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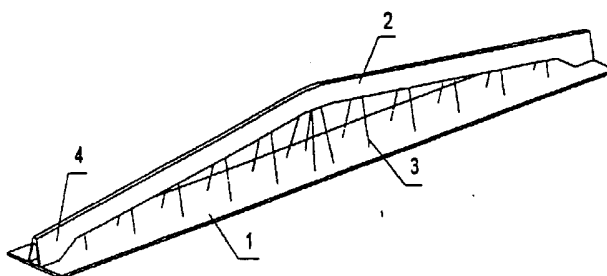
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⑤④ **Virsraksts:** **NETIEŠI IEPRIEKŠ SASPRIEGTA BETONA JUMTA-GRIESTU KONSTRUKCIJA AR PLAKANU SOFITI**

⑤⑦ **Kopsavilkums:** Piedāvātā netieši iepriekš nospriegta betona jumta-griestu konstrukcija ir rūpnieciski ražots celtniecības elements, kas paredzēts industriālu lielu laidumu celtnu būvniecībai. Konstrukcija satur īpaši platu un plānu betona kesona plātni (1) un augšējo betona kopni (2) ar apgriezta V formas šķērsgrīzumu, kas savstarpēji savienoti ar tieviem tērauda cauruļveida balstiem (3), kas tiek izmantoti, lai stabilizētu augšējo kopni (2) pret laterālu lodzīšanos un novērstu elementu (1) un (2) savstarpēju tuvināšanos vai attālināšanos. Kesona plātnes (1) iepriekšēja nospriegšana izsauc augšējās kopnes saspiešanu, kas savukārt pasīvi (netieši) spiež uz konstrukcijas galiem, iedarbojoties ar zināmu ekscentriskumu attiecībā pret šķērsgrīzuma smaguma centru un izraisot galu pagriešanos, kas izliec kesona plātni augšup. Minēto konstrukciju iepriekšējai nospriegšanai piedāvāti divi efektīvi paņēmieni.



IZGUDROJUMA FORMULA

1. Netieši iepriekš saspriegta betona jumta-griestu konstrukcija ar plakanu sofīti kā rūpnieciski ražots celtniecības elements, kas paredzēts industriālu, lielu laidumu celtnu būvniecībai, **raksturīga ar to**, ka tā satur sevīši platu un plānu betona plātni (1) un plānsienu apgrieztā "V" formas augšējo kopni (2), kas savstarpēji savienotas ar telpiski sadalītām tievām tērauda caurulēm-stieņiem (3), līdz ar ko sofītes plātne tiek iepriekš centrāli nospriegta.

2. Paņēmiens jumta-griestu konstrukcijas pēc 1. punkta iepriekšējai nospriegošanai, kas **raksturīgs ar to**, ka sofītes plātnes (1) izlieces regulēšana tiek panākta ar netiešu iepriekšēju nospriegošanu, pie tam sofītes plātnes (1) iepriekšējā nospriegšana izsauc augšējās kopnes (2) abu tās galu (4) pasīvu reakciju, tādā veidā izliecot sofītes plātni (1) augšup caur tās galu griešanos.

3. Paņēmiens jumta-griestu konstrukcijas pēc 1. vai 2. punkta stabilizācijai, kas **raksturīgs ar to**, ka augšējās kopnes (2) laterālā ļodzišanās tiek novērsta ar slīpu, telpiski sadalītu tērauda cauruļu-stieņu (3) palīdzību, pie tam stieņu (3) slīpums ir tāds pats kā augšējās kopnes (2) apgrieztā "V" formas šķērsriezuma slīpums, līdz ar ko plānās sienas saīsina stieņu (3) efektīvo garumu.

INDIRECTLY PRESTRESSED, CONCRETE, ROOF-CEILING CONSTRUCTION
WITH FLAT SOFFIT
TECHNICAL FIELD

The present invention relates to the construction of the roofs of industrial building or other similar buildings of prestressed, reinforced concrete and in particular some steel parts become integral parts of the structure.

The field of the invention is described in IPC Classification E 04 B 1/00 that generally relates to constructions or building elements or more particularly group E 04 C 3/00 or 3/294.

BACKGROUND ART

The present invention deals with a specific flat-soffit roof-ceiling construction of an original concept and shape. Although some similarities to trusses or tied arches are obvious the present construction substantially differs from them in the manner how it works bearing the load. First of all these constructions are intended to solve both the finished ceiling with flat soffit and the roof construction simultaneously. It is intended also to activate the wide soffit plate to contribute as a bearing element instead of being passively hanged on a truss or an arch.

All the other practical intention of the present construction include advantages disclosed by HR-P20000906A that these constructions have when compared to customary roofs and ceilings.

The commonly used prestressing techniques that introduce the compressive force into a structural member of a selected geometry cross-section with tendons positioned below the concrete center of gravity would not achieve proper effects when applied on these constructions because of the absence of such an eccentricity. An achievement of upward deflection of the concrete plate would require lowering of the prestressing tendons below the center of gravity of the overall construction what is unacceptable because it ruins the idea of the flat soffit.

The problem is hence focused to find out an adequate prestressing method which may efficiently reduce the large amount of deflections and eliminate or control cracks in concrete which may occur if tension in the soffit plate is allowed. The present invention provides one more efficient method for prestressing constructions with flat soffit. The present construction also solves the problem of stability of the upper girder against lateral buckling.

The HR-P20000906A application, under the name "Doubly prestressed, composite, roof-ceiling construction with flat soffit for large span buildings" is the most similar known construction. The just mentioned application proposes one efficient method for prestressing of such inverse constructions with low positioned center of the gravity of the cross section and discloses next solution: The wide plate is prestressed once, centrically, before the construction was completed, introducing compression into the soffit plate wherewith the cracks problem in concrete is solved. The construction is then completed and is prestressed once again by means of the steel wedge driven into a special detail positioned at midspan of the upper girder to achieve an upward deflection of the plate rotating its ends. The present invention relate to a very similar but substantially changed construction then the one disclosed in HR-P20000906A is, wherewith one more additional prestressing is provided. In comparison to abovementioned innovation the present construction introduces the stiff upper girder with such design of the cross section shape which is simultaneously rigid and thin-walled, intended to reduce the effective length of the interconnecting pipe-rods compared to considerably stiff steel tubes. Replacement of stiff steel tubes by slender pipe-rods disables transmitting of bending moments from the upper girder to the plate and vice versa. The interconnecting pipe-rods are spaced uniformly over the soffit plate to improve the interconnection and uniformity of the plate self weight distribution on the upper girder. Hence, the connections between rods and the plate became less rigid so the prestressing force introduced in the soffit plate causes no considerable bending of rods what enables larger amount of prestressing to be applied without bending the plate. However, if the centric prestressing of the soffit plate is performed in a small amount it doesn't significantly influence the deflection of the plate. If, on contrary, the large amount of the prestressing force is applied the high compression level considerable influences to the soffit plate deflections. It is one important object of the present invention to

provide one more efficient manner of prestressing constructions with the flat soffit and doesn't dispute the doubly prestressing as a very efficient method.

The present construction solves the problem of stabilizing the upper girder against lateral buckling more efficiently than the abovementioned application. The space-distributed connecting rods, distributed uniformly over the upper plane of the ceiling plate, on certain, determined distances, divide the overall effective length of the upper girder into a plurality of smaller lengths whereby the cross section of the upper girder is of inverse "V" shape what shortens the effective lengths of interconnecting rods and changes their end conditions reducing in that way additionally their effective lengths of buckling.

DISCLOSURE OF THE INVENTION

Description of the drawings:

Fig. 1. presents an isometric view of the construction showing its constitutive parts

Fig. 2. is the cross section of the construction showing its constitutive parts

Fig. 3. illustrates on the simplified model the principle of prestressing (CASE 1)

Fig. 4. illustrates the reduction of the effective length of the interconnecting rod (3) and the manner how the upper girder (2) is stabilized against lateral buckling.

The prestressed roof-ceiling construction is one-way bearing prefabricated element with space-distributed connecting rods for constructing industrial large-span buildings. The construction comprises the distinctly wide and thin concrete plate (1) and the upper concrete girder (2) of an inverse "V"- shaped cross section, as it is shown in Fig. 2, interconnected by slender steel pipe-rods (3). The thin soffit plate is chosen to be distinctly wide to cover a great portion of the site plan of the building at once and to provide the flat soffit in interior.

It is obvious from Fig. 2 and Fig. 4 that the both thin walls of the cross section of the upper girder (2) are extended close towards the plate (1) shortening in that way the buckling length of interconnecting pipe-rods (3). The interconnecting pipe-rods (3) anchored at one side to the upper girder (2) and having the same inclination as the sloped thin walls of its cross-section are on the opposite side anchored into the wide soffit plate (1) stabilizing in that way the upper girder (2) against lateral buckling.

The slender, space distributed steel pipe-rods (3) are also utilized to keep the distance between the soffit plate (1) and the upper girder (2) preventing transition of

bending moments in both directions and reducing the thermal conductivity between the upper girder (2) and the soffit plate (1).

To illustrate how the construction mechanism works the following consideration is made:

- 5 If the construction was not prestressed, both the soffit plate (1) and the upper girder (2) would tend to bent downwards whereby the soffit plate (1), because of its higher self-weight to vertical stiffness ratio, would bent in faster rate than the upper girder (2) what would activate interconnecting rods (3) to resist their movement apart.

If the construction was prestressed and not loaded, the interconnecting elements (3) would be compressed, resisting the soffit plate (1) and the upper girder (2) to approach to each other.

- 15 If the construction is prestressed and only upper girder was loaded, compression in interconnecting rods (3) would increase because in that case the upper girder (2), due to applied load, bents downwards while, at the same time, the soffit plate bents slightly upward so the interconnecting elements (3) resist their additional approach to each other.

- 20 If the construction is prestressed and only soffit plate (1) is loaded compression in interconnecting roads decreases because in that case the soffit plate (1) bents downwards in a faster rate than upper girder (2) and consequently the distance between them tends to increase.

- 25 In any case, the upper girder (2) acts as a bearing element that bears almost the entire bending moment whereby elements (3) are constructed so that they are capable to transmit only a small amount of bending moments to the soffit plate (1) which is very easy to deflect even under bending moments of very low amounts.

- 30 The slender interconnecting rods as a part of the construction play generally a role of a kind of "passive" connectors which are not stressed significantly at any case of loading although they interconnect the two massive concrete parts of the construction, (1) and (2) keeping the distance between them as they tend to get closer or apart under different load cases. It is also possible to find such a combination of load and prestressing at which inner forces in some interconnecting roads are very small or practically equal to zero what emphasizes the difference

between the present constructions and before compared trusses or tied arch. This will be clearer in following, when prestressing will be considered.

There are the two available methods of prestressing such constructions whereby the choice depends on whether we want to get more or less compressed both the soffit plate (1) and the upper girder (2) or some moderate tension will be allowed in the soffit plate (1) concrete. If the first option is chosen, it leads to the double prestressing method case disclosed in HR-P20000906A whereby the upper girder (2) should be made of two parts with disconnection at the midspan. If the other option is chosen the upper girder (2) is made in one piece only.

In order to better explain the difference, in following, the case with the girder of one piece is noted as CASE 1 and the case with two part upper girder is denoted as CASE 2. (The CASE 2 is not the matter of the present invention and is only mentioned here as a possible variant).

CASE 1

This case is illustrated in Fig. 1. As it is obvious from the picture, the upper girder (2) is made of one part. Its ends (4) may be considered as short consoles (no matter whether we consider them to be an integral part of the soffit plate or of the upper girder) that are rigidly connected to the soffit plate (1) and are capable to transmit the bending moments from the upper girder (2). The upper girder (2) is first cast in its own mould and then placed into the soffit plate (1) mould. The prestressing wires are tensioned and anchored at the mould of the soffit plate and the plate (1) is poured. After concrete hardening, the upper girder (2) and the soffit plate (1) become connected by a special detail near supports, the prestressing tendons are released from the mould and the centric prestressing force is introduced into the soffit plate (1) concrete. The prestressing force shortens the soffit plate (1) causing thereby a mutual displacement of both its ends (4) of the upper girder (2) towards each other. Both ends of the upper girder (2) are rigidly connected to the soffit plate (1) over the long connecting lines so that the bending moment can be transmitted at such places into the soffit plate (1). Because of their mutual displacement-deformation both the upper girder (2) and the soffit plate (1) contribute some part of introduced prestressing force. Considering the support ends (4) of the upper girder (2) as short consoles that are integral part of the soffit plate

(1) it is obvious that the shortening of the soffit plate (1) pushes ends of the upper girder (2) towards each-other whereby the upper girder (2) bents upwards resisting in that way their common shortening. As a reaction, ends of the upper girder (2) with major contribution part of the prestressing force push consoles (4), at ends of the soffit plate (1), rotating their ends and producing negative bending moments in the soffit plate (1) bending it upwards. The interconnecting rods (3) between the soffit plate (1) and the upper girder (2) are thereby exposed to a slight compression as they resist their approach each to other. The soffit plate is prestressed directly what prevents cracks to occur in the concrete caused by high level tension but the main effect is the upward deflection of the, thin and slender but weighty, soffit plate what is achieved due to indirect passive reaction of the upper girder (2) that act to both its console-like supports. Hence, the effect of pushing ends is achieved in the same manner as it was achieved in abovementioned HR-P20000906A. The long and slender soffit plate (1) bents in faster rate than the upper girder (2) so that restricted differences between their deflections cause compression in interconnecting rods (3).

CASE 2

According to what was described in application HR-P20000906A, the upper girder (2) was made of two parts and prestressed by double prestressing method, performed in two steps, whereby in first step the soffit plate (1) is prestressed centrically, before the two separated parts of the upper girder being connected at the midspan, so that the first prestressing does not induce any stresses in disconnected halves of the upper girder. In the other step at the interrupting point of the upper girder at the midspan the steel wedge driven into a special detail causes effect of both-side pushing apart of supports deflecting thereby the soffit plate upwards due to rotation of its ends.

In both compared methods the negative bending moment is achieved through rotating ends of the construction to accomplish the upward deflection. But there is a significant difference between the CASE 1 and the CASE 2 that allows us to prestress the construction with smaller or larger force spending thereby more or less prestressing steel.

In practice, in some cases, each of the two considered methods may have some advantages or disadvantages or can be restricted by different reasons.

The CASE 1 generally requires application of a larger amount of the prestressing force than the CASE 2, the force that is capable to shorten the soffit plate (1) and to bend upwards the upper girder (2) simultaneously. The soffit plate is then stressed at the high compression level so in that case an increased expense occur that has to be compared to the expense of the case when both the wedge and fewer cables are applied. If for some reason the soffit plate (1) is not necessary to be prestressed to a large amount it is reasonable to apply some moderate force spending thereby less cables. In that case the upward bending of the soffit plate (1) has to be done anyway so the CASE 2 would be more economic.

Of course, there is lots of possible combinations that may appear varying height or different ratios of the upper girder dimensions, shapes, thickness or width of the soffit plate or applying different density materials (for instance lightweight concrete), varying the prestressing force amounts in both elements (1) and (2) whereby some optimum always exists.

As a special case it is also possible to utilize the combination of both abovementioned cases whereby the wedge for additional prestressing is positioned into connecting detail before the prestressing of the soffit plate is performed so that the wedge is used after the first prestressing for fine leveling the upward deflection of the soffit plate.

DESCRIPTION OF THE PREFERED EMBODIMENT

The upper girder (2) is first cast in its own mould and then placed into the soffit plate (1) mould. The prestressing wires are tensioned on the mould of the soffit plate (1) and the plate is poured. After concrete of the soffit plate (1) is hardened both the elements are connected the upper girder (2) and the soffit plate (1) by special details near the supports. As the soffit plate mould being released the centric prestressing force is introduced into the soffit plate (1) concrete. Both the applied amounts of compression and tension must be previously estimated numerically and decided by an engineer.

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CLAIMS

10 1. The indirectly prestressed, concrete, roof-ceiling construction with flat soffit, as a prefabricated building element for constructing industrial large-span buildings, **characterized** in that comprises the distinct wide and thin concrete plate (1) the thin walled inverse "V" shaped upper girder (2) both interconnected by space distributed slender steel pipe-rods (3) whereby the soffit plate is prestressed
15 centrally.

 2. The principle of prestressing the roof-ceiling construction according to claim 1, **characterized** in that the soffit plate (1) deflection control is performed by the indirect prestressing whereby prestressing of the soffit plate (1) causes the
20 passive reaction of the upper girder (2) towards both its ends (4) bending in that way the soffit plate (1) upwards through rotating its ends.

 3. The stabilizing principle of the roof-ceiling construction according to claim 1 and 2, **characterized** in that the upper beam (2) is prevented against lateral
25 buckling by means of inclined space-distributed, steel pipe-rods (3) with rods (3) following the slope of the inverse "V" cross section of the upper girder (2) whereby the thin walls shorten the effective length of rods (3).

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ABSTRACT

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The indirectly prestressed concrete roof-ceiling construction is prefabricated element for constructing industrial large-span buildings. The construction comprises distinctly wide and thin concrete soffit plate (1) and the upper concrete girder (2), of the inverse "V"-shaped cross section, interconnected by slender steel pipe-rods (3) that are used to stabilize the upper girder (2) against lateral buckling and to prevent parts (1) and (2) to get closer or apart each to another. Prestressing of the soffit plate (1) causes compression in the upper girder (2) which passively (indirectly) pushes the ends of the construction, acting on some eccentricity over the center of gravity of the cross section, causing rotation of its ends bending in that way the soffit plate upwards. There are two efficient methods of prestressing these constructions.

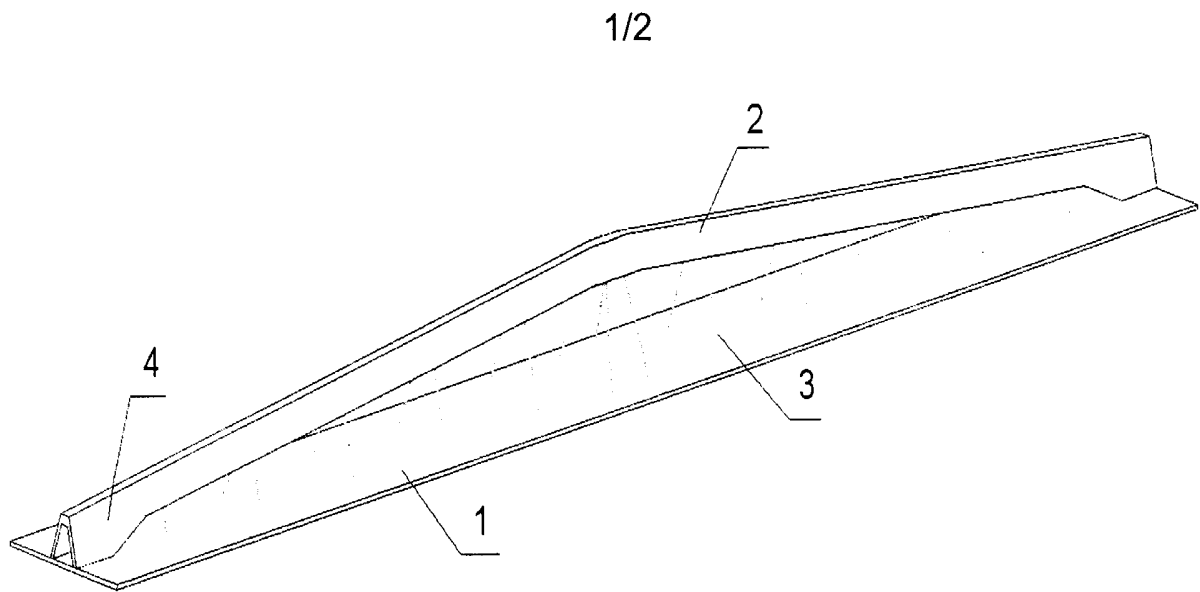


Fig. 1

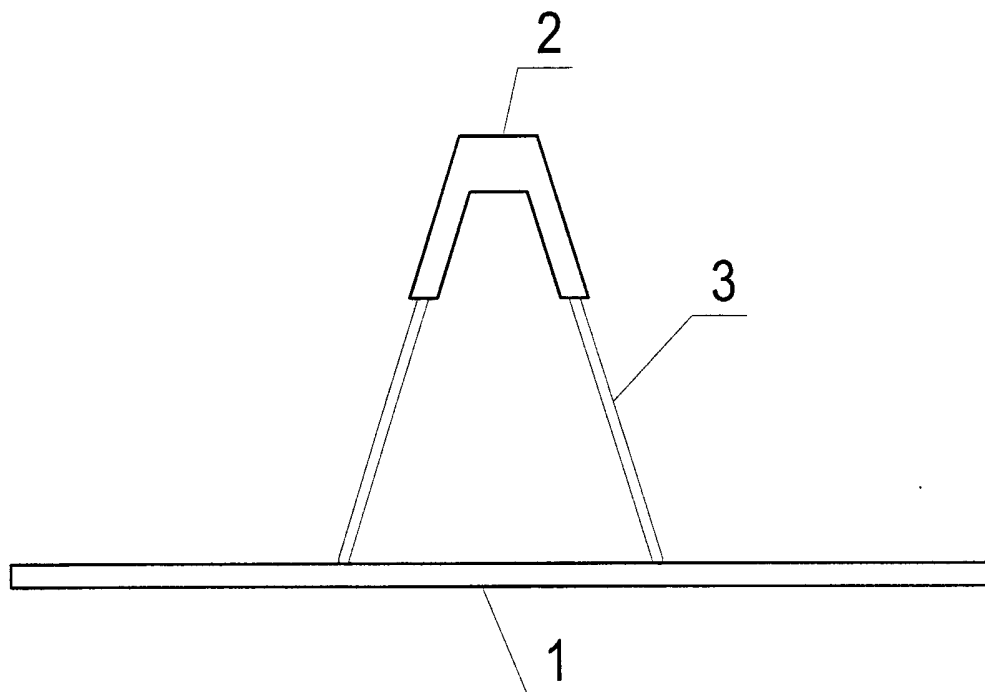


Fig. 2

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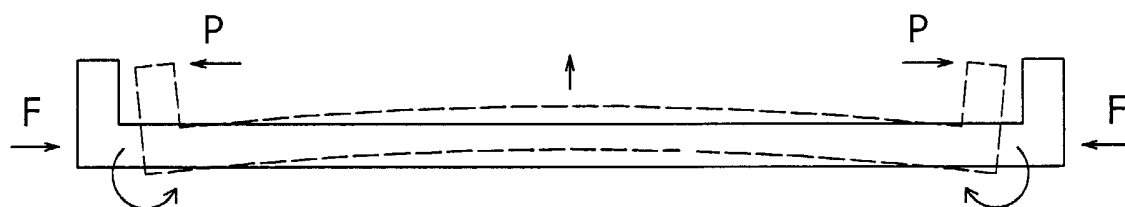


Fig. 3

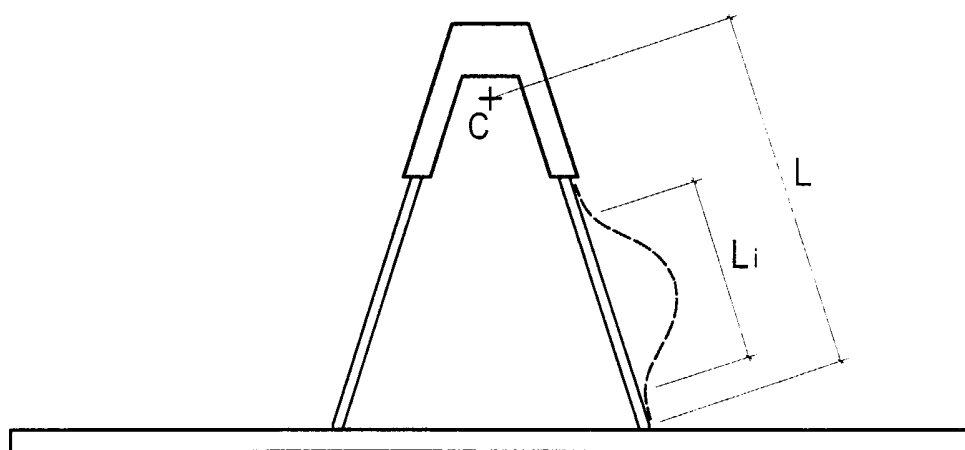


Fig. 4