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<th>(54) Title:</th>
<th>ARRANGEMENT FOR CASTING IN SECTIONS OF A PRESTRESSED CONCRETE BRIDGE IN ACCORDANCE WITH THE CANTILEVER CONSTRUCTION METHOD</th>
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<th>(57) Abstract</th>
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The arrangement comprises one or several casting carriages (3) with front and back runners (5, 15) which cooperate with traversing rails (2, 2a, 2b) and a previously cast bridge section (1). The rear runners abut the underside of the traversing rails. The rear section (23) of the casting carriage is anchored in traversing trolleys equipped with runners (15). The rear section of the casting carriage is linked with runner trolleys by means of a parallelepiped-shaped frame (28-30) with joints in all four corners so arranged that the frame can be swung out laterally about its two lower joint axes (26, 27) (figs. 1 and 3). In order to stabilise the casting carriage a tensioning device is provided between the rear section (23, 30, 33) of the casting carriage and the previously cast concrete bridge section (1, 18), the said tensioning device being capable of regulation in height and intended for prestressing the tie-rods (38) which are fixed between the bridge deck (18) and a part (30) of the casting carriage’s rear section (23) (Fig. 4). For casting in sections of concrete bridges from a bridge pier with superimposed bridge head by way of anchoring section using two casting carriages traversing in opposite directions, which however to begin with are partly dismantled and linked with one another, the arrangement comprises for linking the forward front sections (122) of the casting carriages two substantially plane coupling frames (150) which extend between the front sections (122) their distance from one another corresponding to the gauge of the traversing rails. Each coupling frame has an upper and a lower substantially horizontal flange (151-154) of adjustable length, and the flanges are linked with one another by means of diagonal threaded tie-rods (157, 158) the length of which is also adjustable.
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Arrangement for casting in sections of a prestressed concrete bridge in accordance with the cantilever construction method

The present invention relates to an arrangement for the casting in sections of a prestressed concrete bridge in accordance with the cantilever construction method, comprising a cantilever construction carriage (casting carriage) with a front jib and front and rear runners rolling on a rail track with preferably dual traversing rails on a previously cast bridge section or bridge pier, having two rear runner units each of which comprises two runner sets co-operating with the rails on the same side of the rail track and equipped to abut the top or underside of the said rails, every rear runner unit comprising a frame to which the rear part of the casting carriage is attached.

Casting arrangements of the said type have been previously known, and such an arrangement is e.g. described in Patent 138 855 which is the applicants' property. With the embodiment described in the patent the anchoring frame between the rear end section of the casting carriage and the runner unit is made rigid and incapable of being displaced longitudinally and to the sides. Since the rear end section of the carriage is anchored to the frame it is also not possible to displace (e.g. with a view to adjustment) the end section of the carriage in the lateral direction. The required lateral adjustments must therefore be carried out direct on every one of the formwork panels.

It is one intention of the present invention to simplify the effort of lateral adjustment, and this has been achieved by designing the bearing frame between the rear end section of the casting carriage and the runner unit as a parallelepiped, with joints in all four corners and with the joint axes extending in the longitudinal direction of the rail track, the frame being capable of being swung sideways about its two lower joint axes.

The bearing frame comprises preferably two parallel supports and a horizontal crossbeam at the top, the height of the beam being variable in relation to the support. The crossbeam has suspended tie-rods for attachment to the cast bridge deck so as to relieve the
rear runners.

Whenever the bearing frame with the rear section of the carriage is displaced outward the formwork suspended from the front section of the casting carriage is correspondingly displaced inward since the carriage swings about the bearings of the front runners. As a result lateral adjustment of the formwork panels can be carried out more simply, more accurately and also more quickly.

When the rear end section of the casting carriage is in the right position it has to be fixed to the previously cast concrete deck using to this end tensioning tie-rods extending between the bridge deck and the rear end section of the carriage. The rear, lower runners are in this case not in contact with the underside of the traversing rails, the load acting on the carriage being taken up by the tensioning tie-rods. As the load increases, the tension to which the tie-rods are subject increases, as does also the extension of the tie-rods which may eventually become quite considerable causing a significant "downward deflection", i.e. lowering, of the casting carriage's front section with the suspension for the formwork.

In order to avoid the said disadvantage it is proposed in accordance with the invention for a tensioning device or jack adjustable in height to be fitted between the underside of the casting carriage's rear section and the cast section of the concrete bridge and for the rear tie-rods of the carriage or/and tensioning device to be adjusted in such a way that the tie-rods are stressed at least 10% above the calculated maximum load.

The latter embodiment has the advantage that load-dependent displacement in height of the front section of the carriage and the formwork is avoided while at the same time the tie-rods subject to tension are relieved as the load acting on the front section of the carriage increases, which is the opposite to what has been the case so far.

In order to enable the said tensioning process to be affected in a simple manner the arrangement in accordance with the invention is provided with a tensioning device or jack capable of being regulated in height and possibly equipped with a force measuring device, this being provided between the rear bearing frame supports
under the rear section of the carriage, extending downward to about
the lower ends of the runners and extendable down to the top surface
of the concrete deck.

Arrangements of the above type are also used for section
casting starting from a bridge pier with a superimposed anchoring
section. In this case cantilever construction proceeds in two
opposite directions from the pier and use is made of an arrangement
comprising two cantilever construction carriages (casting carriages)
each carrying its formwork and capable of running on rails located
on a previously cast section of the bridge. Each casting carriage
can be subdivided into a front section comprising a jib and a rear
section. For casting the two first bridge sections starting from
the bridge pier the arrangement also comprises a system of bars for
releasable coupling of the two front sections of the carriages when
the latter are at a distance from one another in the longitudinal
direction facing away from one another in symmetrical fashion. An
arrangement of this type is described in the said Patent 138 855.

With the known arrangement the system of bars comprises a stiff
frame so designed that the relative position of the carriages (to be
precise the front sections of the carriages) cannot be changed and
that the carriages are always in line with one another. Such a design
is hardly efficient when it comes to casting a curving bridge. The
known arrangement does not enable casting along curves since the
carriages are separate from one another and can move independently.

A further intention of the present invention consists in bringing
about an arrangement enabling the casting in sections along curves
- starting from a bridge pier - it being possible to adjust the
relative position of the carriages following their location on the
pier head.

With the solution in accordance with the invention the system
of bars comprises two roughly level coupling frames which together
with the carriages in the coupled state extend between the end
sections of the carriages at a mutual distance which substantially
corresponds to the distance between the traversing rails (track gauge)
and link the carriages with one another in an adjustable manner,
inasmuch as each coupling frame has an upper and a lower basically
horizontal flange of adjustable length. The flanges can be linked with one another by means of diagonal threaded tie-rods of adjustable length and they can be so designed as to be capable of telescoping into one another.

The advantage of the said design consists in the fact that the carriages (the front sections) can be angled in relation to one another in order to match the curvature of the bridge. Another advantage consists in the fact that the same coupling frame can be used for different bridge constructions inasmuch as this can be adapted to the local conditions.

The invention is described in greater detail below on the basis of examples and with reference to the drawings in which:

Fig. 1 is an elevation partly in section of a previously cast bridge section with the arrangement in accordance with the invention, fig. 2 is a front section of the arrangement and a section of a support bridge viewed in the direction of the arrows II-III in fig. 1, fig. 3 is an end section which on a larger scale shows detail A of fig. 1 viewed in the direction of arrow III comprising an embodiment of the invention, and fig. 4 is an end section corresponding to fig. 3 but showing detail A viewed in the direction of arrow III with a different embodiment of the invention.

Fig. 5 shows an arrangement for casting bridge sections starting from a previously cast bridge pier of the kind described in the applicants' Patent 138 855, fig. 6 illustrates the casting method at a later stage of the work, fig. 7 shows an arrangement of the kind presented in figs. 5 and 6 but carried out in accordance with the invention, and fig. 8 is a lateral section or elevation of the same arrangement as shown in fig. 7 but drawn in a larger scale.

Figs. 1 and 2 show a recently cast bridge section 1 which may be the top of a bridge pier and on which are placed parallel traversing rails 2. On the rails there travels a casting carriage 3 with a front jib 4 and lower and upper runners 15 and 5 respectively, which co-operate with the traversing rails 2. To the front end of jib 4 are attached supporting tie-rods 6 extending downward, to the lower ends of which are secured two lower traversing rails 7 freely extending backward, the mutual distance between which is considerably
smaller than the width of the inner formwork (see fig. 2). The rear
section of traversing rails 7 is rollably suspended in brackets 8
with runners 9 so that the rails 7 can be advanced together with
carriage 3. The front section of casting carriage 3 is designated
22 and the rear section 23.

The traversing rails 7 support a formwork carriage 10 with inner
formwork 11,12,13. The carriage has runners 14 and can be displaced
forward and rearward on the rails 7.

Fig. 2 shows that the cross-section of the bridge sections 1 is
roughly box-shaped, with the side walls and the top of the box being
cast between the inner formwork 11,12,13 and the outer formwork 16,17.
The carriageway of the bridge is designated 18. The formwork has
vertical sections suspended from hangers 20 and 21 respectively.

The inner formwork 11,12,13 comprises a steel construction 11,12
arranged on the said formwork carriage 10 so that it can be transported
along the rails 7 and displaced irrespective of the outer formwork
16,17 connected with the same carriage 3 as well as with the aid of
the schematically drawn tie-rods 19. Fig. 1 does not show the outer
formwork.

Fig. 1 shows that a support 8 is provided at the front end of the
last section cast with a view to supporting the rails 7. The required
reinforcing work has been carried out at an earlier stage when the
insides of the outer formwork and the inner formwork were free, and
fig. 1 shows carriage 10 for the inner formwork advanced to such a
point that it is immediately above the outer formwork 16,17 (not
shown in fig. 1). The formwork element can now be adjusted and made
ready for casting of the next section. The arrangement shown in fig.
3 considerably facilitates the work involved in lateral adjustment.

Fig. 3 shows detail A in figs. 1 and 2 seen from the back (or
from the front). As shown in figs. 2 and 3 the traversing rail track
2 comprises two rails 2a and 2b arranged at a distance from one
another, which are secured to the previously cast bridge deck 18 with
the aid of anchoring units 34 and anchor bolts 35.

The rear section 23 of casting carriage 3 comprises inter alia
a longitudinal girder 33, a frame unit 36 and a horizontal crossbeam
or end beam 30 which are rigidly linked with one another. Two supports
or suspended beams 28, 29 are suspended, in a rotatable manner and
at a distance from one another, with the aid of pivot bolts 31, 32
from crossbeam 30, with their lower ends connected with trolley
yokes 24, 25 so as to be capable of being swung to and fro, the said
trolley yokes having from the rear the appearance of an inverted U
with the vertical legs 37 bearing at their lower ends the previously
mentioned runners 15a, 15b. It will be understood that the distance
between supports 28, 29 substantially corresponds to the distance
between the rails 2a, 2b. Owing to excess weight acting on the front
section 22 of casting carriage 3 the runners 15, 15a normally roll
along the underside of the flanges of rails 15a, 15b. A tie-rod 38
for attachment to bridge deck 18 hangs from the end sections of
crossbeam 30. The tie-rods are threaded and provided with nuts
39, 40.

As can be seen from figs. 3 and 4 the joints 26, 27, 31, 32
constitute a parallelepiped. As a rule the supports 28, 29 will be
in the initial position, i.e. they will be substantially vertical as
shown in fig. 4. The supports 28, 29 will be subject to tension owing
to the weight of the front section 22. The lateral position of rear
section 23 may if required be fixed with the aid of devices not shown
in fig. 3. When the casting carriage and the formwork elements are
in the position shown in fig. 1 the formwork elements are suspended
at the front of the casting carriage (roughly at 4, 6) and roughly at
the edge of the preceding cast bridge section. When the rear end
section 23 of the casting carriage with crossbeam 30 is displaced
sideways, with the aid of the arrangement shown in fig. 3, from the
position shown in fig. 4 to the position shown in fig. 3, e.g. to the
left as shown in fig. 3, the formwork panels at the front of the
casting carriage will move correspondingly in the opposite direction,
i.e. to the right, since in this case the casting carriage will pivot an
axis located at a point between the upper runners 5 (see fig. 1).
In this way the lateral adjustment can be carried out quickly and
accurately. Having completed the adjustment the tie-rods 38 are
secured to the bridge deck 18 and tensioned so that runners 15a, 15b
are disengaged from the underside of rails 2a, 2b and both the rails
and supports 28, 29 with runner trolleys 24, 25 are relieved.
Fig. 4 corresponds substantially to fig. 3. Under rear section 23 of the casting carriage 3 and more precisely under the longitudinal carriage beam 33 a tensioning device 42 is suspended in a bracket 41, the said tensioning device extending in its normal, unloaded state nearly down to the anchoring plates 44 for rails 2a, 2b but which are also capable of serving as a base for the device 42. The tensioning device is shown with a threaded spindle 43 and can with the aid of the latter be made to abut the concrete deck 18 so that the tensioning device is clamped between the longitudinal girder 33, i.e. the rear section 23 of the casting carriage, and the concrete deck. When it comes to locking the tensioning device 42 the tie-rods 38 are located in position between crossbeam 30 pertaining to this section and bridge deck 18. In order to tension the tie-rods 38 use is made of a tensioning jack with a force indicator as shown at 45. Instead of a mechanical tensioning device 42 use may be made of a hydraulic jack with a cylinder (42) and a ram (43).

The tensioning device 42, 43 is adjusted in height so that the longitudinal girder 33 lies roughly horizontal. Then the tie-rods 38 are tensioned so as to achieve a prestress which is about 10% higher than the effective loading. Application of this stress ensures that the extension of tie-rods 38 is taken up already when adjusting and releasing the casting carriage and not as used to be the case, when the extension came about gradually in the course of time as the casting process proceeded.

The advantage of the design consists in the fact that the downward deflection at the front of casting carriage 3 is considerably reduced. In addition it offers greater safety against total damage. The tie-rods 38 take up all anchoring forces at the rear as the casting proceeds. If the tie-rods were to break, the entire carriage would tip forward about 5 and total damage could not be avoided. By prestressing the tie-rods they are also fixed. If a break were to occur at the prestressing phase, runners 15a supports 28 and crossbeam 30 would take over the load - for which they are dimensioned - damage being thus avoided. By prestressing these rear tie-rods the strength and stability of the carriage during the casting process is increased.
Another advantage consists in the fact that the casting carriage 3 can now absorb some horizontal forces which can be made use of for the erection. It is thus possible to mount a winch V securing it to the bridge deck or track 2 (see fig. 1) which via a guide pulley S on jib 4 can support a load L without the rear section of the carriage (which may not be entirely assembled) tipping over. As a result the casting carriage becomes more independent of the other lifting capacity of the plant.

For clarity's sake it should be noted that the arrangement 42,43 according to fig. 4 is preferably not in the same cross-sectional plane as the arrangement in accordance with fig. 3. The tensioning arrangement in accordance with fig. 4 can be used with casting carriages equipped with the arrangement in accordance with fig. 3 but also with casting carriages having a rigid rear runner suspension, e.g. of the type shown in Patent 138 855.

Figs. 5 and 6 illustrate stepwise casting of bridge sections from a previously cast pier 101 using two casting carriages of the type described above, and the figures show an arrangement as discussed in the above Patent 138 855.

In fig. 5 101 designates the top of a previously cast pier serving as an anchoring section for the bridge spans to be cast, which bear traversing rails 102. On pier 101 are mounted the front sections 122 of two casting carriages 103 each with its own front jib 104. The formwork carriage for the inner formwork and its lower traversing rails are not shown. The two casting carriage sections 122 are linked with the aid of a rigid coupling frame 121, and a part of the rear end sections 123 of the carriages has therefore been removed in order to enable such coupling without the two carriages together taking up more space than is available on top of pier 101. The first bridge sections already cast are designated 101a and 101b in fig. 6. Fig. 6 shows the situation after removal of coupling frame 121. Each carriage 103 has a front support leg 161, which during erection supports the front section 122 of the carriage on the previously cast section (via traversing rails 102).

Figs. 7 and 8 show a coupling frame 150 designed in accordance with the invention. The coupling frame comprises an upper flange...
which consists of two flange sections 151, 152 longitudinally displaceable in relation to one another and capable of being locked with the aid of bolts 155 which pass through holes 156 in the parts 151, 152. The lower flange comprises in corresponding manner two flange sections 153, 154 designed in the same way. At the ends of the flanges are pivot bolts 162 for fasteners 159 serving to anchor threaded tie-rods 157, 158 which link the diagonally opposite corners or fasteners of the flanges with one another. Between the flanges there may be arranged supports as indicated at 160 but these are strictly speaking not necessary since at the erection stage the flanges are anchored in adjacent rigid rear sections 122 of the casting carriages 105.

As shown both the diagonal rods and the flanges are designed with a view to modifying the length. When erecting the carriages for casting curved bridge sections the two coupling frames 150 are so fitted that the frame at the outer side of the bridge is longer as a result of the fact that the carriages are angled in relation to one another. Generally speaking the two coupling frames are in plane 50 as are the side walls of the casting carriage, see fig. 2, i.e. virtually straight above the traversing rails. The frame lengths and as a result the relative position of the casting carriages can be adjusted if required whereas previously it was not possible to adapt the carriages to the curvature of the bridge prior to separation from one another of the carriages, i.e. after casting of the first and possibly also the second section had been completed. Since the coupling frames can be adjusted they can be used for different bridge projects, and the entire equipment is accordingly more flexible and economic in operation. It will be understood that the arrangement in accordance with figs. 7 and 8 can be used in conjunction with casting carriages as described in Patent 138 055, casting carriages equipped with the arrangement in accordance with fig. 3 and casting carriages equipped with the arrangement in accordance with fig. 4.
PATENT CLAIMS

1. An arrangement for casting in sections prestressed concrete bridges in accordance with the cantilever construction method, comprising a cantilever construction carriage (casting carriage) (3; 103) with a front jib (4) and front and rear runners (5; 15) rolling on a rail track with dual traversing rails (2, 2a, 2b) on a previously cast bridge section (1) or bridge pier (101) with two rear runner units having runners (15a, 15b) co-operating with the rails (2a, 2b) on the same side of the rail track and arranged to abut the underside of the rails in question, with the rear runner units supporting a construction (28-30) in which the rear section (23) of the casting carriage is anchored, characterized in that the construction is a parallelepiped-shaped frame (28-30) with pivot joints (25, 26, 31, 32) in all four corners with the joint axes extending in the longitudinal direction of the rail track (2) and in that the frame can be swung out laterally about its two lower joint axes (26, 27).

2. An arrangement in accordance with claim 1, characterized in that the frame has two parallel supports (28, 29) and a horizontal crossbeam (30) at the top the height of which can be adjusted (at 31a) in relation to the supports and in that the crossbeam (30) has suspended tie-rods (38) for securing to the cast bridge deck (18) with a view to releasing the rear traversing runners (15).

3. A method for stabilising the casting carriage when casting in sections prestressed concrete bridges in accordance with the cantilever construction method with an arrangement comprising the casting carriage (3) which has a front jib (4) and front and rear traversing trolleys with runners (5, 15) which co-operate with traversing rails (2) on a previously cast bridge section (1) or bridge pier (101), with each of the rear runners comprising two sets with runners co-operating each with its rail (2a, 2b) which extend parallel to the other rail on the same side of the bridge section and are equipped to abut the underside of the corresponding rail, the rear section (23) of the casting carriage being linked with the said trolleys by means of a construction
characterized in that a tensioning device (42, 43) or jack adjustable in height is fitted between the underside of the casting carriage's rear section (23) and the cast concrete bridge section (1, 18) and in that the rear tie-rods (36) and/or tensioning device are adjusted in such a way that the tie-rods are prestressed about 10% above the calculated maximum effective loading.

4. An arrangement for implementing the process in accordance with claim 3 comprising a casting carriage (3; 103) with a front jib (4) and front and rear runners (5; 15) rolling on a rail track with dual traversing rails (2, 2a, 2b) on a previously cast bridge section (1) or bridge pier (101) with two rear runner units with runners (15a, 15b) which co-operate with the rails (2a, 2b) on the same side of the rail track and are arranged to abut the underside of the corresponding rail and where the rear runner units bear a construction (28-30) in which the rear section (23) of the casting carriage is anchored; characterized in that a tensioning device (42, 43) or jack capable of being regulated is mounted under the rearmost section (23, 33) of the carriage and extends downward to a level close to the lower ends of the runners (15), capable of being extended so as to abut the upper surface of the concrete deck (18).

5. An arrangement for casting in sections prestressed concrete bridges in accordance with the cantilever construction method, with cantilever construction taking place in two opposite directions from a bridge pier (101) with a superimposed anchoring section (pier head), the said arrangement comprising two cantilever construction carriages (guide carriages 103) which can be traversed on rails located on a previously cast section (102) of the bridge and each of them bearing its own formwork, with each of the carriages being capable of subdivision into a front section (122) comprising a jib (104) and a rear section (123), and where the arrangement for casting of the two first bridge sections from the bridge pier comprises a system of bars (121) for detachable coupling of the two front sections (122) of the carriages when these are arranged at a distance from one another in the longitudinal direction (122) and so that they face away from one
another in a symmetrical manner, characterised in that the system of bars comprises two substantially level coupling frames (150) equipped to extend in the operating state between the front sections (122) of the carriages at a relative distance substantially corresponding to the distance between the traversing rails (102) (track gauge) and adjustably to connect the carriage sections (122) with one another inasmuch as each coupling frame (150) has an upper and a lower substantially horizontal flange (151, 152; 153, 154) of adjustable length.

6. An arrangement in accordance with claim 5 characterised in that the flanges are connected with one another by means of diagonal threaded tie-rods (157, 158) of adjustable length.

7. An arrangement in accordance with claim 5 or 6 characterised in that the flange sections can be telescoped into one another.
### INTERNATIONAL SEARCH REPORT

**International Application No:** PCT/NO83/00020

#### I. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or to both National Classification and IPC:

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#### II. FIELDS SEARCHED

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SE, NO, DK, FI classes as above

#### III. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of Document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to Claim No.</th>
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<td>Y</td>
<td>NO, B, 138 855 (HGSVEIS A/S) 14 August 1978</td>
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<td>CH, A5, 590 970 (KURT KOSS) 31 August 1977 &amp; FR, 2 264 133 DE, 2 510 015 GB, 1 505 145 US, 4 087 220 JP, 50 132 732 AT, 365 258</td>
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<td>A</td>
<td>DE, B2, 2 555 311 (DYCKERHOFF &amp; WIDMANN AG) 23 March 1978</td>
<td>6,7</td>
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<td>A</td>
<td>US, A, 3 937 165 (THIVANS) 10 February 1976</td>
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#### IV. CERTIFICATION

Date of the Actual Completion of the International Search:

1983-08-31

Date of Mailing of this International Search Report:

1983-09-09

International Searching Authority:

Swedish Patent Office

Signature of Authorized Officer:

Ingemar Hedlund