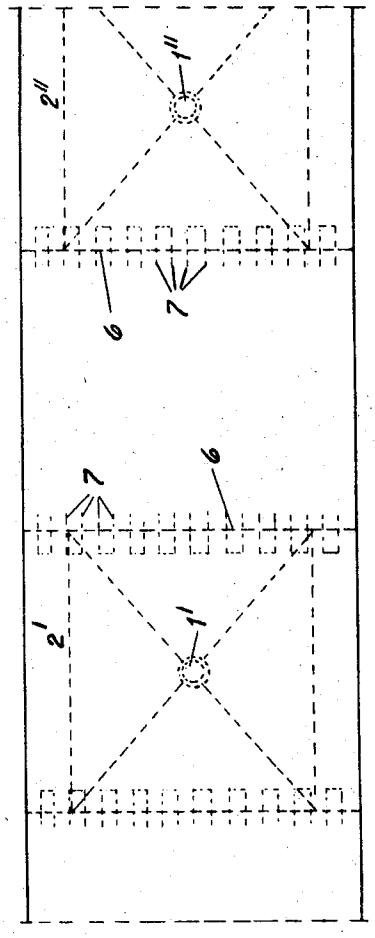


FIG. 2

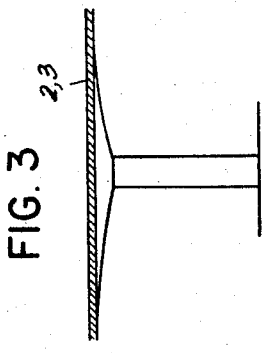


FIG. 3

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FIG. 4

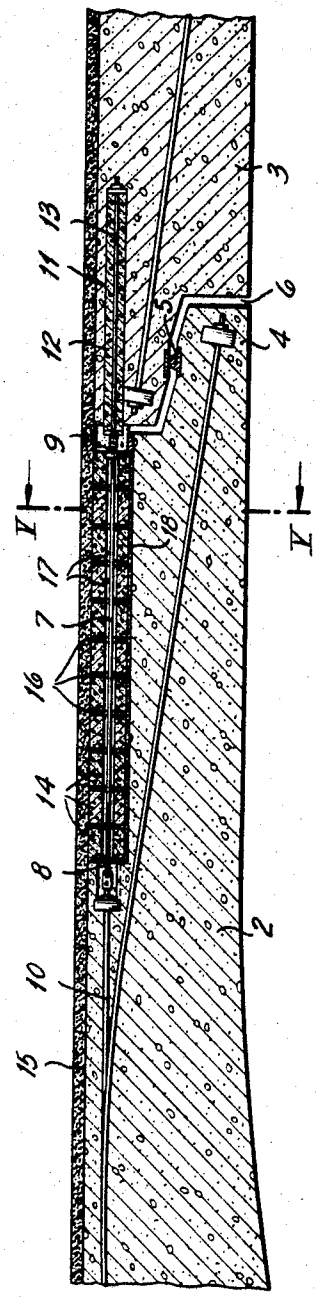
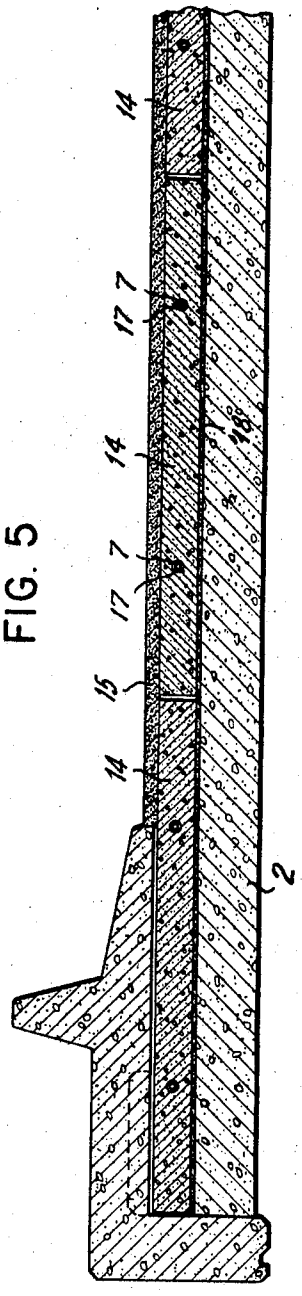


FIG. 5



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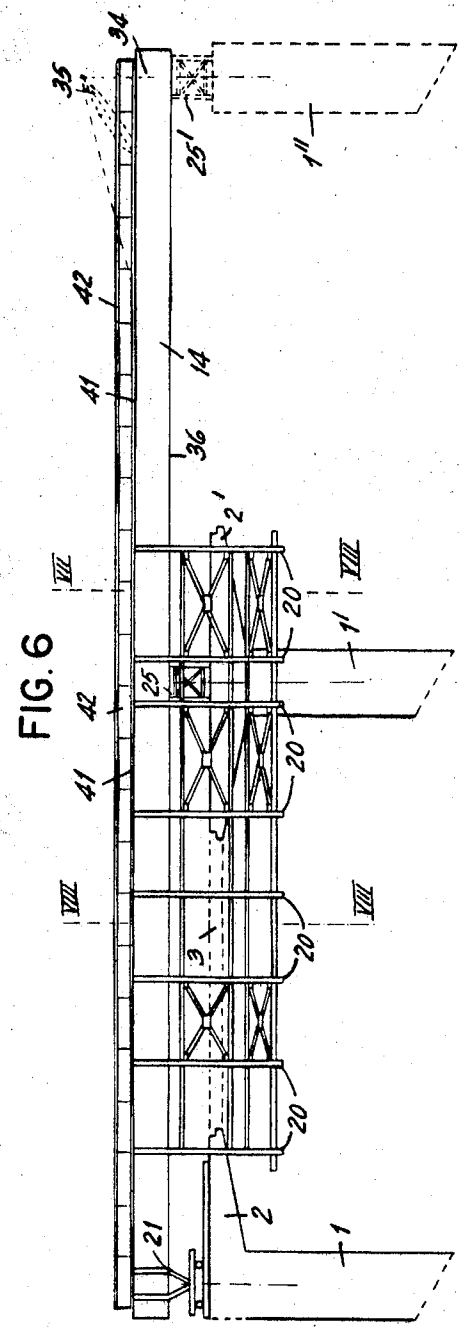


FIG. 6

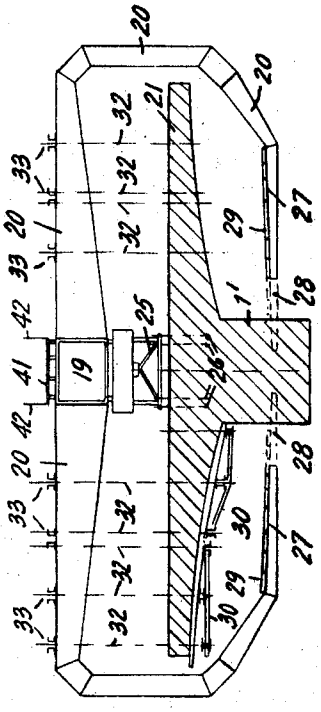


FIG. 7

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FIG. 9

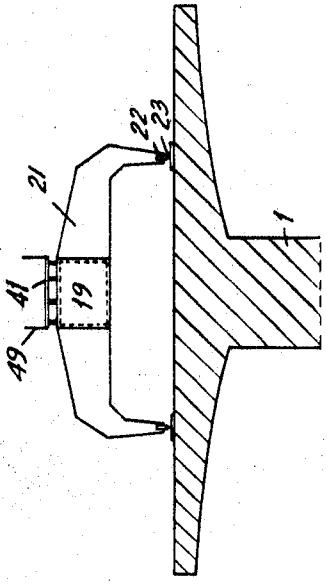


FIG. 8

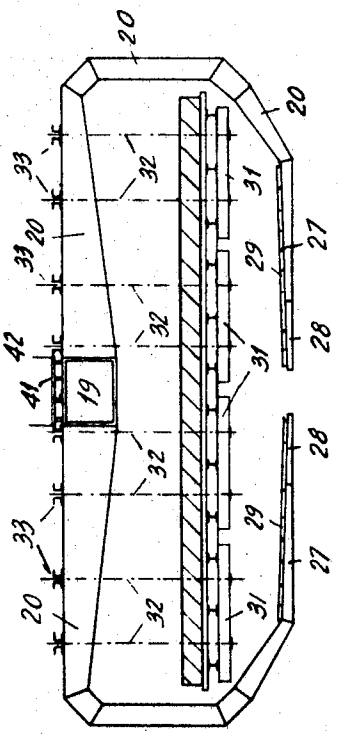
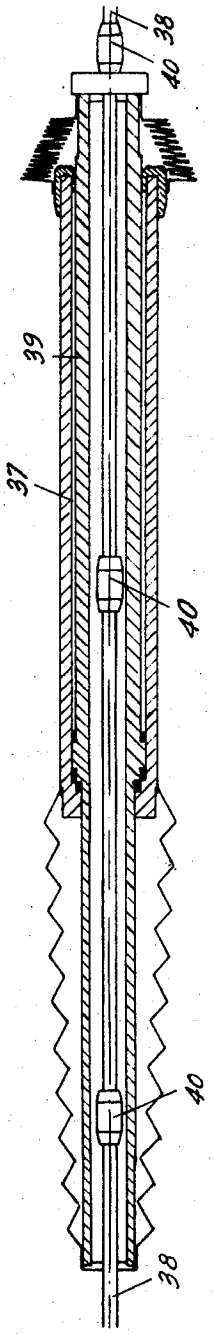


FIG. 10



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3,425,076

CONCRETE HIGHWAY FORMED IN THE FASHION OF A BRIDGE AND METHOD OF CONSTRUCTING SAME

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Original application May 29, 1963, Ser. No. 284,797. Divided and this application Dec. 18, 1967, Ser. No. 691,556
Claims priority, application Germany, June 1, 1962, D 39,057, D 39,058; Mar. 28, 1963, D 41,230
U.S. Cl. 14—7 4 Claims
Int. Cl. E01d *19/00;* E04b *1/16*

ABSTRACT OF THE DISCLOSURE

Bridge-like elevated highway and method for constructing such highway, where substantially rectangular sections forming the carriageway cantilever out freely in all directions from supports and additional slab sections are supported between the cantilever sections, being supported on the ends thereof, and resilient tensioning members rigidly anchored in contiguous sections extend through expansion joints between the cantilever sections and the sections supported therebetween.

The invention relates to a bridge-like elevated highway of prestressed concrete, comprising substantially rectangular sections which cantilever out freely in all directions from column-like supports. The subject matter of the present application is divided out of parent application Ser. No. 284,797 filed May 29, 1963. The parent application covers apparatus for constructing highways or bridges in accordance with the invention, while the present application is concerned with the method for constructing highways or bridges originally disclosed in the parent application and the highway or bridge structure constructed in accordance with the method.

Description of the prior art

In known elevated highways of the kind specified, substantially square carriageway slab sections cantilever out freely in all directions from all the intermediate columns, such sections being disposed immediately adjacent one another. This leads to a relatively large number of expansion joints. In bearing structures of this kind the between-supports distances, and therefore the between-joints distances, are something like 30 meters. These joints, which must be bridged by appropriate structure, must in any case be considered weak points since the carriageway surfacing is interrupted at the joint and since the conventional steel transition disturbs traffic, wears, and requires constant attention.

The nearer the supports are to one another, the greater is the number of joints. Where the supports are not so far apart, the movements to be dealt with and evened out are much less and the joints can be of much simpler construction than when the supports are far apart from one another. Constructions with closely spaced columns, however, have proved unsatisfactory for elevated highways because there are so many joint transitions, each of which is noted as an impact by the vehicles passing over them, that the transitions are a disturbance to comfort and even to road safety.

Summary of the invention

It is an object of the invention to provide an elevated highway which obviates the disadvantages of the known structures, i.e., the reduced separation between joints and the considerable overall height near the supports, but loses none of the advantages of the known structures, such advantages residing more particularly in the statically very desirable mushroom shape of the supports.

According to the invention, therefore, in an elevated highway of the kind specified with carriageway portions cantilevering out from central supports, further slab-like sections are placed lengthwise of the carriageway between the cantilever sections and freely supported on the ends thereof; resilient tensioning members which are rigidly anchored in the contiguous sections and which extend through the expansion joints interconnect the cantilever sections and the sections therebetween; and means are provided so to distribute the total changes in length caused by temperature differences over an appropriately long stretch of the carriageway surfacing covering, for example asphalt, over the joint that such surfacing is not impaired by changes in length.

The provision of a freely borne bearer—known as a suspended span—between every pair of mushroom sections means that, as compared with the prior art, the negative bending moments near the supports can be reduced considerably for a given span, so that the overall height of the bearing construction can be reduced. The height of the suspended span is, for instance, only about $\frac{1}{25}$ of its span or $\frac{1}{50}$ of the bridge span. This reduced height, which is barely half as much as the height of the thinnest prestressed concrete bridge beams previously known, is operative for $\frac{5}{8}$ of the total span, i.e., as far as the connection to the mushroom section.

A suspended span having twice as many cross-joints as the prior art elevated highway is the result of a special construction of the carriageway transitions at the expansion joints, such that the carriageway surfacing can extend uninterruptedly and uniformly over the whole length of the bridge. It is therefore another object of the invention so to construct the joints that there is a smooth connection between the various components of the elevated highway, i.e., between the mushroom supports and the suspended spans. It was recognized that the joints need not be uniformly distributed throughout the bridge length but can be placed correspondingly closer together and near the expansion joints if means are provided for distributing changes in length at the expansion joints between the various elements of the construction over a distance sufficient to ensure that such changes do not impair the carriageway surfacing.

According to the invention, therefore, the tensioning members interconnecting the structural elements which abut one another at the expansion joints are in the form of tendons extending through concrete joists which are pierced transversely of their longitudinal axis and which are mounted for displacement and closely adjacent one another, transversely of bridge length, in a recess in one element, the joists being covered by the continuous carriageway surfacing above them.

The invention also relates to a method of and apparatus for producing the prestressed concrete elevated highway according to the invention.

As a result of the ever increasing wish, found in the building industry as elsewhere, for greater rationalization, the trend in bridge building is steadily away from erecting superstructure on fixed scaffolding. Instead of relatively complicated building methods being used which require considerable labor and equipment, endeavors are made to split building up into a number of steps which are repeated regularly. The result is that the bridge bearing structure is produced in sections of a size varying in length from a few meters to a complete span. In a method which is very advantageous for erecting an elevated highway according to the invention, starting from a scaffold bearer which extends over one bridge span and cantilevers freely into the

immediately following span, the carriageway section which cantilevers freely from the leading support is first concreted in a length of about half a between-supports span, then prestressed, then removed from its formwork, whereafter the suspended span between the leading support and the rear support bearing the already finished part of the elevated highway is concreted, prestressed and then freed from its formwork, whereafter the scaffold bearer is advanced on trestles disposed on the leading pier and on the next pier erected in the meantime, whereafter the procedure is repeated.

The method according to the invention can be performed very advantageously by means of an apparatus wherein the scaffold bearer is a torsionally rigid steel box girder which extends along the longitudinal axis of the bridge bearing structure above the carriageway. To take up twisting moments produced by one-sided loading, the box girder is connected at its rearward end to a gantry which extends transversely of the bridge and which has running rollers, and tendons locate the girder relatively to the leading span-bounding support in the region where such girder is supported by such support.

Brief description of the drawings

Embodiments of the invention in the form of an elevated highway, and a method of constructing the same, will now be described by way of example and with reference to the accompanying drawings, wherein:

FIGURE 1 is a longitudinal section through an elevated highway;

FIGURE 2 is a plan view corresponding to FIG. 1;

FIGURE 3 is a cross-section taken along the line III—III of FIG. 1;

FIGURE 4 is an enlarged cross-sectional view showing to an enlarged scale the joint construction IV in FIG. 1, the cross-section being through the joint;

FIGURE 5 is a section taken along the line V—V of FIG. 4;

FIGURE 6 is a side elevation of the scaffold used for practicing the method in accordance with the invention and diagrammatically shows the building process;

FIGURE 7 is a cross-sectional view taken along the line VII—VII of FIG. 6;

FIGURE 8 is a cross-sectional view taken along the line VIII—VIII of FIG. 6;

FIGURE 9 is an end elevation of the scaffold bearer near that part of the bridge which has already been constructed, and

FIGURE 10 is a sectional view, to an enlarged scale, of the press used to advance the scaffold bearer.

Description of the preferred embodiment

An elevated highway according to the invention comprises supports or columns or the like **1**, **1'**, **1''** and so on disposed at appropriate distances apart from one another. The supports have mushroom-like tops which extend in all directions so that widened parts **2**, **2''**, **2'** are produced which form the carriageway. The gaps between the mushrooms are bridged by means of flat suspended spans **3**, **3'** or the like supported on bracket-like steps **4** which can be seen in FIGURE 4 and which project from the widened parts **2**. Sliding bearings **5** are interposed between the part **4** and the suspended span **3**. Variations in length of the superstructure due to temperature differences are taken up by gaps **6**. The suspension spans **3**, **3'** can be strengthened in the region of the carriageways. The length of the suspended span **3** is about half the distance between two adjacent supports. For instance, span length is about 15 meters if the between-supports distance is 30 meters.

Uniform movement of all the sliding bearings **5** is ensured by means of tensioning members **7** which are concreted into the structure and anchored in the components **2**, **3** flanking a gap. As a rule, the tensioning members **7** are in the form of high-grade steel tensioning bars and have screwthreads at their ends **8**, **9**. At the end near the support **2**, the bars **7** are connected, for instance, by means of a screwthreaded tube, to the ends of tendons **10** anchored there and at the end facing suspended span **3**, the tendons **13** of anchoring members **11** are connected, also by means of a screwthreaded tube, to the projecting ends of the bars **7**. The anchoring members **11** take the form of a concrete member **12** which is concreted into the structure as a prefabricated part, with tendon **13** extending through the member **12** lengthwise thereof.

The factor governing the length of the tensioning members **7** is that, as already stated, asphalt carriageway surfacings can bridge gap movements of 0.75 mm. without any risk of cracking. In the example illustrated, the between-supports distance is about 30 meters. Since a suspended span is used, changes in length due to temperature variations are distributed between two gaps. Since a gap must extend over a length of about 1.50 meters, the distance over which length variations must be distributed is about 10% of the length of the suspended span. At this length, temperature changes make the tensioning bars **7** expand about **10** times as much as the concrete of the structure, i.e., 5 mm./m. This corresponds to a tensile difference in the steel bar of 10,400 kg./cm.^{2}. The steel bars are so fitted that the tension operative upon them at the minimum temperature, i.e., when the gap is at its widest, is about 11,400 kg./cm.^{2}, and about 1000 kg./cm.^{2} at maximum temperature, i.e., when the gap is at its narrowest.

In order that the width of the gap **6** may be uniformly distributed among a relatively large number of correspondingly smaller gaps, concrete joists or the like **14** which extend transversely of bridge length are threaded onto the bars **7** anchored in the two components **2**, **3** and are received in a recess below carriageway surfacing **15** of the support structure **2**. For accurate opening and closing of the gaps the joists **14** are separated from one another by asbestos sheeting **16** or some similar material, whereafter, once the complete joint or gap construction has been finished, the joists **14** are bonded to the bars **7** by adhesive cement being forced into the gaps left between the bars **7** and channels **17** in the joists. For mobility, the joists **14** rest on a sand bed **18**.

When a temperature drop makes the structure contract, the gap **6** opens. Consequently, the bars **7** anchored in the two components **2**, **3** are elongated because such components move apart from one another. Because of the bond between the bars **7** and the joists **14**, the elongation is imparted to the joists **14** so that the total gap opening is distributed uniformly among the gaps between the joists **14**, the last mentioned gaps being filled with asbestos sheeting **16**. The number of gaps between the joists **14**, i.e., the length of the complete gap structure, must be so adapted to the overall length of the elevated highway that the maximum opening of any individual gap is 0.75 mm., a figure which can readily be tolerated by the asphalt surfacing **15**. An elevated highway supported by supports at a standard spacing can then be kept free from disturbing transition constructions even though the carriageway construction is of very slender design.

The low overall height achieved by using suspension spans is useful in planning urban elevated highways, more particularly because the distance between the level of the bottom highway and the level of the top highway can be kept to a minimum, with a corresponding reduction in the lengths and heights of the associated slip roads and their construction. The columns, which are secured in the foundation and in the mushroom head, can have the lowest cross-section which is statically necessary, since no space is required for bearings. The lower road is therefore kept substantially free for connections to the upper road.

The elevated highway of the example first described can be constructed in the following way be means of the scaffold bearer which also forms part of the invention.

FIGURE 6 diagrammatically shows construction proceeding. A finished part of the bridge ends at the support **1** which bears the mushroom section **2**. Another support

1' has been erected at a distance of one normal span from the support 1. The mushroom 2' associated with the support 1' has just been finished in the example shown in FIGURE 6. A flat suspension span 3 has been placed in position, in the manner illustrated in FIGURE 4, between mushroom 2 and mushroom 2'. Above the supports 1 and 1' is a frame or scaffolding construction comprising a box girder 19 and a number of cross-bearers or girders 20 which cantilever out on both sides. At its rearward end the box girder 19 is suported by a gantry 21 which is mounted on the mushroom 2 and which extends perpendicularly to the bridge longitudinal axis and which, with the interposition of rollers 22 and rails 23, is borne by the carriageway surface 24. Like the girder 19, the gantry 21 is a steel construction which can be of the solid or lattice kind and which takes up twisting moments caused by one-sided stressing of the scaffold girder 19. The same is stiffened conventionally by diaphragms. The girder 19 is supported by support 1' with the interposition of a trestle 25 and, during construction, is secured to the concrete structure by means of tendons 26 which can be seen in FIGURE 7.

The cross-bearers 20 which, like the box girder 19, can be any kind of steel construction, engage, as it were, around the bridge cross-section and form therebelow a working platform 27 which can be seen in FIGURE 7 and which can have a plank covering 29. The inwardly extending parts 28 of the cross-bearers 20 can be telescopic in order to bridge the gap below the carriageway construction and between consecutive supports. The bottom formwork for the carriageway construction is suspended on the cross-bearers 20 by means of cross-pieces 30, 31 and hangers 32. The hangers 32 can either be anchored directly above the cross-bearers 20 or can be anchored to intermediate bearers 33 so disposed on the cross-bearers 20 as to extend lengthwise of the bridge.

Using the system just described, work on the bridge by the method according to the invention proceeds as follows:

In the state of construction shown in FIGURE 6 the scaffold bearer rests on the supports 1, 1' and projects over the full length of the following span of the bridge. Near the support 1' the carriageway section 2' which mushrooms from the support 1' has just been concreted. After the section 2' has been prestressed—prestressing being effected in a manner known per se after the concrete has hardened—the formwork is lowered onto the platform 27 by slacking of the hangers 32 (FIGURE 7) and the suspended span 3 is mounted between mushroom 2 and mushroom 2', conveniently with the use of special formwork which can be assembled while the previous section is hardening and being prestressed. While these jobs are proceding, the foundation and pillar including a support platform of the next support 1'' can be erected from end 34 of girder 19 by means of a derrick 35 disposed at such end. All this work can be done from the end of the girder 19, except for excavations for the foundation of the next support.

After the suspension span 3 has hardened, been prestressed and had its formwork removed, the entire scaffold construction is advanced by one span. Previously, the tendons 26 must be released near the trestle 25, and another trestle 25' must be built on the next support 1''.

A hydraulic press disposed on the trestle 25 substantially at the level of the bottom edge 36 of the girder 19 now advances the complete scaffold construction; the gantry 21 moves forward on its own rollers 22, and the box girder 19 moves forward on sliding bearings at the trestles 25, 25'. The hydraulic press used for this purpose, which is illustrated in FIGURE 10, has a piston 39 which has a very long stroke and which cooperates with a bar-like element 38. The same has, at intervals corresponding to the stroke of the piston 39, thickened parts 40 against which the press piston 39 bears. The press 37 is mounted on the trestle 25, and the element 38, which can take the form of a tensioning bar or steel rope or a cable or the like, is disposed below or laterally of the box girder 19 and has its rear end secured somewhere near the gantry 21.

The complete scaffold construction is therefore advanced stepwise relatively to the trestle 25. Once the scaffold construction has reached a position where the gantry 21 is substantially above the support 1', the trestle 25 is dismantled, and the box girder 19 is moved into its end position and clamped by the elements 26, in the region of the trestle 25', to the next support (not shown). The box girder 19 is now ready to be used again so that the cycle of operations can be repeated.

The construction according to the invention of bridge bearing structures by means of a scaffold construction comprising a box girder extending lengthwise of the bridge bearing structure, and cross-bearers which extend out of the box girder and which engage around the bridge cross-section and which form a working platform below the bridge carriageway, is not limited by the dimensions or spans of the bridges to be produced. Bridges of any desired cross-sectional shapes and of varying spans can be produced after minor changes.

Conveyance of all the material required at the construction site and of labor from that part of the bridge which has already been finished to the place where work is proceeding near the bridge spans which are just being built, i.e., to the end of the bearer 19, is by the way of a passageway 41 which is provided on the top of the girder 19 and which, with its railings 42, acts, as it were, as a transport bridge. The system described above therefore enables the building of a bridge bearing structure to proceed solely in one direction, by advance of the bridge end being built, in a very simple manner and with no need to use or upset transport facilities at ground level.

The building system described above also makes it possible to produce bridge spans which in plan are curved, since only bridge sections of the length of about half a span are concreted at any one time and it is a relatively simple matter to move the scaffold bearer 19 along a curve. In this event, in the operative state the bearer 19 is always at a tangent to the bridge highway, and when advanced it can readily be turned to suit the required curvature.

Having now described my invention with reference to the embodiments illustrated in the drawings, I do not wish to be limited thereto, but what I desire to protect by Letters Patent of the United States is set forth in the appended claims.

I claim:

1. A method of constructing an elevated highway on a plurality of piers including columns disposed in a series at intervals in the general direction of the longitudinal extent of the highway, said method comprising the steps of mounting a scaffold bearer on the first and second said columns in the series to span the distance between said first and second columns with one portion of said scaffold bearer while freely cantilevering another portion of said scaffold bearer across the space to the location of the next column in the series with the scaffold having one end disposed on an existing carriageway portion at said first column and the other end of the bearer extending beyond said second column, concreting and prestressing from said scaffold a new carriageway portion cantilevering freely in opposite directions from said second column to a length corresponding substantially to one-half the distance between columns, then concreting and prestressing a carriageway section in the general form of a slab between said existing cantilevering carriageway portion on said first column and the new carriageway portion completed on said second column, and then advancing said scaffold bearer on trestles disposed on said second column and on said next column to repeat the operations.

2. Bridge-like elevated highway of prestressed concrete, comprising contiguous substantially rectangular slab-like sections forming a carriageway and cantilevering out freely in all directions from column-like supports and at least one slablike section placed lengthwise of the carriageway between the cantilever sections and freely supported on the ends thereof, resilient tensioning members rigidly anchored in the contiguous sections and extending through the expansion joints interconnecting the cantilever sections and the sections therebetween, and means effective to distribute the total changes in length caused by temperatures differences over an appropriately long stretch of the carriageway surfacing, such as asphalt, covering the joint that such surfacing is not impaired by changes in length.

3. An elevated highway as set forth in claim 2, where said tensioning members are in the form of tendons extending through concrete joists which are pierced transversely of their longitudinal axis and mounted for displacement and closely adjacent one another, transversely

of the bridge length, in a recess in one element, said joists being covered by the continuous carriageway surfacing above them.

4. An elevated highway as set forth in claim 3, where the concrete joists are mounted on a sand bed in order that they may be displaceable.

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U.S. Cl. X.R.

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