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(54) **V-Block having an improved lead-in curve for bending metal plates or sheets.**

(57) V block (1) for bending plates or sheets (3) in a flat side (8) provided with an elongated recess (7) having a V-shaped profile, having lead-in curves (2) which run according to a curve whose radius of curvature (pj) adopts at least two different values, in such a way that the local contact pressure (σj) between plate or sheet (3) and V block (1) remains limited and prevents damage to the plate or sheet (3), and the wear (Wej) of the V block (1) is limited, the radius of curvature (ρj) preferably increasing towards the flank (6) of the recess (7) and optimally running according to a logarithmic spiral, which can be approximated by composing the curve from as large a number as possible of sections having a constant radius of curvature (r) between points of said logarithmic spiral.

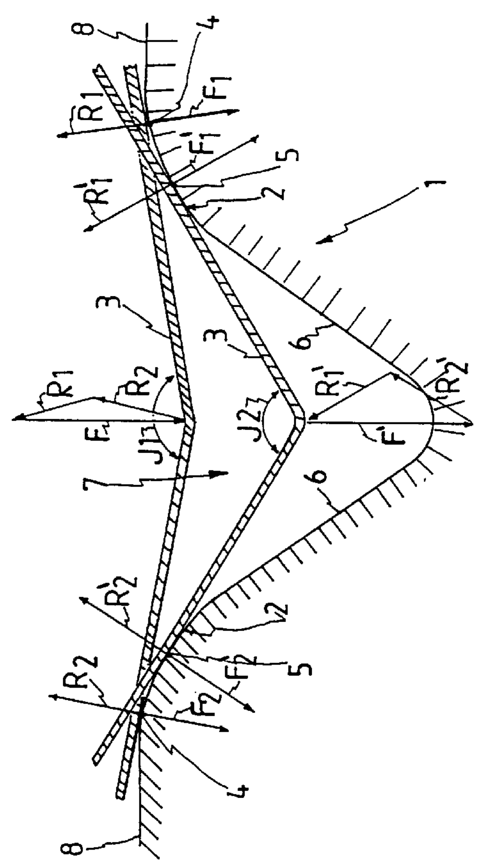

FIG. 1

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The present invention relates to an implement for bending metal plates or sheets, known under the name V block, and more in particular to the shape of the lead-in curve of implements of this type.

The known V blocks mainly consist of one solid piece, having at least one flat side, in which a straight, elongated recess is provided whose profile over the entire length is identical and V-shaped. The shape of said recess is moreover preferably symmetrical with respect to a plane extending in its longitudinal direction, which is perpendicular to the flat topside of the V block (hereinafter called the plane of symmetry of the recess).

The flat topside of the V block merges into the flanks of the recess via roundings. Said roundings have a profile whose radius of curvature is identical at every point. The profile of said roundings is designated by the name "lead-in curve".

Below the lead-in curve, the flanks are constructed to be planar and converge in a downward direction, and they meet where they form the lowest part of the recess. The lead-in curve is thus a curve whose start adjoins the flat side of the V block and whose end adjoins one of the flanks of the recess.

The profile of the V-shaped recess is likewise rounded below, where the two flanks merge into one another.

An important characteristic of a V block consists of the so-called V value which on the profile of the recess represents the following distance: "the distance between the intersections of, on the one hand, the straight lines coinciding with the rectilinear portion of each flank of the recess and, on the other hand, the straight line coinciding with the flat topside of the V block, measured along the last mentioned straight line".

Another characteristic of a V block consists of the value of the angle between the flanks of the V-shaped recess. This is the angle - on the profile of the recess - between the straight lines coinciding with the rectilinear portion of each flank, measured between those portions of said straight lines which extend from the intersection towards the topside of the recess.

The known V blocks are constructed in such a way that the lateral edges run parallel with the plane of symmetry of the recess, and the front side and rear side - into which the recess opens - are perpendicular to said plane of symmetry and to the topside. The following will show that the length of the V block and thus of the recess determines the length of the bend which can be achieved with the aid of this implement. The width of the V block is only slightly less than the width of the recess and the lead-in curves situated on both sides thereof.

Bending of a plate or sheet, with the aid of a V block, is effected as follows. The plate or sheet is positioned on the flat topside of the V block in such a way that the imaginary line on the plate or sheet, where the bend is to be achieved, coincides with the plane of symmetry of the recess. Said line which in the following is called the bending line must not be longer, in this case, than the length of the V-shaped recess.

Bending itself is effected by means of a pressure implement or ram arranged above the V block. This pressure implement has a narrow rectilinear underside having a virtually constant width and a length which is at least equal to the length of the bending line. Said pressure implement is positioned in such a way that said underside extends along the length of the recess and is parallel to the flat topside of the V block, the centre line of said underside being situated in the plane of symmetry of the recess.

The pressure implement is furthermore positioned on means which are able to move said implement vertically up and down and which, inter alia, are designed in such a way that, if the pressure implement is moved to the topside of a plate or sheet, a sufficient downward force can be generated to bend said plate or sheet. During the movements of the pressure implement the position indicated hereinabove with regard to the recess in the V block is maintained at all times.

After the plate or sheet has been correctly positioned, the pressure implement is moved, from a position where its underside is positioned above the plate or sheet, downward as far as the plate or sheet. It follows from the above that, as this happens, the longitudinal axis of the underside of the pressure implement coincides with the bending line.

By means of the pressure implement, a downward force is then exerted on the plate or sheet, abreast of the bending line which is located above the recess, and where the plate or sheet is thus not supported. The plate or sheet rests, on both sides of the recess, on the flat side of the V block. As a result of this downward force there are produced, abreast of said two supporting surfaces, upward reaction forces which, owing to the symmetrical positioning, form two identical but opposite moments with the downward force.

Said bending moments ensure that the plate or sheet is bent symmetrically. As the pressure implement continues to move downwards in the recess, the plate or sheet is bent further.

From the instant where the bend begins to form in the plate or sheet, the plate or sheet rests on the lead-in curves. As the plate or sheet bends further, said support surface is positioned further and further down on the lead-in curves.

The pressure implement is finally moved into such a position, that the desired bending angle in the plate or sheet has been obtained. The term bending angle here refers to the angle which is formed between the portions of a plate or sheet, which are situated on each side of the bending line. In the case of a bent plate or sheet this is the angle (< 180°) which is formed between the angle-forming portions of the plate or sheet (this, on a cross-section, is the angle (< 180°) between the straight lines coinciding with the rectilinear portions of the plate or sheet on each side of the bend). In the case of a flat plate or sheet, the "bending angle" is equal to 180°.

For further explanation of the problem on which this invention is based we refer to the accompanying Figures in which:

Figure 1 represents a vertical cross-section of a V block, on which a bent plate or sheet is presented at two different bending angles;

Figure 2 shows, in graphic form, the size of the force exerted by the plate or sheet on the V block (according to the prior art) as a function of the bending angle of said plate or sheet;

Figure 3 presents, in graphic form, the size of the contact pressure arising between plate or sheet and V block - according to the prior art - as a function of the bending angle of the plate or sheet;

Figure 4 presents, in graphic form, the ratio "slip speed/rolling speed" as a function of the bending angle of the plate or sheet, for a V block according to the prior art;

Figure 5 presents, in graphic form, the wear of a V block according to the prior art as a function of the bending angle of the plate or sheet.

Figure 1 presents, in vectorial form, the forces (F, F1, F2, R1, R2, F', F'1, F'2, R'1, R'2) acting on the plate or sheet (3) and on the V block (1) at the instant that the pressure implement (not shown) exerts a force (F) on the plate or sheet (3).

In the case of the V block (1) from Figure 1, according to the prior art the radius of curvature (ρ_j) of the lead-in curves (2) is constant.

In the course of bending a plate or sheet (3), the pressure implement (not shown) exerts a vertical force (F) in the centre of the plate or sheet. At a certain time, said plate or sheet (3) has attained a bending angle (j1) (the topmost situation of the plate or sheet on Figure 1). The plate or sheet (3) is supported abreast of the points (4) by the roundings (2) of the V block (1). The vertical force (F) gives rise to two forces (F1, F2) on the V block (1), as a result of which two reaction forces (R1, R2) opposite thereto are produced, each of which act, with the same respective force, on the plate or sheet (3) in one of the support points (4). Said forces (F1, F2) and said reaction forces (R1, R2) have a direction perpendicular to the plate or sheet (3) and a magnitude so as to be able to form, together with the vertical force (F), a closed triangle of forces. Their projection on a vertical, in other words, must be equal to half the force (F).

Owing to the forces (F1, F2) abreast of the support points (4), the material of the V block (1) is indented slightly, so that as a matter of fact one has to talk in terms of support surfaces, abreast of the points (4).

Owing to the opposite moments which are formed, on the one hand, by the forces (F2) and (R2) and, on the other hand, by the forces (F1) and (R1), the plate or sheet (3) is bent.

At a later time, the plate or sheet (3) encounters a situation where the bending angle (j2) has been achieved (the lowermost situation of the plate or sheet in Figure 1). The plate or sheet (3) is now supported, abreast of the points (5) lower than the points (4), by the roundings (2). The vertical force (F') which is of the same size as the force (F) now gives rise, in the same manner as described above for bending angle (jl), to forces (F'1, F'2) and reaction forces (R'1, R'2), directed perpendicular to the plate or sheet (3). As can be ascertained in Figure 1, after comparing the magnitude of the forces (F1, F2, R1, R2) at bending angle (j1) and (F'1, F'2, R'1, R'2) at bending angle (j2), said respective forces are larger at bending angle (j2).

The accompanying Figure 2 shows the course of a reaction force (R1), (R2) as a function of the bending angle (j). The reaction force (R1), (R2) is expressed in [N/mm], being the reaction force (in Newtons) per mm in length of the plate or sheet which rests on the lead-in curve.

The accompanying Figure 3 shows the course of the contact pressure (σ_j) (between plate or sheet (3) and lead-in curve (2)) as a function of the bending angle (j). Said contact pressure is directly proportional to the square root of the forces (F1), (F2). It is the force per unit surface of the contact area abreast of point (5).

The wear (We_j) of the V block can be calculated mathematically with the aid of the formula:

$$\mathit{Wear}\ (We_j) = \mathit{contact\ pressure}\ (\sigma_j) \times \left[\frac{\mathit{slip\ speed}}{\mathit{rolling\ speed}} \right]$$

The slip speed at a certain point of the lead-in curve (function of the bending angle (j)) is the speed at which the plate or sheet moves in a direction tangential to the lead-in curve at that point. This is the speed of the pressure implement (dY_j) multiplied with the sine of the angle (∅) between the straight line according to the travelling direction of the pressure implement and the straight line perpendicular to the rounding.

The rolling speed at a certain point of the lead-in curve is the speed with which a point of the plate or sheet moves as a result of rolling over the lead-in curve at that point. This is therefore the radius of curvature (ρ_j) at that point, multiplied with the angular speed ($d\rho_j$). The ratio between slip speed and rolling speed was calculated mathematically and plotted, as a function of the bending angle (j), in Figure 4. By applying the abovementioned formula for calculating the wear, Figure 5 is obtained, where the wear of the V block is plotted as a function of the bending angle (j) of the plate or sheet (3).

From the above it is thus clear that, as the bending angle (j1, j2) decreases, greater wear (Wej) of the V block (1) arises, and the contact pressure between plate or sheet (3) and V block (1) increases up to considerable magnitudes. On the other hand, in the case of the known V blocks, the plate or sheet will slide more than it will roll over the roundings (2).

The high wear (Wej) of the V block (1) abreast of the roundings (2) as a result of the high contact pressure (σj) and high slip speed is a major drawback of the known V blocks. Another drawback is that, as a result of the high contact pressure (σj) an imprint is formed in the bent plate or sheet (3). Still another drawback consists in the fact that permanent markings on that plate or sheet (3) are produced, owing to the plate or sheet (3) sliding over the roundings (2) more than it rolls.

The object of the invention is to overcome the abovementioned drawbacks by providing a V block, whose wear is reduced and by means of which - if the V value of the V block is chosen correctly - plates or sheets can be bent without causing imprints or marks thereon. For the sake of clarity of the following description, reference is made to the V block (1) from Figure 1, under the assumption that the radius of curvature (ρj) corresponds to the characterizing features of the invention.

According to the invention, a V block (1) is then presented for bending plates or sheets (3), consisting of a solid piece having at least one flat side (8), which via roundings (2) merges into the flanks (6) of an elongated recess (7) having a V-shaped profile which is provided in said flat side (8), while the profile of the recess (7) and of said roundings (2) is identical over their entire length, characterized in that the roundings in profile have a lead-in curve (2) whose radius of curvature (ρ) adopts at least two different values, and in that at at least one point on the lead-in curve (2) the radius of curvature (ρ) is greater than the radius of curvature (ρi) of the start of the lead-in curve - where it merges into the flat side (8) of the V block (1).

The advantage of a V block of this type is that it reduces the imprint of the plate or sheet at too high a contact pressure (σj).

During bending of a plate or sheet there is exerted, namely, at the point where the plate or sheet (3) is in contact with the rounded transitions (2) between flat side (8) and flanks (6) of the recess (7), a force by said plate or sheet on the lead-in curves, which produces a small deformation of the material of the V block. As a result there is formed, instead of a contact line, a contact area whose area is directly proportional to the radius of curvature of the lead-in curves (2) at that point. A greater radius of curvature (ρj) consequently results, for the same force, in a smaller contact pressure (σj) (force per unit surface). In order to reduce or avoid the imprint in the plate (3), the radius of curvature (ρj) must be such, on at least one point of the lead-in curve (2), that at that point where in the case of the intended use too large a force is exerted, it has a value which is greater than the radius of curvature (ρi) of the start of the lead-in curve (2), so that said contact area is sufficiently large to reduce the contact pressure (σj) or to keep it below the value at which imprinting is obtained in the plate or sheet to be bent (for the correct choice of the V value of the V block). By limiting the contact pressure (σj) the wear (Wej) of the V block according to the invention is likewise limited.

A particularly advantageous embodiment of this invention is obtained by giving the rounded transitions (2) between flat side (8) and flanks (6) of the V-shaped recess (7) a profile which is defined by a curve whose various values of the radius of curvature (ρj) increase from the flat side (8) towards the flank (6) of the recess (7).

In an embodiment of this type, according to the invention, the problem of imprinting of the plate - at too high a contact pressure (σj) - is overcome in an even more efficient way.

After all, during bending of a plate or sheet, as described for the application of the known V blocks, an increasing force (F'1 > F1; F'2 > F2) is observed on the roundings (2), as the plate or sheet (3) is given a smaller bending angle (j2 < j1). Since a smaller bending angle corresponds to a contact area between plate or sheet (3) and V block (1), which is situated lower down on said roundings (2), the abovementioned problem is overcome in a particularly efficient manner by letting the various values of the radius of curvature (ρj) of the profile of said roundings (2) increase in the direction of the flank (6) of the recess (7).

A further advantage of a V block having a radius of curvature (ρj) of the roundings (2), which increases in a downward direction, consists in the plate or sheet rolling over the rounding to a greater extent than was the case for the roundings which do not have such a feature.

This advantage, combined with the advantage of the contact pressure (σj) kept within limits has the following associated advantages: namely, that the V block (1) will be subject to less wear (Wej), and that any marking on the plate (owing to slipping in combination with a high contact pressure) will be avoided.

The drawbacks of the known V blocks are overcome in an even more efficient manner by ensuring for a V block (1) having an angle β that the ratio of the radius of curvature (ρe) of the end of the profile of the rounding (2) - where it merges into a flank (6) of the recess (7) - with respect to the radius of curvature (ρi) of the start of the profile of the rounding (2) - where it merges into the flat side (8) of the V block (1) - is within the limits defined by the following formulae:

Lower limit:

$$\frac{\rho e}{\rho i} = e^{1{,}1(90\ -\ \beta/2)\cdot\frac{\pi}{180}}$$

Upper limit:

$$\frac{\rho e}{\rho i} = e^{1{,}5(90\ -\ \beta/2)\cdot\frac{\pi}{180}}$$

If, however, within the abovementioned limits the following ratio is employed:

$$\frac{\rho e}{\rho i} = e^{1{,}2(90\ -\ \beta/2)\cdot\frac{\Pi}{180}}$$

the described drawbacks are reduced to an absolute minimum.

The most advantageous course of the lead-in curve (2), in the light of the drawbacks to be overcome, is achieved, however, if the lead-in curve (2) has the coordinates defined by the following equations, in a rectangular set of x-y axes having its origin in the starting point of the curve (where it merges into the flat side (8) of the V block) and having a horizontal X axis in the extension of that flat side (8), and directed towards the other lead-in curve (2), and having a vertical, upwards-directed Y axis

$$x = \frac{\rho i}{\sqrt{(1+m^2)}}[e^{m.\phi}.\sin(\phi).\cos(\alpha) + [e^{m.\phi}.\cos(\phi) - 1].\sin(\alpha)]$$

$$y = \frac{\rho i}{\sqrt{(1+m^2)}}[\,-\,e^{m.\phi}.\sin(\phi).\sin(\alpha) + [e^{m.\phi}.\cos(\phi) - 1].\cos(\alpha)]$$

with $0 \leqq \phi \leqq 90°\text{-}\beta/2$ ($\beta > 0°$)

in which:

- m is a constant value from 1.1 to 1.5 inclusive,
- ϕ is the angle, varying from 0 to 90°-β/2, which is formed between the Y axis and the straight line perpendicular to the rounding
- $\alpha = \tan^{-1}(m)$
- β is the angle of the V block
- ρi is the radius of curvature of the start of the curve.

A curve of this type is denoted with the name "logarithmic spiral".

The optimum course of the lead-in curve is obtained if in the abovementioned equations m = 1.2.

For practical reasons, however, preference is given to an approximation of this optimal lead-in curve. This involves composing the lead-in curve from a number of successive portions having a constant radius of curvature (sections of a circle). The greater the number of portions into which the lead-in curve is subdivided, the better, obviously, the approximation.

The coordinates of starting and end point of each portion are defined according to the abovementioned equations for the (x, y) coordinates.

The value of the radius of curvature is defined according to the following equation:

$$r = (X_{i+1} - X_i)/[(\sin(\phi_{i+1}) - \sin(\phi_i)]$$

in which:

x_{i+1}: is the x coordinate of the end point of a particular portion of the lead-in curve

x_i: is the x coordinate of the starting point of that portion

ϕ_{i+1}: is the value of the angle ϕ for the end point of that portion of the lead-in curve

ϕ_i: is the value of the angle ϕ for the starting point of that portion of the lead-in curve

The coordinates (x_c, y_c) of the centre of curvature of each portion are defined according to the following equations:

$$x_c = x_i - r \cdot \sin(\phi_i)$$
$$Y_c = Y_i - r \cdot \cos(\phi_i).$$

In the following, the advantages are discussed in more detail, and a number of examples of possible embodiments according to the invention are provided.

In doing so, reference is made to the accompanying Figures in which:

Figure 6 indicates how the radius of curvature (ρj) of the lead-in curve varies as a function of the bending angle (j) of the plate or sheet, for a possible embodiment of a V block according to the invention;

Figure 7, for a V block according to Figure 6, indicates how the reaction force (Rj) increases as a function of the bending angle (j) of the plate or sheet;

Figure 8 represents the variation in contact pressure (σj) as a function of the bending angle (j);

Figure 9 represents the variation in ratio slip speed/rolling speed as a function of the bending angle (j);

Figure 10 represents the variation in wear (in Newtons per mm^2) as a function of the bending angle (j);

Figure 11 depicts a lead-in curve of a V block according to the invention, the V block having a V value of 8 and an angle of 30°;

Figure 12 depicts a lead-in curve of a V block according to the invention, the V block having a V value of 6 and an angle of 30°;

Figure 13 depicts a lead-in curve of a V block according to the invention, the V block having a V value of 16 and an angle of 86°.

In Figures 7, 8, 9 and 10, the same variables (reaction force, contact pressure, slip speed/rolling speed, and wear) are presented for a V block according to the invention as a function of the bending angle (j) as were presented on Figures 2, 3, 4 and 5 for a known V block.

A comparison of the respective Figures clearly shows that both the contact pressure (σj) and the wear (Wej) of the V block are considerably reduced when a V block according to the invention is used.

The drawbacks indicated of the known V blocks have thus been overcome. The contact pressure (σj) remains - if the V value of the V block is chosen correctly - below the value at which imprinting of the plate or sheet is caused. The slip speed is smaller, compared to the rolling speed (in particular at bending angles at which the contact pressure is the largest) so that (partly owing to the limited contact pressure) the marks in the plate or sheet are prevented, and the wear of the V block becomes much smaller.

Figures 11, 12, 13 depict the course of the lead-in curve, as it is preferentially implemented in practice, by approximating the optimal curve by composing it from a large number of successive sections having a constant radius of curvature (r), according to the equations from Claim 7.

In the Tables below, with the aid of the respective examples of Figures 11, 12 and 13, the values of r, x_c, y_c calculated according to these equations are given for the successive sections of the curve situated between the points having coordinates (x, y), which are calculated according to the equations for the optimal curve from Claims 5 or 6.

1. For V=8 with an angle of 30° (see Figure 11)				
x	y	r	xc	yc
0.000	0.000			
1.841	0.000	1.581	1.841	-1.581
1.979	-0.006	1.756	1.826	-1.755
2.131	-0.026	1.949	1.792	-1.946
2.297	-0.063	2.165	1.736	-2.154
2.477	-0.120	2.403	1.655	-2.378
2.670	-0.201	2.668	1.543	-2.619
2.877	-0.308	2.963	1.395	-2.874
3.095	-0.447	3.289	1.208	-3.142
3.323	-0.622	3.652	0.975	-3.420
3.557	-0.838	4.055	0.690	-3.705
3.796	-1.099	4.502	0.348	-3.993
4.035	-1.411	4.998	-0.059	-4.278
4.270	-1.779	5.548	-0.535	-4.554
4.493	-2.210	6.158	-1.088	-4.812
4.699	-2.707	6.834	-1.723	-5.044
4.878	-3.277	<--- end of profile		

2. For V=6 with an angle of 30° (see Figure 12)				
x	y	r	xc	yc
0.000	0.000			
3.705	0.000	0.949	3.705	-0.949
3.787	-0.004	1.053	3.695	-1.053
3.878	-0.016	1.170	3.675	-1.168
3.978	-0.038	1.299	3.642	-1.292
4.086	-0.072	1.442	3.593	-1.427
4.202	-0.120	1.601	3.526	-1.571
4.326	-0.185	1.778	3.437	-1.724
4.457	-0.268	1.974	3.325	-1.885
4.594	-0.373	2.191	3.185	-2.052
4.734	-0.503	2.433	3.014	-2.223
4.878	-0.659	2.701	2.809	-2.396
5.021	-0.847	2.999	2.565	-2.567
5.162	-1.068	3.329	2.279	-2.732
5.296	-1.326	3.695	1.947	-2.887
5.419	-1.624	4.101	1.566	-3.027
5.527	-1.966	<--- end of profile		

3. For V=16 with an angle of 30° (see Figure 13)				
x	y	r	xc	yc
0.000	0.000			
2.998	0.000	2.480	2.998	-2.480
3.134	-0.004	2.649	2.989	-2.648
3.278	-0.016	2.828	2.970	-2.827
3.432	-0.037	3.020	2.938	-3.016
3.594	-0.068	3.225	2.894	-3.216
3.765	-0.111	3.444	2.835	-3.427
3.945	-0.167	3.677	2.760	-3.648
4.133	-0.237	3.926	2.666	-3.879
4.330	-0.323	4.193	2.554	-4.120
4.535	-0.426	4.477	2.419	-4.371
4.747	-0.547	4.780	2.261	-4.630
4.967	-0.689	5.104	2.078	-4.898
5.193	-0.854	5.451	1.867	-5.172
5.424	-1.042	5.820	1.626	-5.452
5.659	-1.256	6.215	1.352	-5.737
5.897	-1.499	<--- end of profile		

Claims

1. V block (1) for bending plates or sheets (3), consisting of a solid piece having at least one flat side, which via roundings merges into the flanks of an elongated recess having a V- shaped profile which is provided in said flat side, while the profile of the recess and of said roundings - called lead-in curves - is identical over their entire length, characterized in that the roundings in profile have a lead-in curve (2) whose radius of curvature (ρ) adopts at least two different values, and in that at at least one point on the lead-in curve (2) the radius of curvature (ρ) is greater than the radius of curvature (ρi) of the start of the lead-in curve - where it merges into the flat side (8) of the V block (1).

2. V block (1) according to Claim 1, characterized in that the different values of the radius of curvature (ρ) increase from the flat side (8) towards the flank (6) of the recess (7).

3. V block (1), according to Claim 1 or 2, characterized in that the ratio of the radius of curvature (pe) of the end of the lead-in curve - where it merges into a flank of the recess - with respect to the radius of curvature (ρi) of the start of the lead-in curve - where it merges into the flat side of the V block - for a V block having an angle β is within the limits defined by the following formulae:
   Lower limit:

$$\frac{\rho e}{\rho i} = e^{1,1(90 - \beta/2).\frac{\pi}{180}}$$

   Upper limit:

$$\frac{\rho e}{\rho i} = e^{1,5(90 - \beta/2).\frac{\pi}{180}}$$

4. V block (1) according to Claim 3, characterized in that the ratio $\frac{\rho e}{\rho i}$ is equal to $e^{1,2(90-\beta/2).(\frac{\Pi}{180})}$.

5. V block (1) according to one or more of the preceding claims, characterized in that the profile of a lead-in curve (2) has the coordinates (x, y), defined by the following equations, in a rectangular set of x-y axes having its origin in the starting point of the curve (where it merges into the flat side (8) of the V block (1)) and having a horizontal X axis in the extension of that flat side (8), and directed towards the other lead-in curve (2), and having a vertical, upwards-directed Y axis

$$x = \frac{\rho i}{\sqrt{(1+m^2)}}[e^{m.\phi}.\sin(\phi).\cos(\alpha) + [e^{m.\phi}.\cos(\phi) - 1].\sin(\alpha)]$$

$$y = \frac{\rho i}{\sqrt{(1+m^2)}}[-e^{m.\phi}.\sin(\phi).\sin(\alpha) + [e^{m.\phi}.\cos(\phi) - 1].\cos(\alpha)]$$

with $0 \leqq \phi \leqq 90°-\beta/2$ ($\beta > 0°$)
in which:

- m is a constant value from 1.1 to 1.5 inclusive,
- ϕ is the angle, varying from 0 to $90°-\beta/2$, which is formed between the Y axis and the straight line perpendicular to the rounding
- $\alpha = \tan^{-1}(m)$
- β is the angle of the V block
- ρi is the radius of curvature of the start of the curve.

6. V block (1) according to Claim 5, characterized in that m = 1.2.

7. V block (1) according to Claim 5 or 6, characterized in that the lead-in curve having coordinates (x, y) is approximated by composing it from a number of portions having a constant radius of curvature, in that the coordinates of start and end point of each portion are defined according to the equations according to Claim 5 or 6, in that the value of the radius of curvature (r) is defined according to the following equation:

$$r = (X_{i+1} - X_i)/[(\sin(\phi_{i+1}) - \sin(\phi_i)]$$

in which:

x_{i+1}: is the x coordinate of the end point of a particular portion of the lead-in curve
x_i: is the x coordinate of the starting point of that portion
ϕ_{i+1}: is the value of the angle ϕ for the end point of that portion of the lead-in curve
ϕ_i: is the value of the angle ϕ for the starting point of that portion of the lead-in curve

and in that the coordinates (x_c, y_c) of the centre of curvature of each portion are defined according to the following equations:

$$x_c = x_i - r \cdot \sin(\phi_i)$$
$$y_c = y_i - r \cdot \cos(\phi_i)$$

in which (x_i, y_i) are the coordinates of the starting point of the portion having the constant radius of curvature.

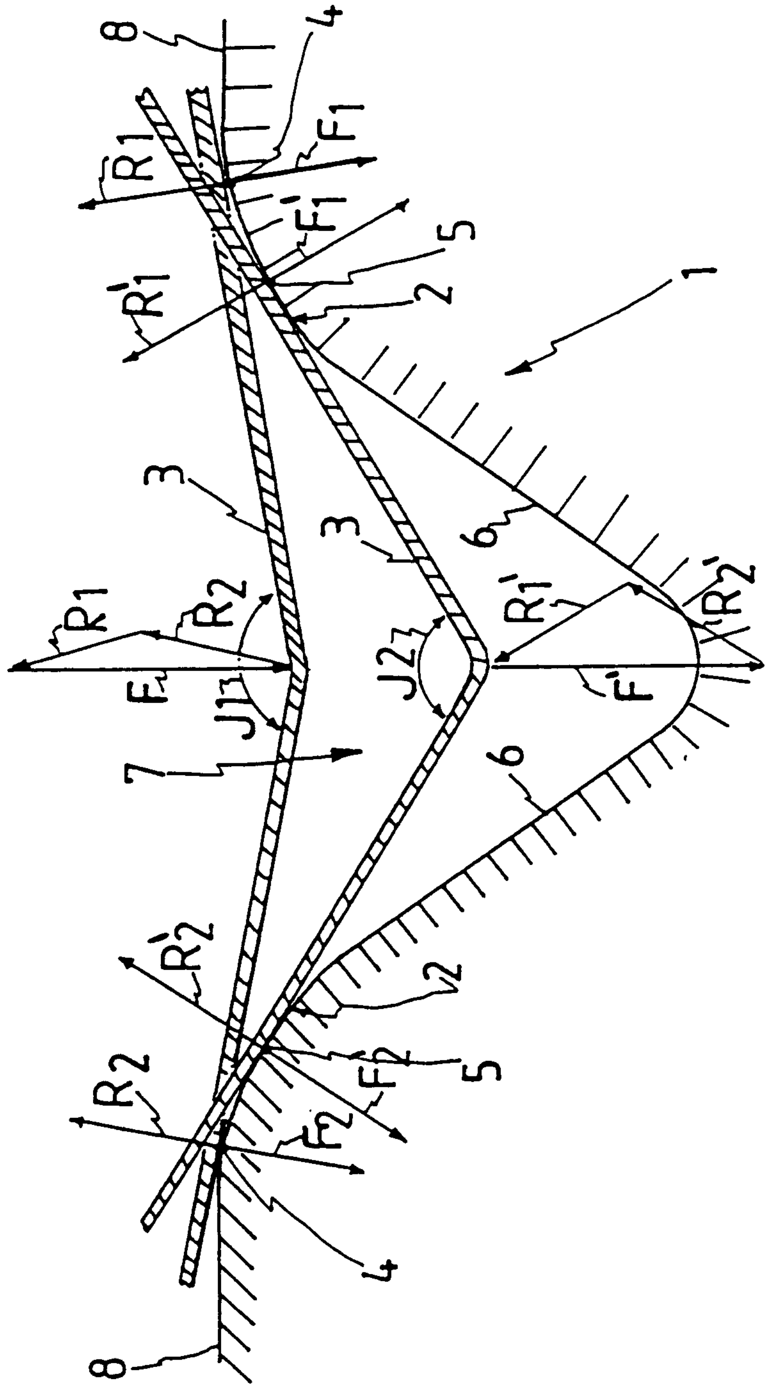

FIG. 1

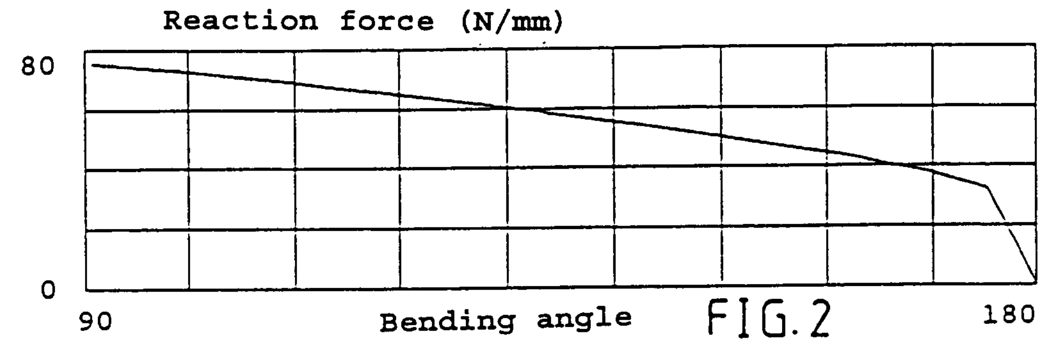

FIG.2

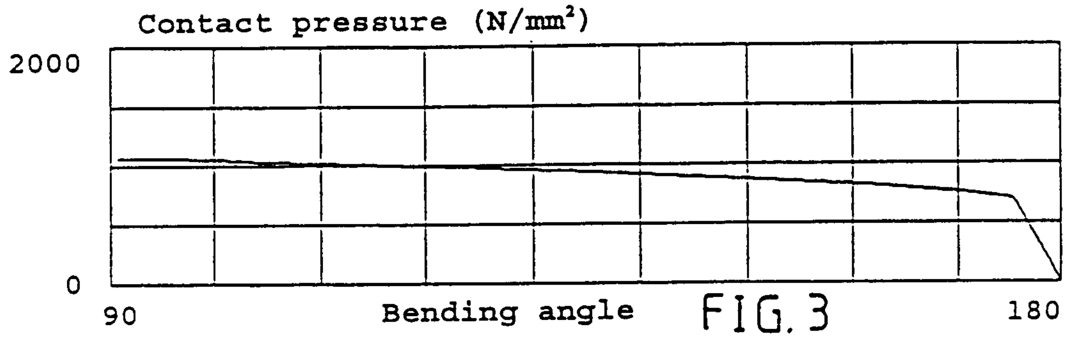

FIG.3

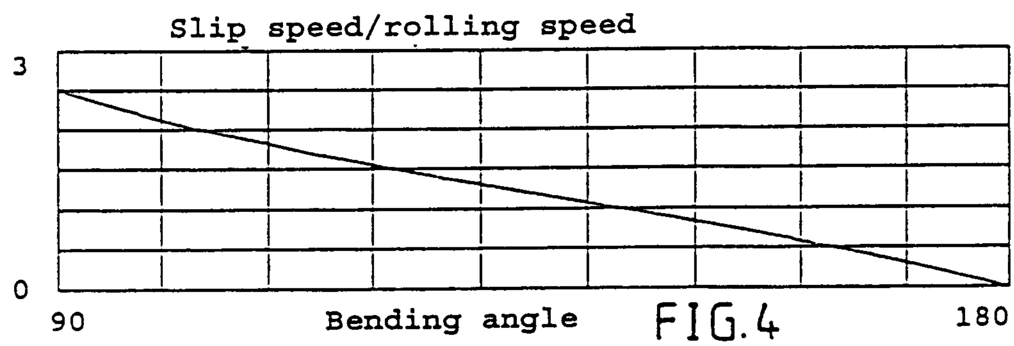

FIG.4

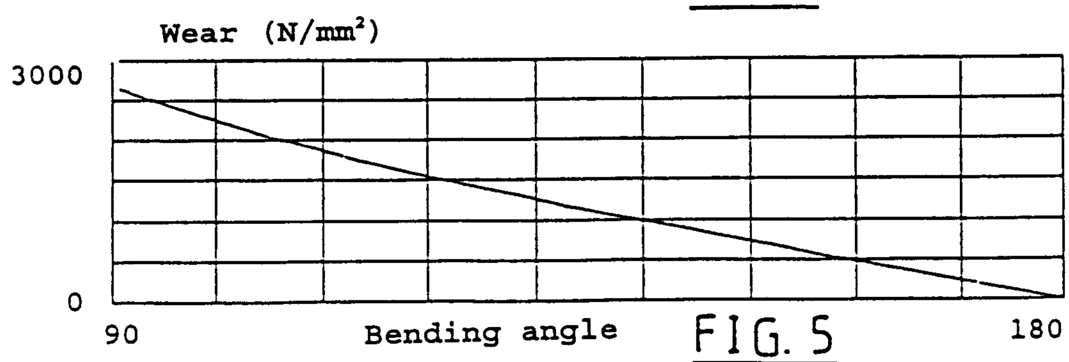

FIG.5

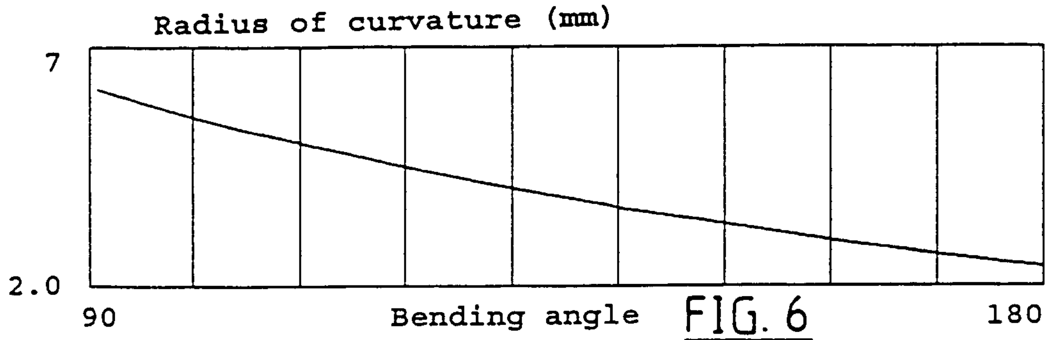

FIG. 6

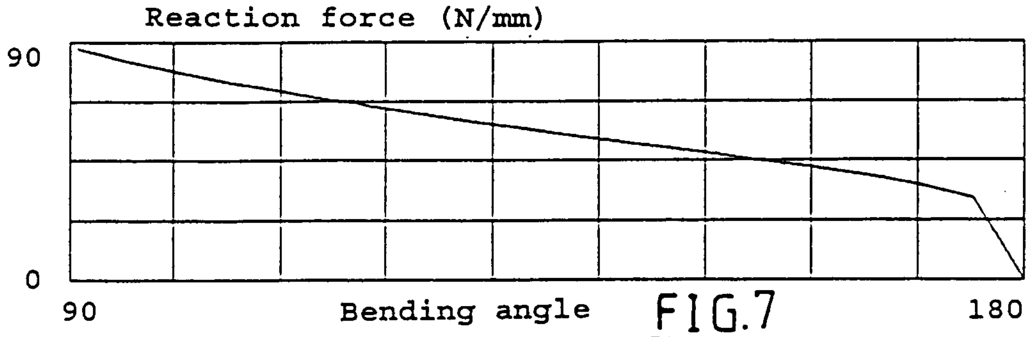

FIG. 7

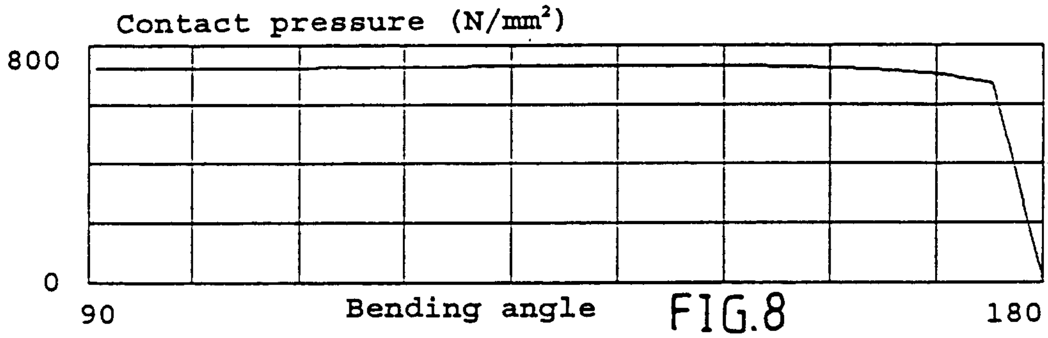

FIG. 8

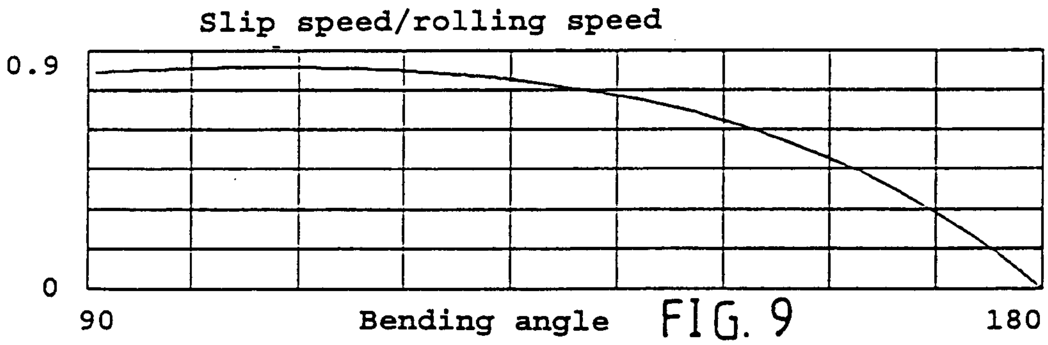

FIG. 9

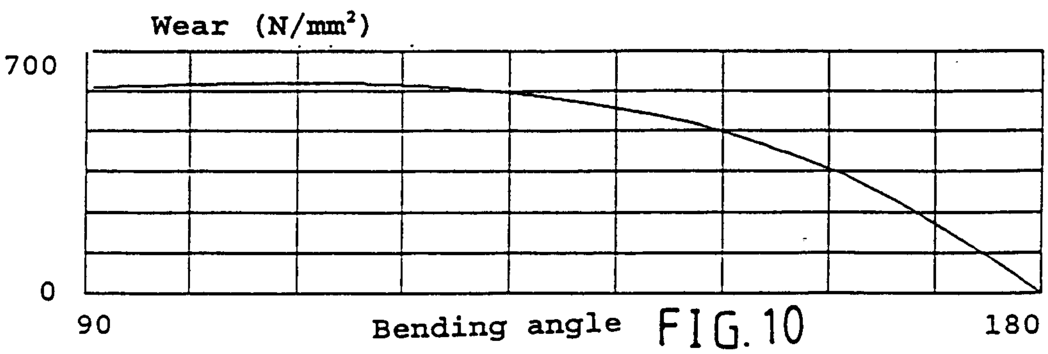

FIG. 10

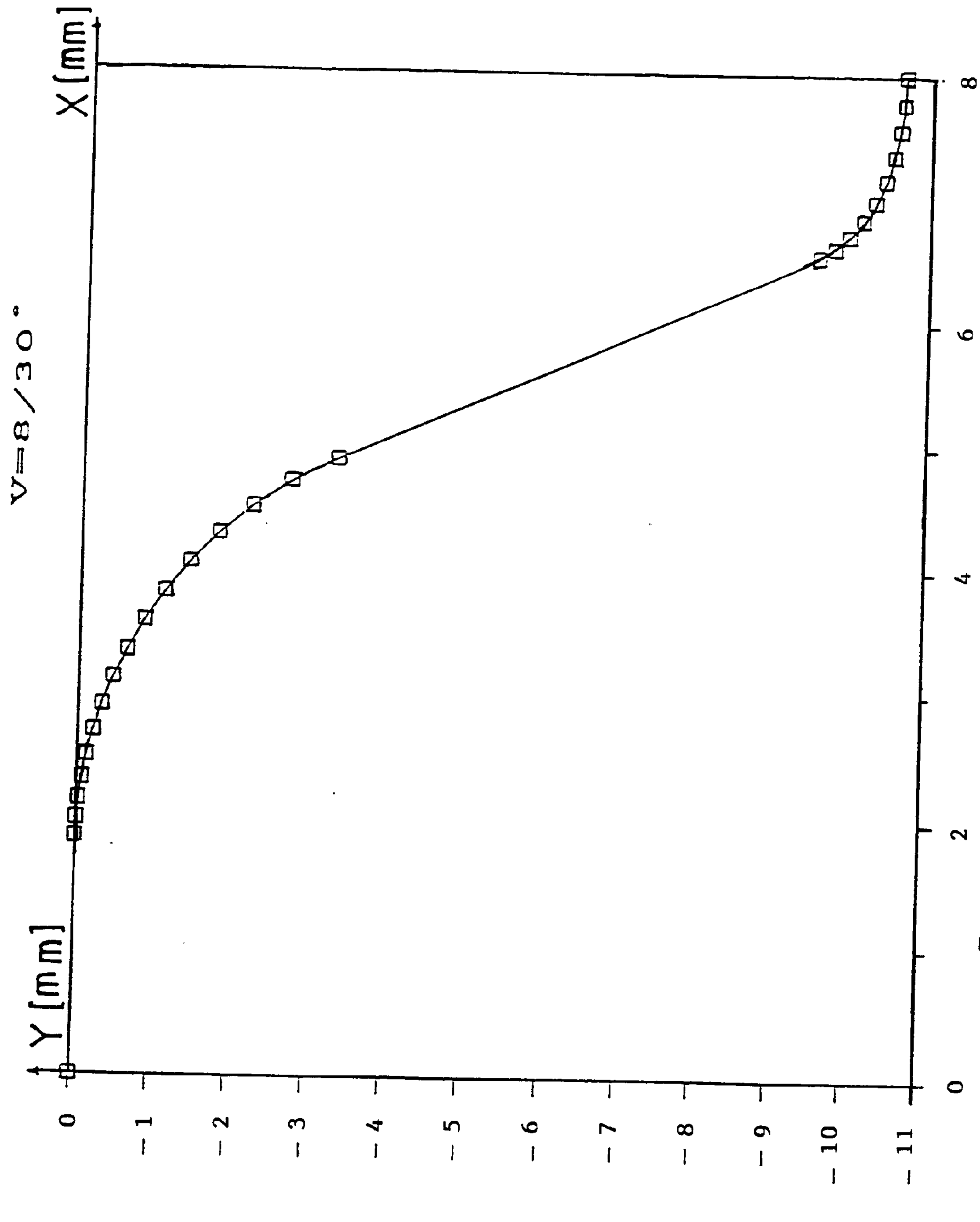

FIG. 11

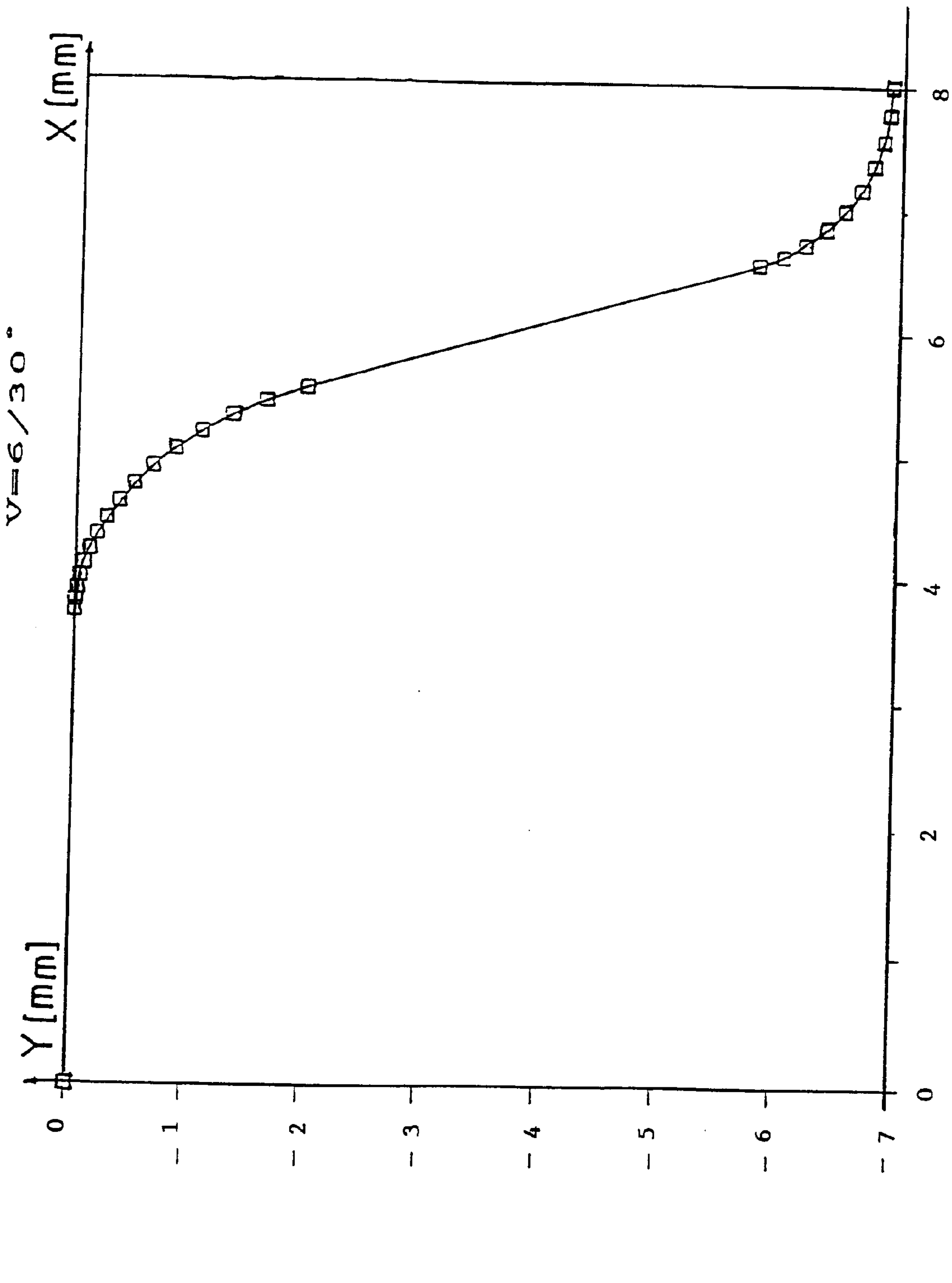

FIG. 12

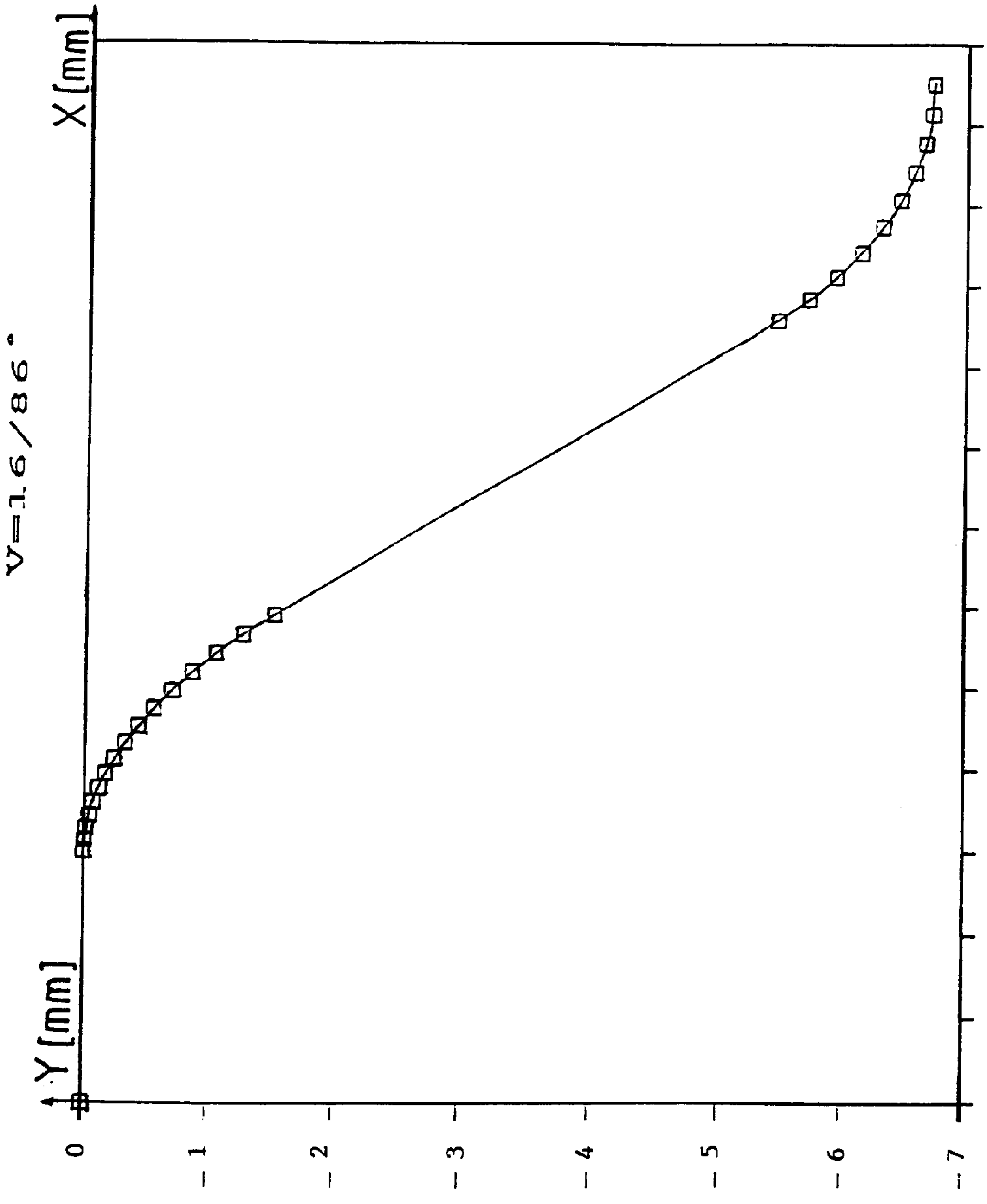

FIG.13

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 20 2993

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	KURT LANGE 'Lehrbuch der UMFORMTECHNIK', Band 3, 'BLECHUMFORMUNG,' 1975 , SPRINGER VERLAG , BERLIN * page 129, line 5 - line 12; figure 4.29 *	1,2	B21D5/02
A	GERHARD OEHLER 'Biegen unter Pressen, Abkantpressen, Abkantmaschinen, Walzenrundbiegemaschinen, profilwalzmaschinen' 1963 , CARL HANSER VERLAG , MüNCHEN * figure 9 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

B21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 February 1994	Ris, M

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