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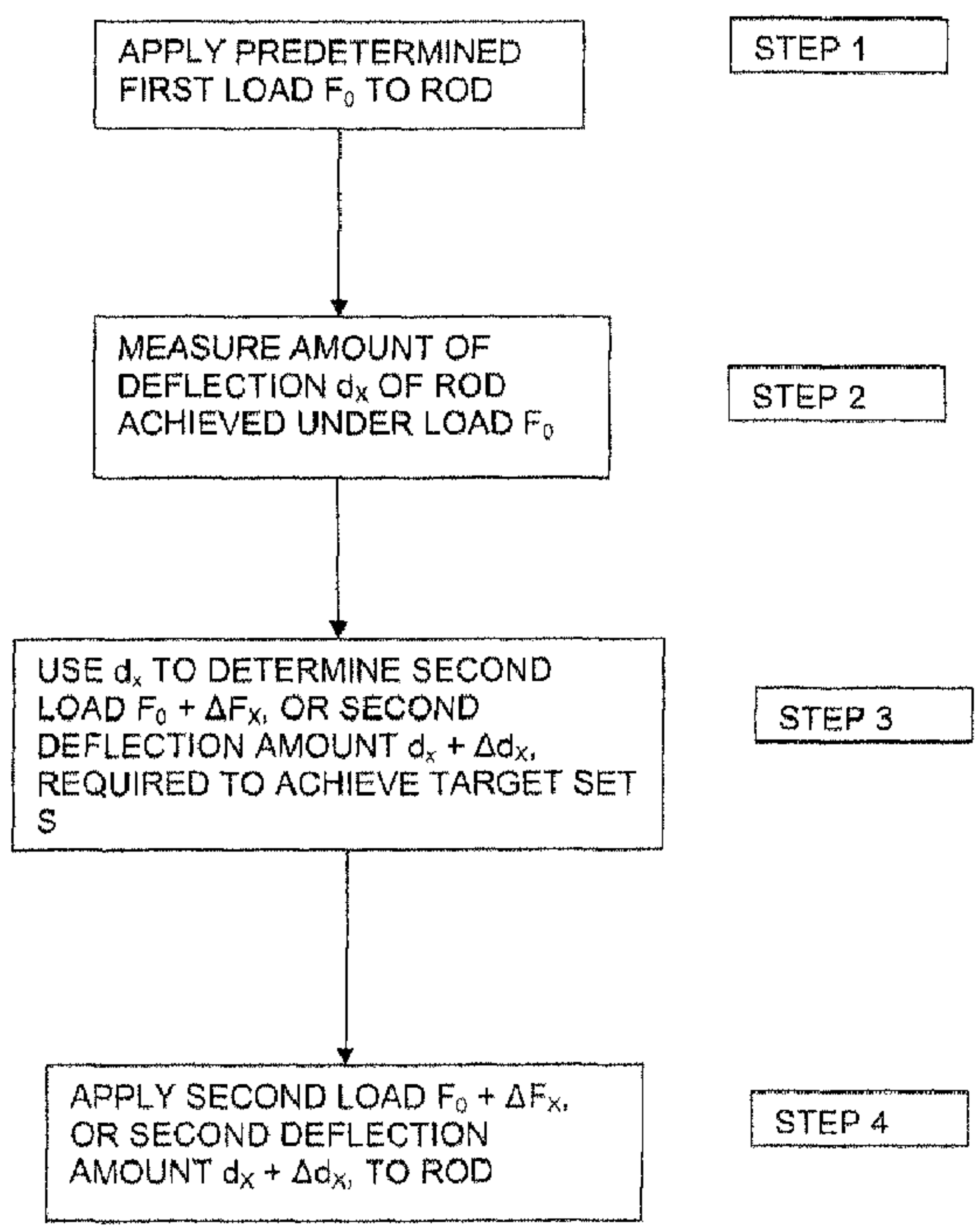
(54) **Titre : PROCEDES DE FABRICATION D'UN SERRE-RAIL ELASTIQUE**
(54) **Title: METHODS OF MANUFACTURING A RESILIENT RAIL CLIP**



(57) **Abrégé/Abstract:**
A method of manufacturing a resilient rail clip comprises bending a rod, made of metal having a hardness value falling within a known hardness value range, into a predetermined shape and then subjecting the bent rod to a cold setting process in order to

(57) **Abrégé(suite)/Abstract(continued):**
induce in the bent rod a predetermined amount of permanent set (S). One cold setting process comprises applying a first load (F_0) to part of the bent rod so as to cause a first amount of deflection of that part of the bent rod, which first load (F_0) is a predetermined load having a value equal to or greater than that required to reach the yield point of metal having the highest hardness value in the said hardness value range, measuring the first amount of deflection (d_x) of the said part of the bent rod achieved by applying the predetermined first load (F_0), determining, on the basis of the measured deflection amount (d_x), either (i) a second load ($F_0 + \Delta F_X$), which, when applied to the said part of the bent rod, will cause the bent rod to acquire the predetermined amount of permanent set (S), or (ii) a second amount of deflection ($d_x + \Delta d_x$) of the said part of the bent rod required in order to bring about in the bent rod the predetermined amount of permanent set (S), and applying the second load ($F_0 + \Delta F_X$) to the said part of the bent rod or deflecting the said part of the bent rod by the determined second amount of deflection ($d_x + \Delta d_x$). An alternative cold setting process comprises deflecting part of the bent rod by a predetermined first amount (d_0) by applying a first load (F_x) having a value equal to or greater than that required to reach the yield point of metal having the highest hardness value in the said hardness value range, measuring the amount of the first load (F_x) required to achieve the predetermined first amount of deflection (d_0), determining, on the basis of the measured load, either (i) a second deflection amount ($d_0 + \Delta d_x$) required in order to bring about in the bent rod the predetermined amount of permanent set (S), or (ii) a second load ($F_x + \Delta F_X$), which, when applied to the said part of the bent rod, will cause the bent rod to acquire the predetermined amount of permanent set (S), and deflecting the said part of the bent rod by the determined second deflection amount ($d_0 + \Delta d_x$) or applying the determined second load ($F_x + \Delta F_X$) to the said part of the bent rod.

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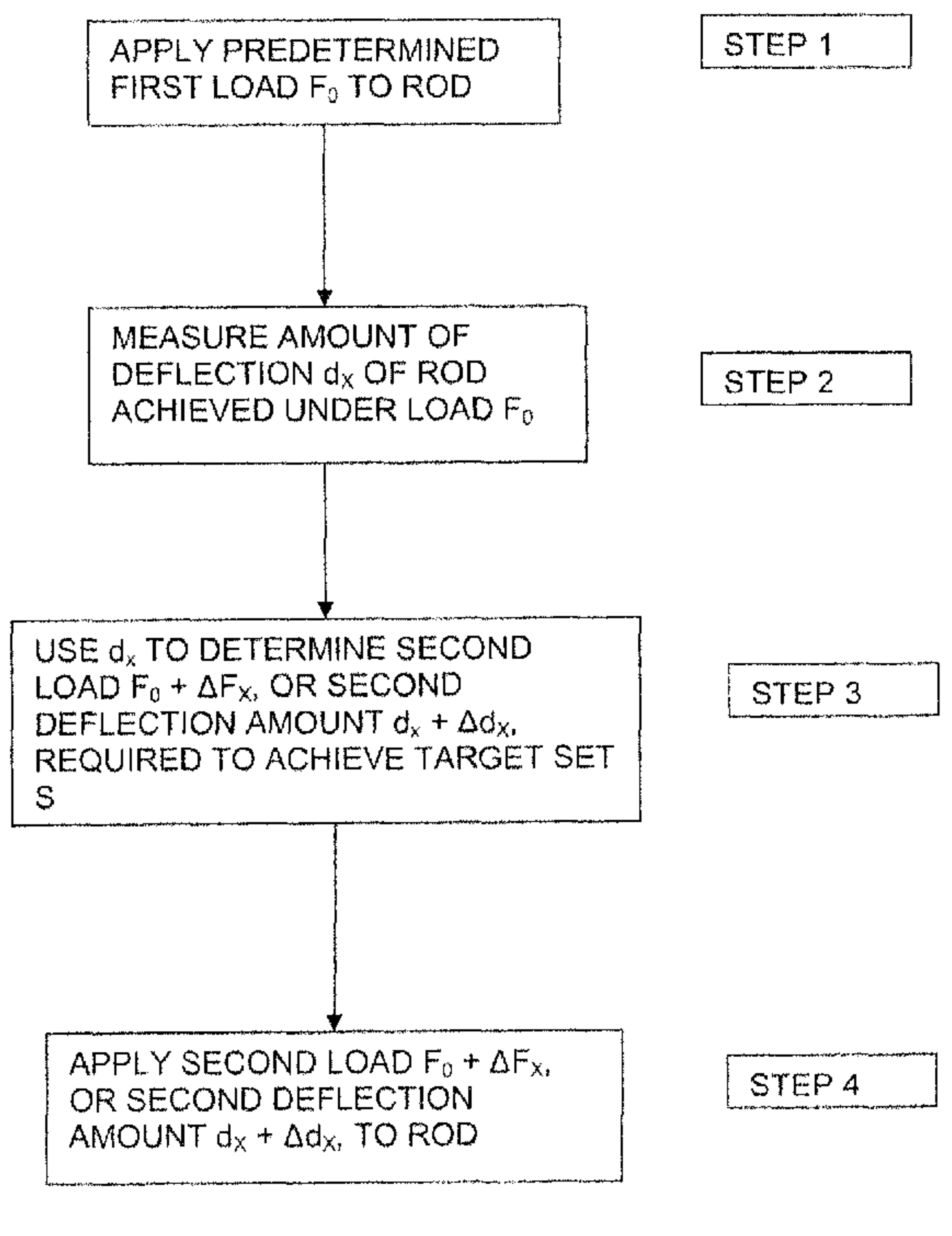
(54) Title: METHODS OF MANUFACTURING A RESILIENT RAIL CLIP

FIG. 2A



(57) Abstract: A method of manufacturing a resilient rail clip comprises bending a rod, made of metal having a hardness value falling within a known hardness value range, into a predetermined shape and then subjecting the bent rod to a cold setting process in order to induce in the bent rod a predetermined amount of permanent set (S). One cold setting process comprises applying a first load (F_0) to part of the bent rod so as to cause a first amount of deflection of that part of the bent rod, which first load (F_0) is a predetermined load having a value equal to or greater than that required to reach the yield point of metal having the highest hardness value in the said hardness value range, measuring the first amount of deflection (d_x) of the said part of the bent rod achieved by applying the predetermined first load (F_0), determining, on the basis of the measured deflection amount (d_x), either (i) a second load ($F_0 + \Delta F_X$), which, when applied to the said part of the bent rod, will cause the bent rod to acquire the predetermined amount of permanent set (S), or (ii) a second amount of deflection ($d_x + \Delta d_x$) of the said part of the bent rod required in order to bring about in the bent rod the predetermined amount of permanent set (S), and applying the second load ($F_0 + \Delta F_X$) to the said part of the bent rod or deflecting the said part of the bent rod by the determined second amount of deflection ($d_x + \Delta d_x$). An alternative cold setting process comprises deflecting part of the bent rod by a predetermined first amount (d_0) by applying a first load (F_x) having a value equal to or greater than that required to reach the yield point of metal having the highest hardness value in the said hardness value range, measuring the amount of the first load (F_x) required to achieve the predetermined first amount of deflection (d_0), determining, on the basis of the measured load, either (i) a second deflection amount ($d_0 + \Delta d_x$) required in order to bring

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Published:

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about in the bent rod the predetermined amount of permanent set (S), or (ii) a second load ($F_x + \Delta F_X$), which, when applied to the said part of the bent rod, will cause the bent rod to acquire the predetermined amount of permanent set (S), and deflecting the said part of the bent rod by the determined second deflection amount ($d_0 + \Delta d_x$) or applying the determined second load ($F_x + \Delta F_X$) to the said part of the bent rod.

METHODS OF MANUFACTURING A RESILIENT RAIL CLIP

The present invention relates to a method of manufacturing a resilient rail clip.

Various forms of resilient rail clips are known, for example as shown and described in GB1510224A and EP0619852B. A known method of manufacturing a resilient rail clip comprises bending a metal rod (usually made of steel) into a predetermined shape and then subjecting the bent rod to a cold setting process to achieve the final form of the clip.

Such rods have a common load-deflection characteristic with a common slope (clip stiffness) up to the elastic limit of the metal from which the bent rod is formed. Cold setting is intended to take the bent rod beyond that elastic limit, thereby inducing a permanent deflection (set) into the resulting clip, such that if it is then unloaded and taken up the load-deflection characteristic a second time, the load-deflection characteristic will be linear up to a much higher load, that is up to the load at which the new characteristic intercepts that for the original rod. One of the key problems in cold-setting is that the metal rods from which the clips are made themselves vary in hardness, typically between 44 and 48 Rockwell hardness. Since the elastic limit of rods made from softer metal is lower than that of rods made from harder metal, if all rods are taken to a fixed deflection, they will all unload down slightly different parallel lines and take on different and varying amounts of set. The softer rods will take on more set, the harder ones less set. This is illustrated in Figure 1A of the accompanying drawings, which shows the load-deflection characteristics of a soft clip and a hard clip and the difference in set Δ_S between them after cold setting. This difference in set results in clips that have different geometries (above and beyond the variation already inherent in manufacture), where the geometry depends on the hardness. Thus, although these cold-set clips will all have the same stiffness, regardless of hardness, driving these clips into a fixed assembly which deflects them all by the same amount will result in the clips generating slightly different loads at the portion (the “toe”) of the clip which bears on the railway rail. It is impractical to measure the hardness of each clip to be cold set directly before the start of the cold-setting process. Moreover, as shown in Figures 1B and 1C of the accompanying drawings, the problem cannot be overcome simply by changing the fixed amount of deflection applied during cold-setting (Fig. 1B), or by applying a fixed force instead of a fixed deflection (Fig. 1C), as this does not address the underlying problem. In the past, in an attempt to address this problem, the rod is repeatedly cold-set a number of times, but this is not fully effective.

According to an embodiment of a first aspect of the present invention there is provided a method of manufacturing a resilient rail clip comprising bending a rod, made of metal having a hardness value falling within a known hardness value range, into a predetermined shape and then subjecting the bent rod to a cold setting process in order to induce in the bent rod a predetermined amount of permanent set, wherein the cold setting process comprises: applying a first load to part of the bent rod so as to cause a first amount of deflection of that part of the bent rod, which first load is a predetermined load having a value equal to or greater than that required to reach the yield point of metal having the highest hardness value in the said hardness value range; measuring the first amount of deflection of the said part of the bent rod achieved by applying the predetermined first load; determining, on the basis of the measured deflection amount, either (i) a second load, which, when applied to the said part of the bent rod, will cause the bent rod to acquire the predetermined amount of permanent set, or (ii) a second amount of deflection of the said part of the bent rod required in order to bring about in the bent rod the predetermined amount of permanent set; and applying the determined second load to the said part of the bent rod or deflecting the said part of the bent rod by the determined second amount of deflection.

According to an embodiment of a second aspect of the present invention there is provided a method of manufacturing a resilient rail clip comprising bending a rod, made of metal having a hardness value falling within a known hardness value range, into a predetermined shape and then subjecting the bent rod to a cold setting process in order to induce in the bent rod a predetermined amount of permanent set, wherein the cold setting process comprises: deflecting part of the bent rod by a predetermined first amount by applying a first load having a value equal to or greater than that required to reach the yield point of metal having the highest hardness value in the said hardness value range; measuring the amount of the first load required to achieve the predetermined first amount of deflection; determining, on the basis of the measured first load, either (i) a second deflection amount required in order to bring about in the bent rod the predetermined amount of permanent set, or (ii) a second load, which, when applied to the said part of the bent rod, will cause the bent rod to acquire the predetermined amount of permanent set; and deflecting the said part of the bent rod by the determined second deflection amount or applying the determined second load to the said part of the bent rod.

Reference will now be made, by way of example, to the accompanying drawings, in which:

Figures 1A to 1C (described above) show the load-deflection characteristics of two rail clips of different respective hardness which have been cold set according to a previously-proposed method;

Figures 2A and 2B show respective flow diagrams depicting two alternative cold setting processes used in embodiments of the present invention;

Figure 3A shows a rail clip undergoing part of a cold setting process used in an embodiment of the present invention and Figure 3B shows the same rail clip after cold setting with a set caused by that cold setting process; and

Figures 4A and 4B each show the load-deflection characteristics of two rail clips of different respective hardness, the thicker lines showing the characteristics after the clips have been cold set according to a method embodying the present invention and the thinner lines showing the characteristics of the clips before cold setting, in which Figures 4A and 4B correspond respectively to methods embodying the first aspect and the second aspect of the present invention.

According to an embodiment of the present invention a rod of metal, having a hardness value falling within a known hardness value range, is bent into a predetermined clip shape (see Figure 3A) and then subjected to a two-stage cold setting process, as shown in the flow diagrams of Figure 2A or 2B. Firstly, the rod is loaded to a level equal to or beyond the yield point of a rod having a hardness value at the top of the hardness value range (STEP 1). Then, depending on the method being used, either a measurement is taken of how much deflection d_X has resulted in STEP 1 from a fixed applied force F_0 (STEP 2, Figure 2A), or how much force F_X has been required in STEP 1 to reach a fixed deflection d_0 (STEP 2, Figure 2B). In the method of Figure 2A, which embodies the first aspect of the present invention, the measured deflection d_X is then used to determine the amount of force $F_0 + \Delta F_X$ or second deflection amount $d_X + \Delta d_X$ (STEP 3, Figure 2A) required in order to induce in the bent rod a predetermined amount of permanent set S in a second stage of the process, during which the larger force or deflection is applied to the rod. Similarly, in the method of Figure 2B, which embodies the second aspect of the present invention, the measured force F_X is then used to determine the deflection $d_0 + \Delta d_X$ or second load $F_X + \Delta F_X$ (STEP 3, Figure 2B) required in order to induce in the bent rod a predetermined amount of permanent set S in a second stage of the process, during which the larger deflection or force is applied to the rod. In each case the measured values are used by equipment (and/or by a person) to find the additional force/deflection required, for example by reference to a predetermined look-up table or by calculation. In the second processing stage (STEP 4), the rod is subjected to the force or deflection determined in STEP 3 of the preceding stage, the amount of which will vary depending on the hardness of the rod, such that the resulting clip (see Figure 3B) is always set to a point that lies along a line that is parallel to the initial load-deflection characteristic of the original rod, as shown in Figures 4A and 4B. In other words, as shown in Figures 4A and 4B, each clip when unloaded will always fall back along an extension of this line, and thus all clips made using this method will have the same amount of set, and therefore the same finished geometry, as each other, regardless of the hardness of the rod. Thus, employing a method embodying the present invention allows the geometry of the clip after the cold-setting process to be closely defined, and in particular it may be more precisely defined than the geometry of the clip before the cold-setting process.

Figure 4A shows the load-deflection characteristics for clips of different respective hardness, before (thinner lines) and after (thicker lines) cold setting by a method embodying the first aspect of the present invention, in which a measurement is taken of how much deflection, d_H (hard clip) or d_S (soft clip), has resulted from application to the clip of a fixed applied force F_0, and the measured deflection for that clip (d_H/d_S) is then used to determine the amount of force, $F_0 + \Delta F_H$ (hard clip) or $F_0 + \Delta F_S$ (soft clip), or the amount of deflection, $d_H + \Delta d_H$ (hard clip) or $d_S + \Delta d_S$ (soft clip), required in order to achieve a predetermined amount of permanent set S. All clips cold set in this manner, throughout the whole of the hardness range, will have the same set S. Similarly, Figure 4B shows the load-deflection characteristics for clips of different respective hardness, before (thinner lines) and after (thicker lines) cold setting by a method embodying the second aspect of the present invention, in which a measurement is taken of how much force, F_H (hard clip) or F_S (soft clip), is required in order to achieve a fixed deflection d_0 of the clip, and the measured force for that clip (F_H/F_S) is then used to determine the amount of deflection, $d_0 + \Delta d_H$ (hard clip) or $d_0 + \Delta d_S$ (soft clip), or the amount of force, $F_H + \Delta F_H$ (hard clip) or $F_S + \Delta F_S$ (soft clip), required in order to achieve a predetermined amount of permanent set S. All clips cold set in this manner, throughout the whole of the hardness range, will have the same set S.

These methods are particularly advantageous when using hydraulic equipment of the type having force and deflection control, as this allows the determination to be made effectively instantaneously so that there is scarcely a pause in the cold-setting process.

Claims

1. A method of manufacturing a resilient rail clip comprising bending a rod, made of metal having a hardness value falling within a known hardness value range, into a predetermined shape and then subjecting the bent rod to a cold setting process in order to induce in the bent rod a predetermined amount of permanent set, wherein the cold setting process comprises:

applying a first load to part of the bent rod so as to cause a first amount of deflection of that part of the bent rod, which first load is a predetermined load having a value equal to or greater than that required to reach the yield point of metal having the highest hardness value in the said hardness value range;

measuring the first amount of deflection of the said part of the bent rod achieved by applying the predetermined first load;

determining, on the basis of the measured deflection amount, either (i) a second load, which, when applied to the said part of the bent rod, will cause the bent rod to acquire the predetermined amount of permanent set, or (ii) a second amount of deflection of the said part of the bent rod required in order to bring about in the bent rod the predetermined amount of permanent set; and

applying the determined second load to the said part of the bent rod or deflecting the said part of the bent rod by the determined second amount of deflection.

2. A method of manufacturing a resilient rail clip comprising bending a rod, made of metal having a hardness value falling within a known hardness value range, into a predetermined shape and then subjecting the bent rod to a cold setting process in order to induce in the bent rod a predetermined amount of permanent set, wherein the cold setting process comprises:

deflecting part of the bent rod by a predetermined first amount by applying a first load having a value equal to or greater than that required to reach the yield point of metal having the highest hardness value in the said hardness value range;

measuring the amount of the first load required to achieve the predetermined first amount of deflection;

determining, on the basis of the measured first load, either (i) a second deflection amount required in order to bring about in the bent rod the predetermined amount of permanent set, or (ii) a second load, which, when applied to the said part of the bent rod, will cause the bent rod to acquire the predetermined amount of permanent set; and deflecting the said part of the bent rod by the determined second deflection amount or applying the determined second load to the said part of the bent rod.

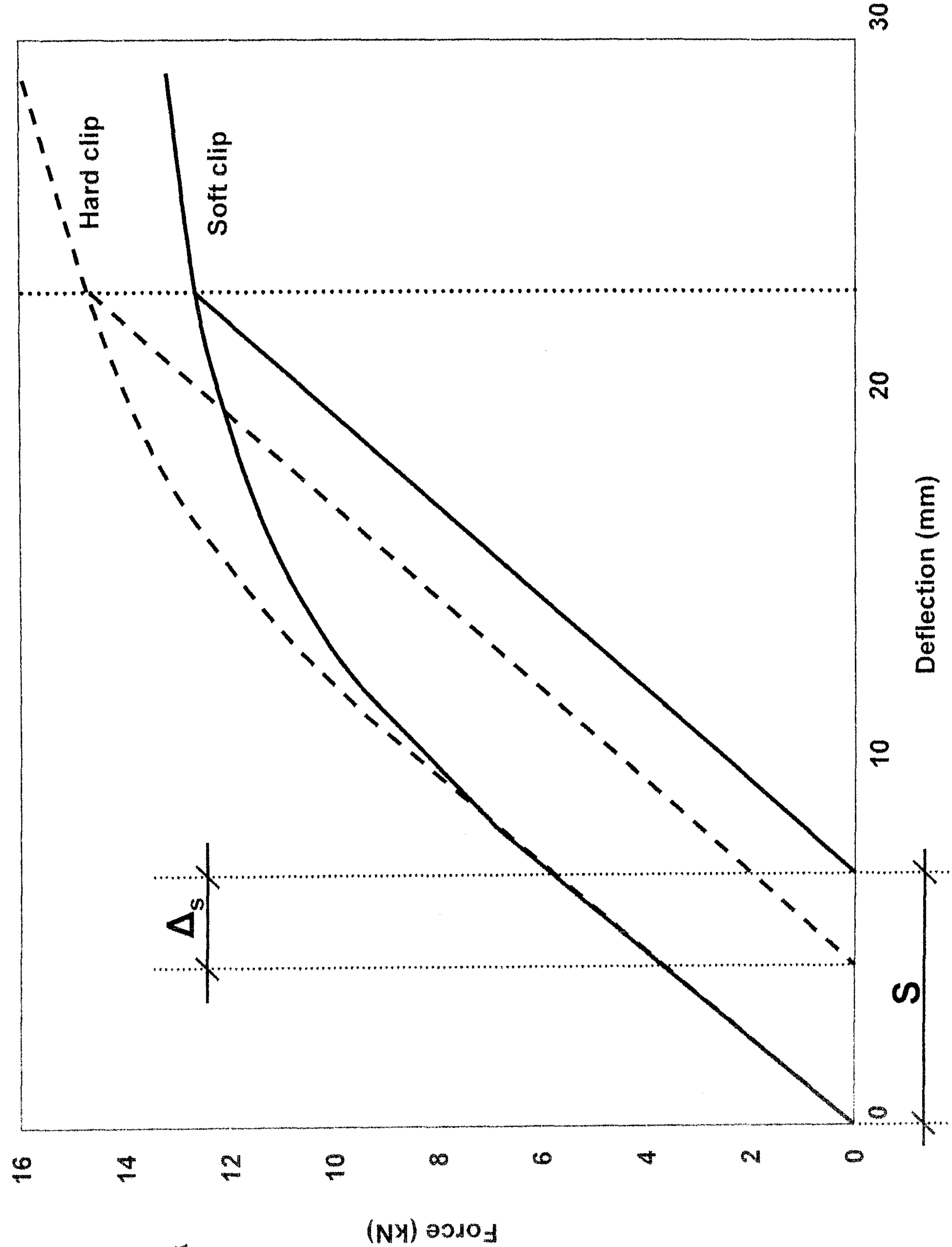
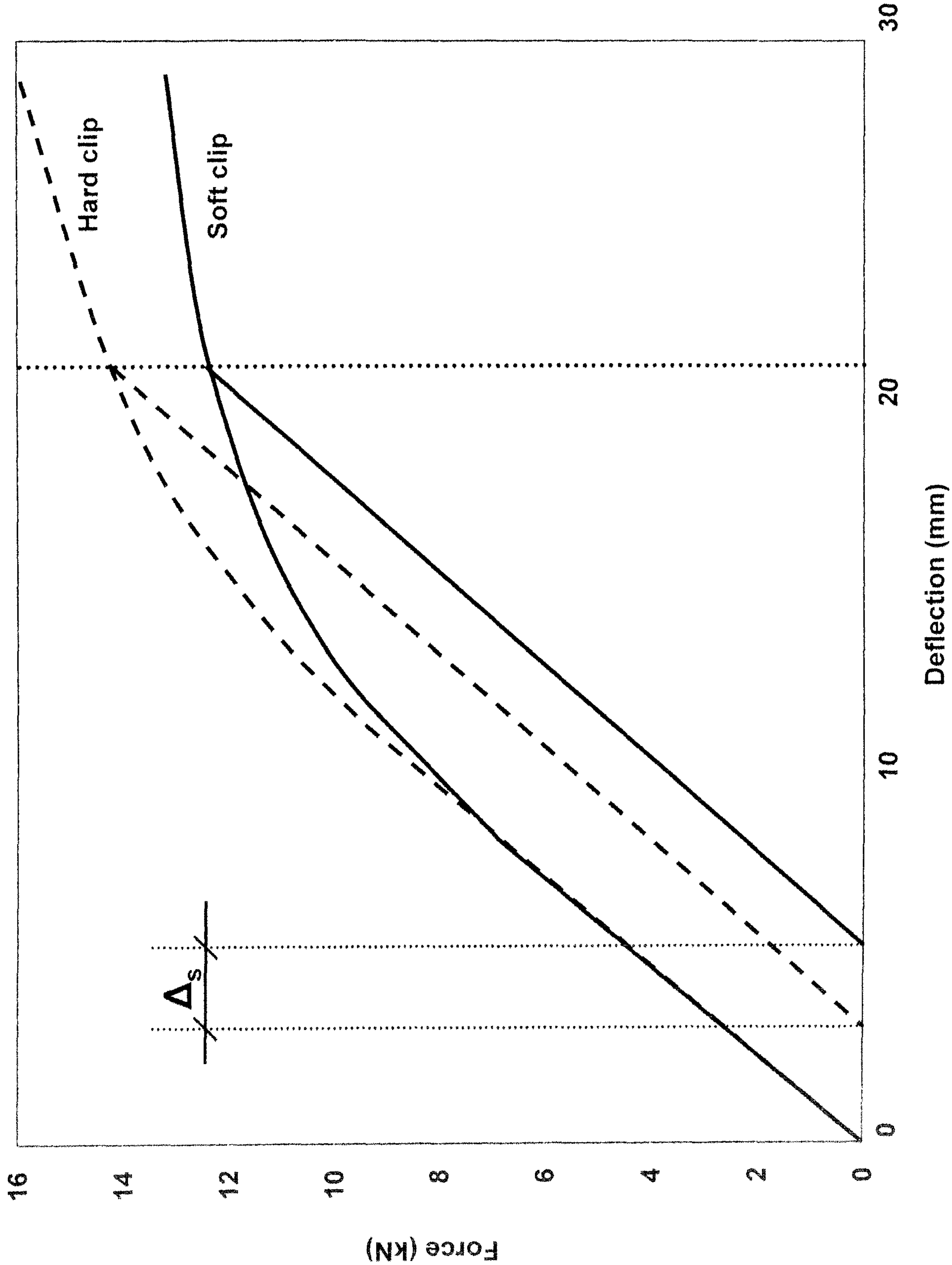

Hard clip
Soft clip
Δ_s
S
Deflection (mm)
0
10
20
30
Force (KN)
0
2
4
6
8
10
12
14
16

FIG. 1A


Hard clip
Soft clip
Δ_s
Force (kN)
Deflection (mm)
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2
4
6
8
10
12
14
16
0
10
20
30

FIG. 1B

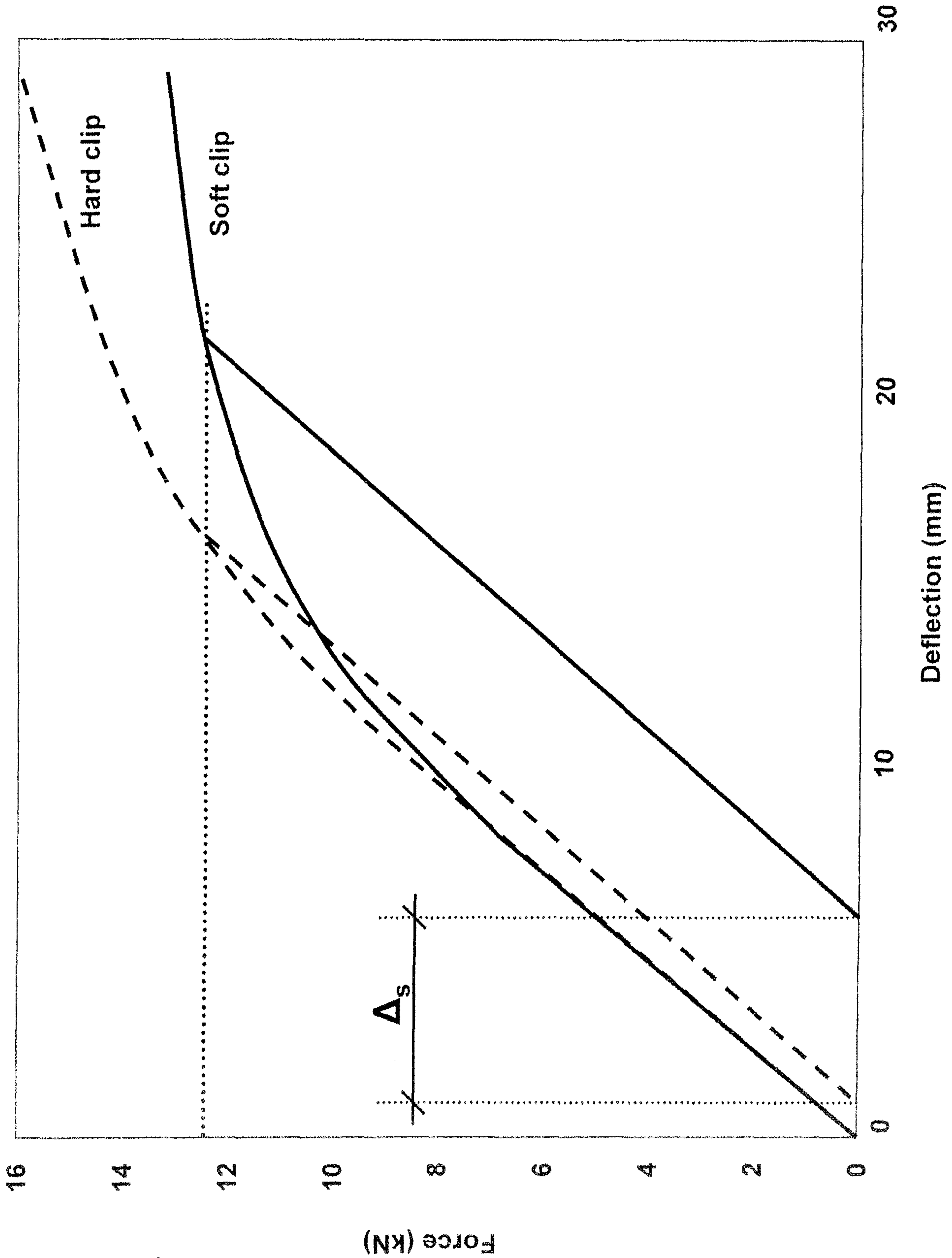

Force (kN)
0
2
4
6
8
10
12
14
16
Deflection (mm)
0
10
20
30
Hard clip
Soft clip
Δ_s

FIG. 1C

FIG. 2A

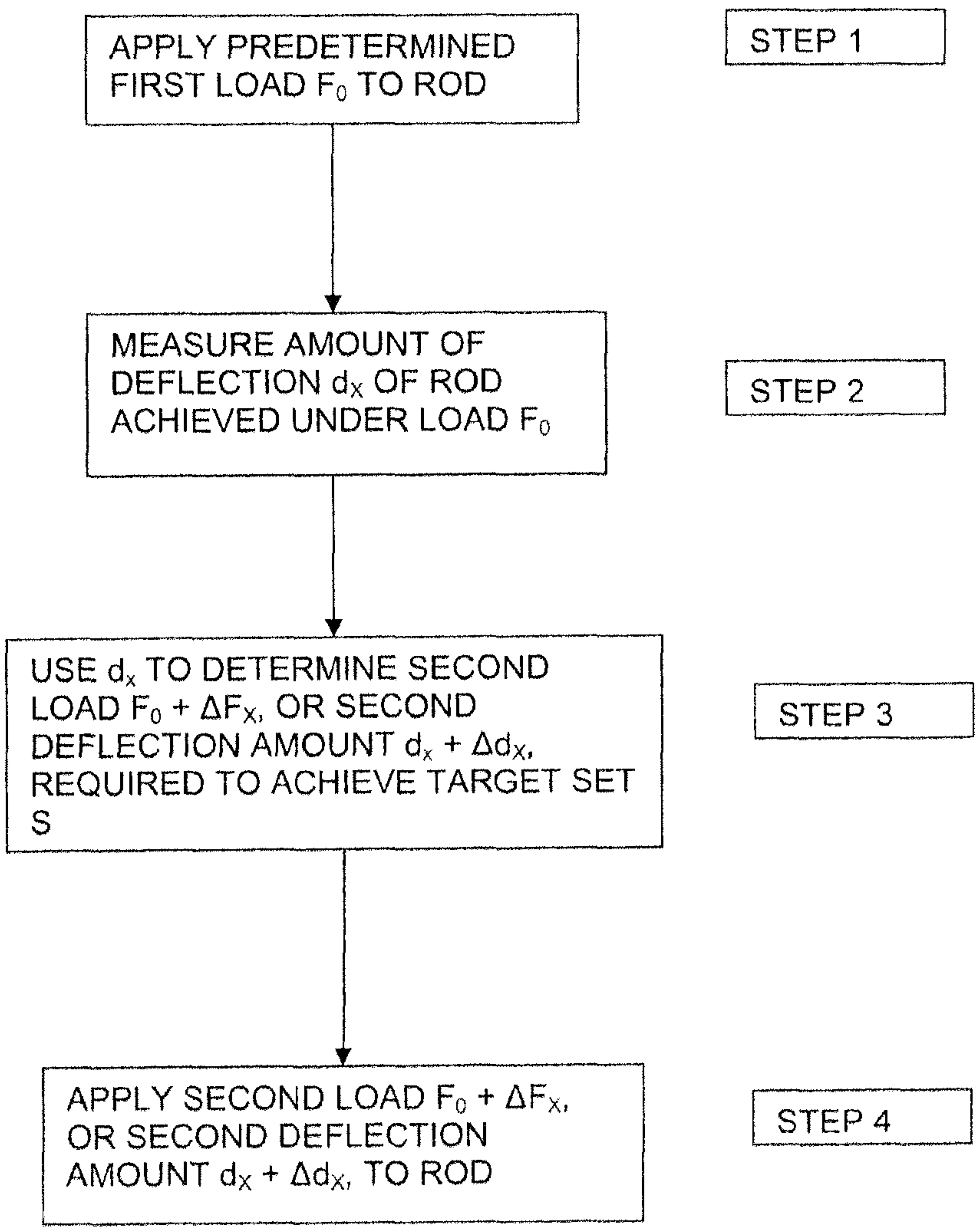
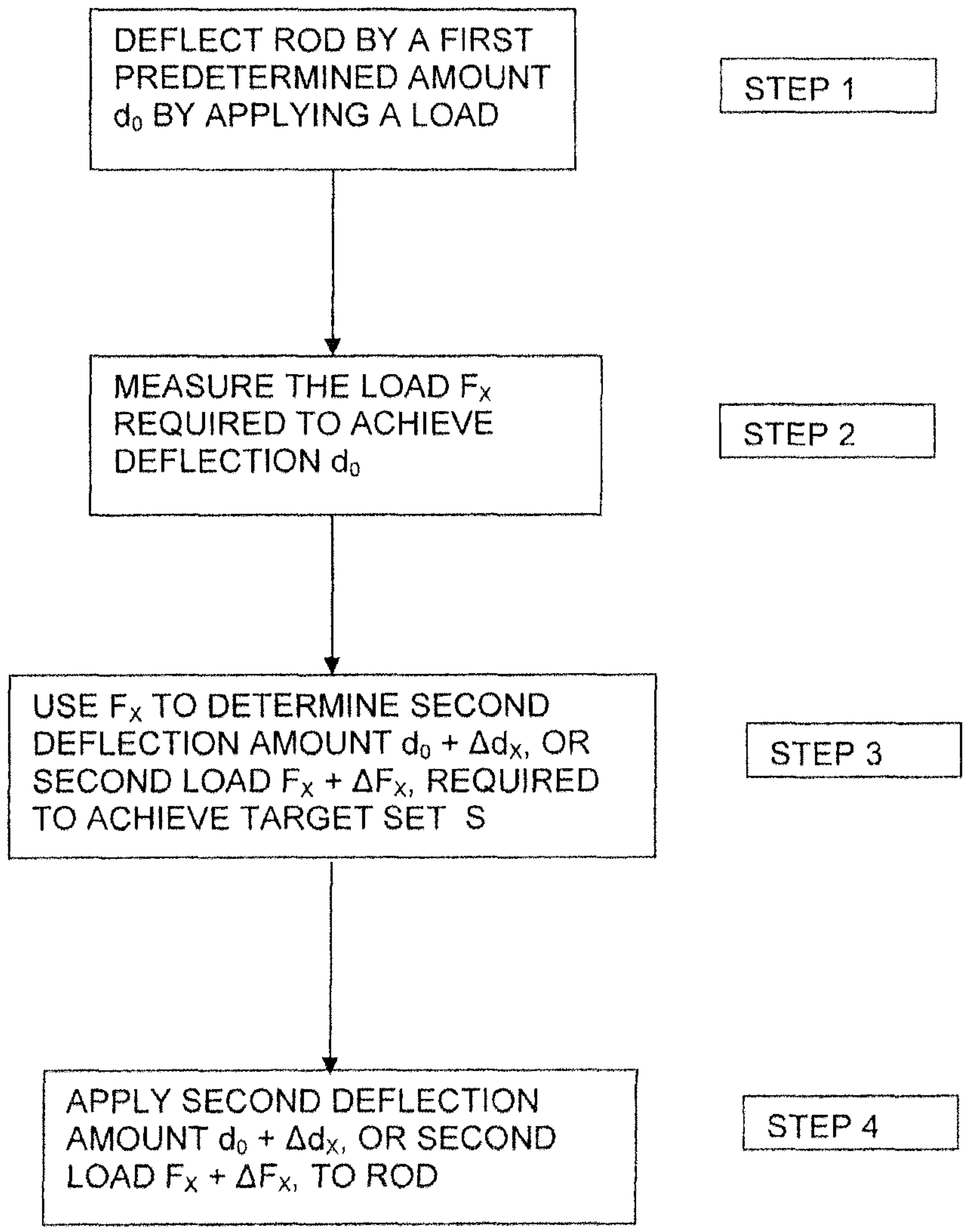

APPLY PREDETERMINED FIRST LOAD F_0 TO ROD
STEP 1
MEASURE AMOUNT OF DEFLECTION d_X OF ROD ACHIEVED UNDER LOAD F_0
STEP 2
USE d_x TO DETERMINE SECOND LOAD $F_0 + \Delta F_X$, OR SECOND DEFLECTION AMOUNT $d_x + \Delta d_X$, REQUIRED TO ACHIEVE TARGET SET S
STEP 3
APPLY SECOND LOAD $F_0 + \Delta F_X$, OR SECOND DEFLECTION AMOUNT $d_X + \Delta d_X$, TO ROD
STEP 4

FIG. 2B


DEFLECT ROD BY A FIRST PREDETERMINED AMOUNT d_0 BY APPLYING A LOAD
STEP 1
MEASURE THE LOAD F_X REQUIRED TO ACHIEVE DEFLECTION d_0
STEP 2
USE F_X TO DETERMINE SECOND DEFLECTION AMOUNT $d_0 + \Delta d_X$, OR SECOND LOAD $F_X + \Delta F_X$, REQUIRED TO ACHIEVE TARGET SET S
STEP 3
APPLY SECOND DEFLECTION AMOUNT $d_0 + \Delta d_X$, OR SECOND LOAD $F_X + \Delta F_X$, TO ROD
STEP 4

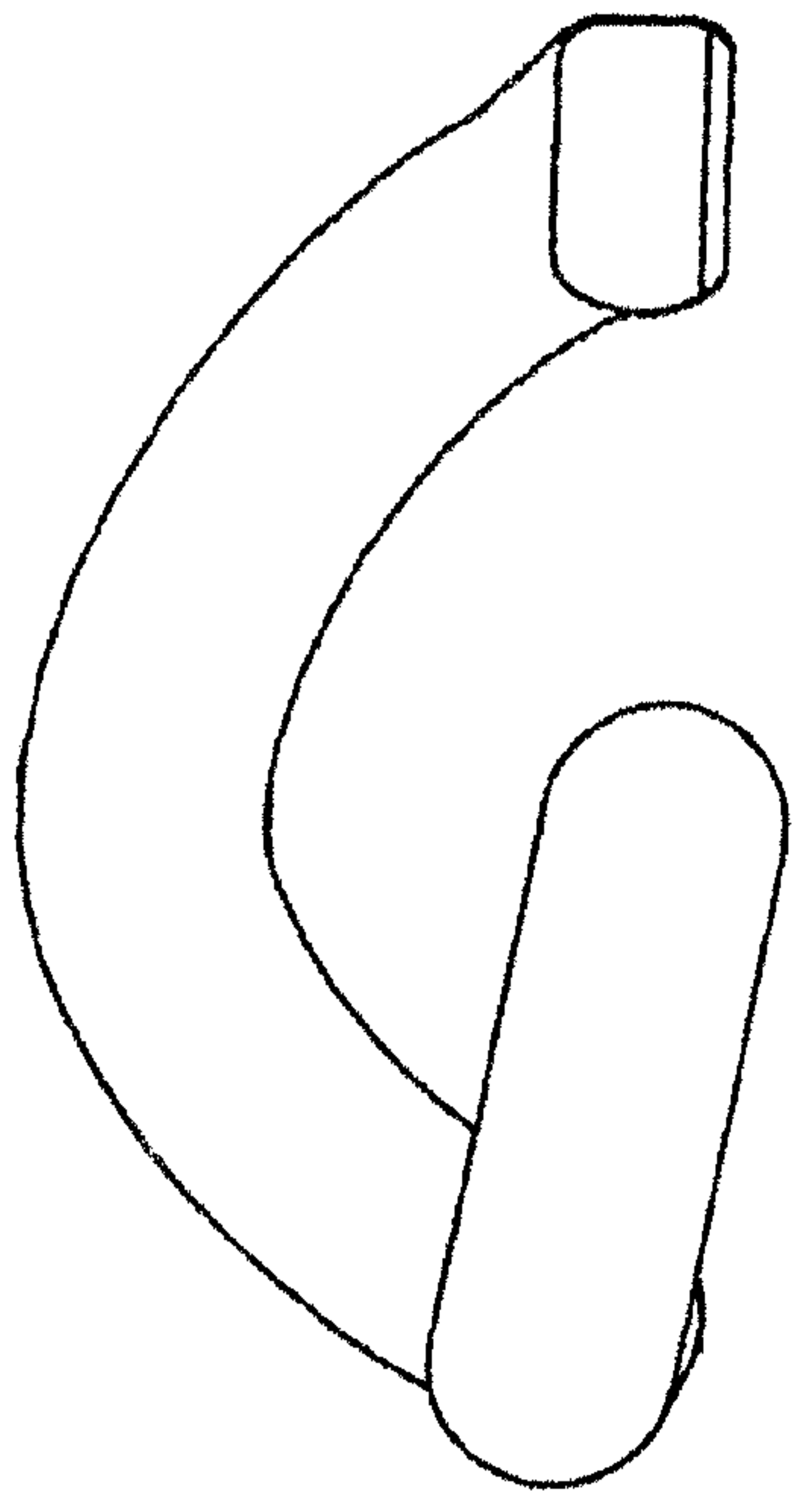


FIG. 3B

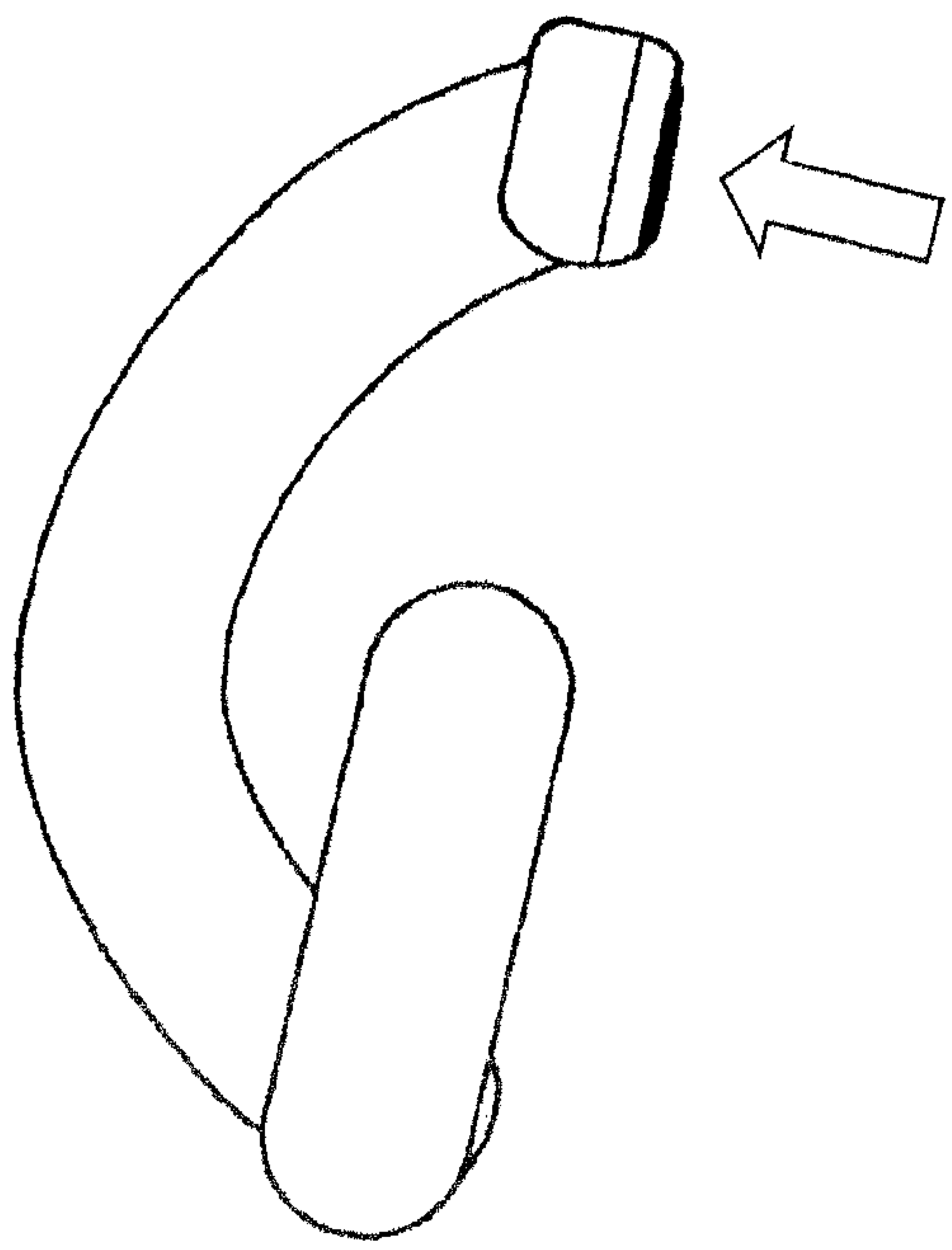
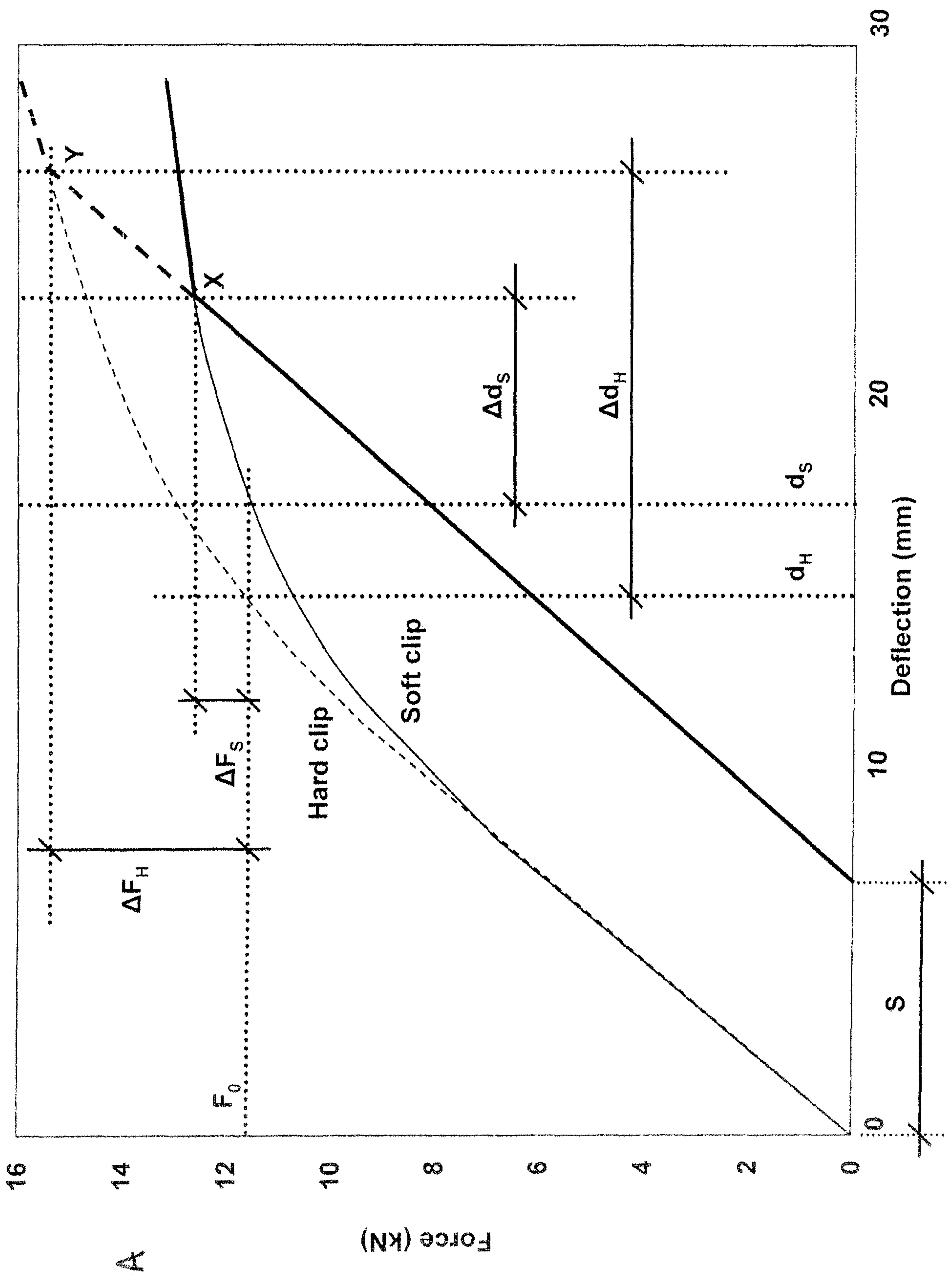


FIG. 3A


Force (kN)
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2
4
6
8
10
12
14
16
Deflection (mm)
0
10
20
30
S
d_H
d_S
Δd_S
Δd_H
ΔF_H
ΔF_S
F_0
Hard clip
Soft clip
X
Y

FIG. 4A

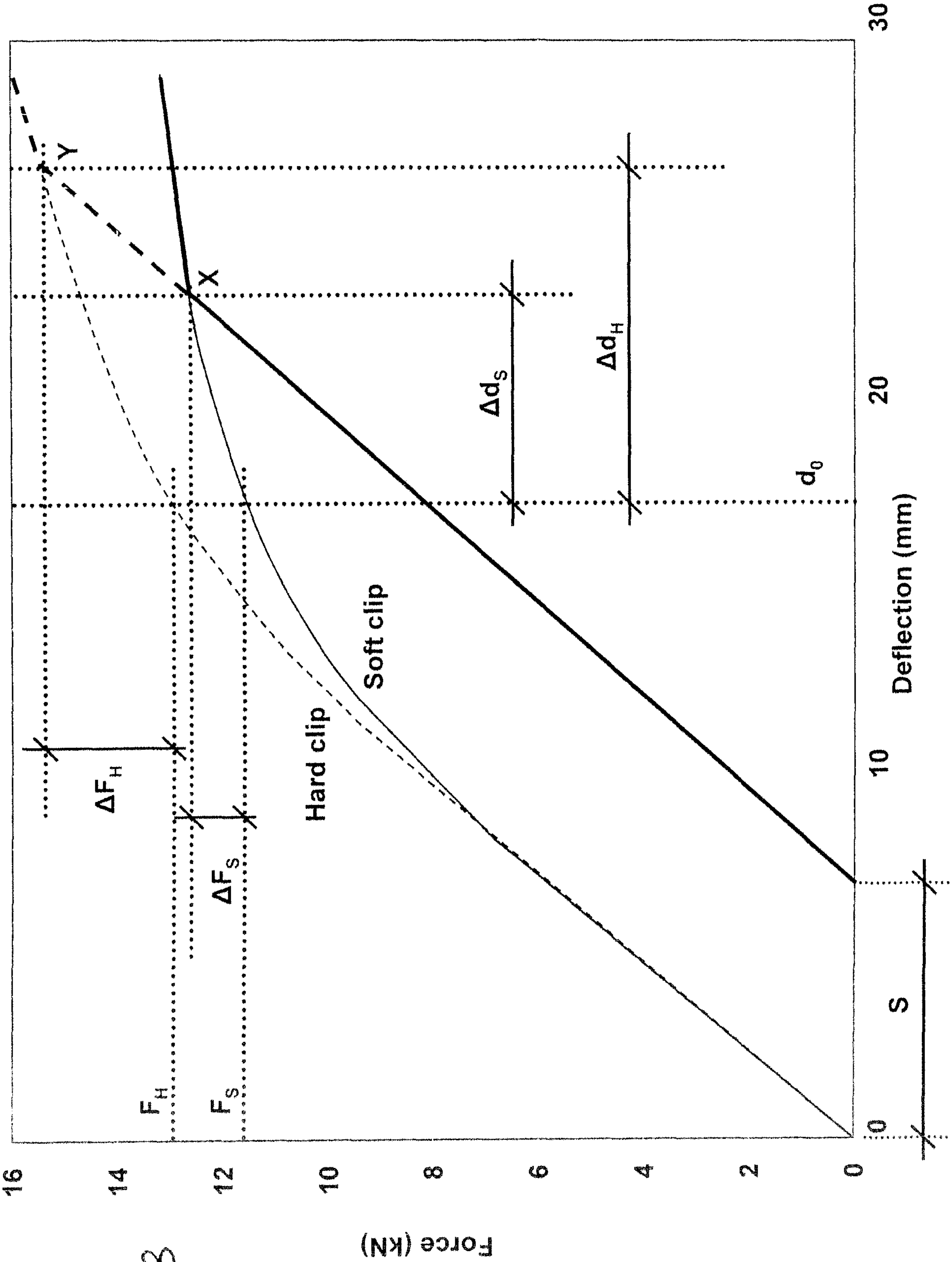
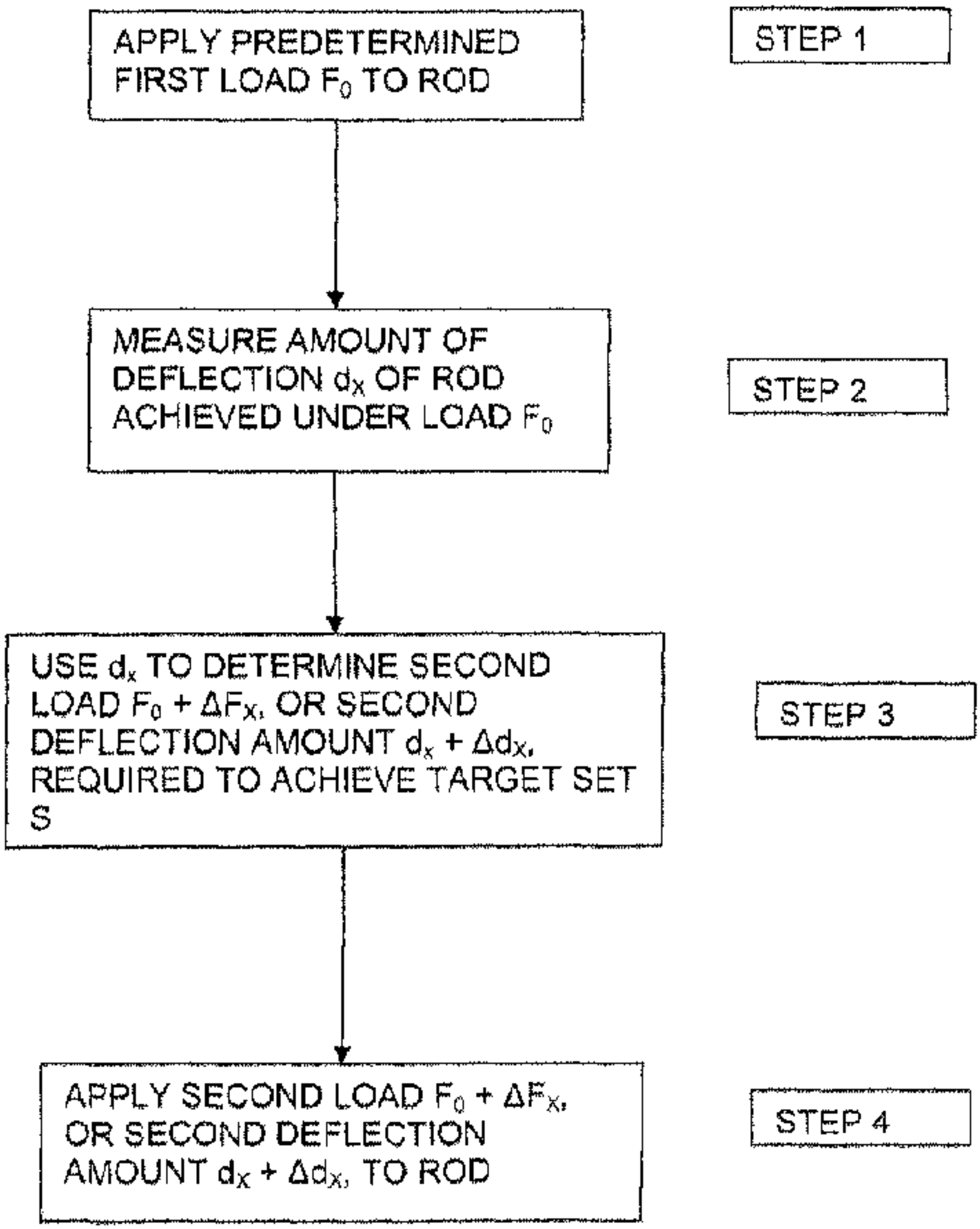

Force (kN)
0
2
4
6
8
10
12
14
16
Deflection (mm)
0
10
20
30
S
d0
Hard clip
Soft clip
X
Y
FH
FS
ΔFH
ΔFS
ΔdS
ΔdH

FIG. 4B


APPLY PREDETERMINED FIRST LOAD F_0 TO ROD
STEP 1
MEASURE AMOUNT OF DEFLECTION d_X OF ROD ACHIEVED UNDER LOAD F_0
STEP 2
USE d_x TO DETERMINE SECOND LOAD $F_0 + \Delta F_X$, OR SECOND DEFLECTION AMOUNT $d_x + \Delta d_X$, REQUIRED TO ACHIEVE TARGET SET S
STEP 3
APPLY SECOND LOAD $F_0 + \Delta F_X$, OR SECOND DEFLECTION AMOUNT $d_X + \Delta d_X$, TO ROD
STEP 4