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(54) **EMBOSSING UNIT**

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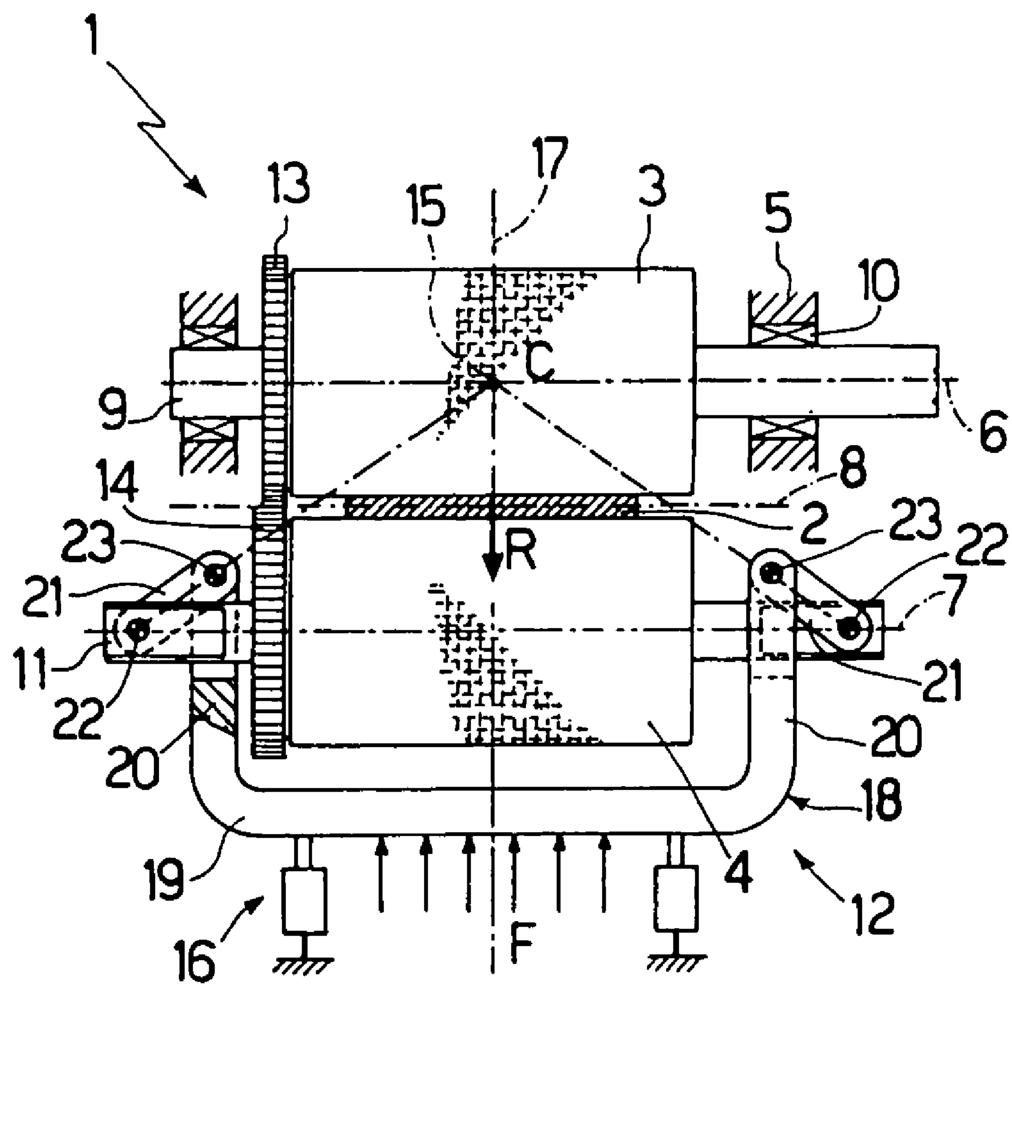
(57) **ABSTRACT**

An embossing unit, wherein sheet material is fed between a first and a second embossing roller counter-rotating respectively about a first and a second axis of rotation defining a plane, one of the embossing rollers being subjected, in use, to a compression force towards the other embossing roller; and wherein at least one of the axes of rotation oscillates about a virtual hinge or instantaneous centre of rotation, which is movable, in the plane defined by the axes of rotation, in response to displacement, along a pitch line of tangency between the embossing rollers, of a point of application of a reaction force.



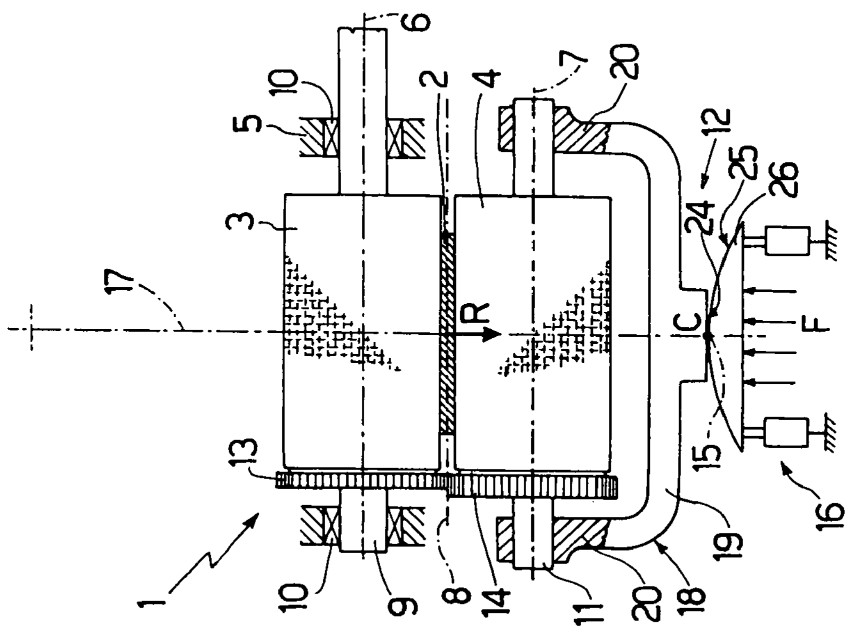

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Fig.2

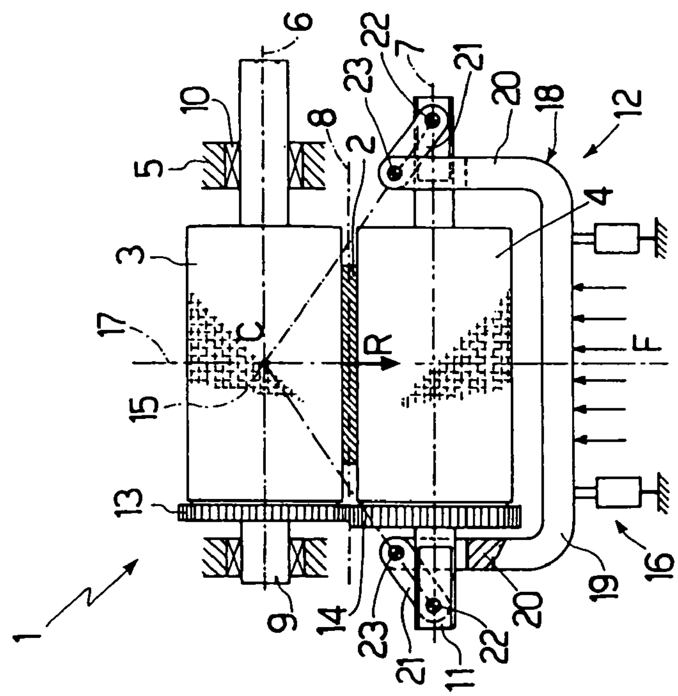
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Fig.1

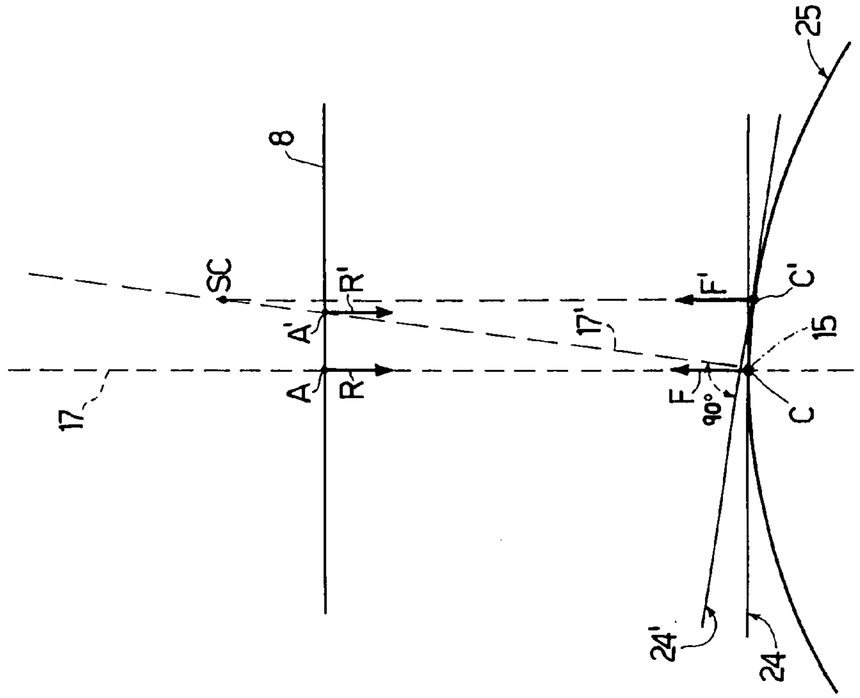
8
SC
A'
R'
F'
C'
17'
15
A
R
F
90°
C
17
24'
24
25

Fig.4

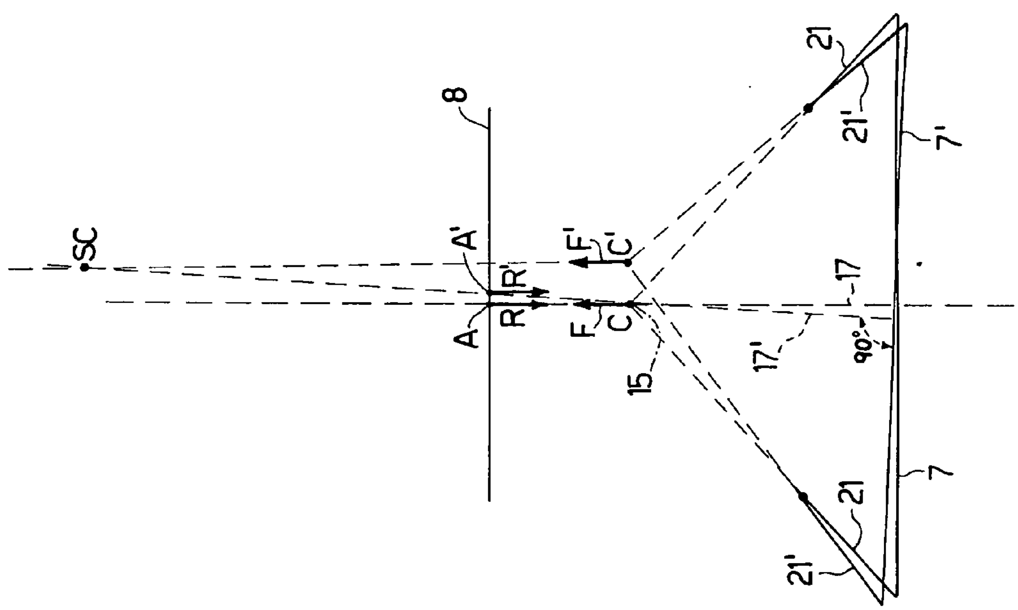
SC
8
A'
R'
F'
C'
A
R
F
C
15
17
17'
90°
21
21'
7'
7

Fig.3

EMBOSSING UNIT

[0001] The present invention relates to an embossing unit.

[0002] The present invention may be used to advantage for embossing strips (or sheets) of packing material (e.g. aluminium or foil or other materials) in the tobacco industry, to which the following description refers purely by way of example.

[0003] More specifically, the present invention relates to an embossing unit of the type comprising a first and second embossing roller counter-rotating respectively about a first and second axis of rotation defining a plane, the embossing rollers being tangent to each other along a pitch line lying in said plane; and a push assembly for pressing the embossing rollers against each other to grip, in use, the sheet material for embossing between the embossing rollers with a given compression force; at least one of the axes of rotation being an oscillating axis oscillating about a third axis perpendicular to said plane and defining, in said plane, a centre of rotation.

BACKGROUND OF THE INVENTION

[0004] In known embossing units of the type described above, one of the two embossing rollers is normally a drive roller mounted to rotate about a fixed axis of rotation, while the other embossing roller is normally a driven roller, which is mounted for rotation on a support, oscillates about a fixed pivot or hinge, and is subjected to said compression force which necessarily passes through the hinge axis.

[0005] To minimize axial displacement of the driven embossing roller in response to oscillation of the driven embossing roller about its fixed hinge, the fixed hinge is normally located as close as possible to the axis of the driven embossing roller and, therefore necessarily, on the opposite side of the driven embossing roller to the drive embossing roller.

[0006] In such a structure, if, as a result of any anomaly, e.g. transverse slip of the work strip with respect to a central reference position, the point at which the reaction force is applied is moved along the pitch line of tangency, the compression force—still passing through the fixed hinge—is misaligned with respect to the reaction force, thus producing a moment which tends to amplify the effects of the anomaly. In other words, a destabilizing moment is produced, which tends to rotate the driven embossing roller away from its parallel position with respect to the drive embossing roller. When this occurs and the elastic reaction of the work material between the two embossing rollers fails to restore the system to its initial condition, i.e. in which the two embossing rollers are parallel, the system, being unable to rebalance itself, assumes an improper position, which results in creasing of the work strip and/or in uneven embossing caused by the difference in compression to which the strip is subjected along the pitch line of tangency.

[0007] By way of a solution to the problem, the structure is normally subjected to a number of intricate adjustments designed to restrict the oscillation range of the driven roller to a narrow stable "region", in which the elastic reaction of the work material is sufficient to compensate the negative effects induced by any anomaly in the original balance of the system.

[0008] Despite the care and precision with which the adjustments are made, however, it is obviously impossible to predict the precise actual response of the work material, with the result that the structure remains highly unreliable.

[0009] To solve the problem, the structure could be modified so that the fixed hinge is located on the opposite side of the drive embossing roller to the driven embossing roller. In which case, the driven embossing roller would theoretically come close to the condition of a "suspended" body, thus resulting in an intrinsically stable system. In such a structure, however, the distance between the fixed hinge and the axis of the driven embossing roller would result in unacceptable axial displacement of the driven embossing roller in response to even relatively minor oscillation of the driven embossing roller about the fixed hinge. Moreover, in the event the system becomes destabilized, rebalancing again depends entirely on the elastic reaction of the work material.

SUMMARY OF THE INVENTION

[0010] It is an object of the present invention to provide an embossing unit of the type described above, designed to eliminate the aforementioned drawbacks.

[0011] According to the present invention, there is provided an embossing unit as claimed in the attached claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] A number of non-limiting embodiments of the invention will be described by way of example with reference to the accompanying drawings, in which:

[0013] **FIG. 1** shows a schematic, partly sectioned, functional vies of a first preferred embodiment of the embossing unit according to the present invention;

[0014] **FIG. 2** shows a schematic, partly sectioned, functional vies of a second preferred embodiment of the embossing unit according to the present invention;

[0015] **FIGS. 3 and 4** show operating graphs of the **FIGS. 1 and 2** embossing units respectively.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Number **1** in **FIGS. 1 and 2** indicates as a whole an embossing unit for embossing a continuous strip (or a sheet) **2** of packing material (normally a strip or sheet of foil).

[0017] Embossing unit **1** comprises two known embossing rollers **3** and **4**, which are fitted to a frame **5** to rotate about respective axes **6** and **7**, and have respective cylindrical outer surfaces having respective numbers of tips (not shown) meshing along a pitch line **8** of contact coplanar with axes **6** and **7** of embossing rollers **3** and **4**.

[0018] More specifically, embossing roller **3** is a drive roller fitted to a respective shaft **9**, which is coaxial with axis **6**, is fitted to frame **5** with the interposition of bearings **10**, and is connected angularly to an output shaft (not shown) of a known motor (not shown), fixed to frame **5** to receive a given drive torque from the motor.

[0019] Embossing roller **4** is fitted in rotary manner, with the interposition of internal bearings (not shown), to a shaft **11** coaxial with axis **7** and fitted in angularly fixed manner to a supporting unit **12**, and is rotated by embossing roller **3** via a gear transmission comprising a gear **13** fitted to shaft **9**, and a gear **14** coaxial with axis **7** and integral with embossing roller **4**.

[0020] Supporting unit **12** allows embossing roller **4** to oscillate about an instantaneous centre of rotation or hinge C—in the example shown, a virtual hinge—having an axis **15** perpendicular to, and movable transversely in, a fixed plane defined by axes **6** and **7**. Supporting unit **12** is interposed between embossing roller **4** and a push assembly **16**, which in turn is interposed between supporting unit **12** and frame **5**, and transmits to embossing roller **4** a compression force F passing at all times through instantaneous centre of rotation or hinge C and directed onto embossing roller **3** in a direction substantially perpendicular to axis **6** to grip strip **2** between embossing rollers **3** and **4**.

[0021] At least in an original balanced embossing condition, axes **6** and **7** are parallel to each other and perpendicular to a reference axis **17** through the centre line of embossing rollers **3** and **4** and, in use, through the centre line of work strip **2** between embossing rollers **3** and **4**.

[0022] Supporting unit **12** comprises a U-shaped fork **18** defined by a cross member **19**, located on the opposite side of embossing roller **4** to embossing roller **3**, and by two arms **20** perpendicular to cross member **19** and located on opposite sides of embossing roller **4** and symmetrically with respect to reference axis **17**.

[0023] In the **FIG. 1** example, supporting unit **12** is an articulated unit defined by an articulated quadrilateral whose frame is defined by fork **18**, which is fitted to frame **5** to move towards drive embossing roller **3** perpendicularly to axis **6** and in the direction of compression force F, and with cross member **19** positioned parallel to axis **6**. The articulated quadrilateral also comprises a cross member defined by shaft **11**; and two connecting rods **21** (or ties, given that, in the articulated structure defined by the above quadrilateral, the two connecting rods **21** are mounted to operate in traction) perpendicular to axis **15** and converging with each other towards embossing roller **3**. More specifically, the intersection of the lines of action of connecting rods **21** defines, at any instant, the position of instantaneous centre of rotation or hinge C. Each connecting rod **21** is hinged, by two pins **22** and **23** parallel to axis **15**, at one end to a respective end of shaft **11**, and at the other end to the free end of respective arm **20**.

[0024] In a variation not shown, the two connecting rods **21** are mounted to operate in traction, but diverge, i.e. arms **20** are located outwards of relative pins **22** with respect to reference axis **17**.

[0025] In the **FIG. 2** example, supporting unit **12** is an articulated "rocking" unit, in which the opposite ends of shaft **11** are fixed to the free ends of arms **20**, and a surface **24** of cross member **19**—which surface may be flat, as in the embodiment shown, or, in a variation not shown, may be an outwardly convex curved surface—rocks on a surface **25** of a base **26**, which, together with fork **18**, defines supporting unit **12** and is fitted to frame **5** with the interposition of push assembly **16** to move, on frame **5**, in the direction of compression force F. In the example shown, surface **25** is curved with its convexity facing cross member **19**, but, in a variation (not shown) in which surface **24** is curved, may also be flat or even curved with its concavity facing cross member **19**. In a variation not shown, surface **24** may be curved with its concavity facing base **26**, and surface **25** may be curved with its convexity facing cross member **19**.

[0026] In actual use, surfaces **24** and **25** roll, without sliding, on each other, and the point of contact between cross member **19** and surface **25** defines the instantaneous centre of rotation or hinge C (a virtual hinge in this case too), which is movable along surfaces **24** and **25** as a function of the angular position of embossing roller **4** about axis **15**.

[0027] Operation of embossing unit **1** will now be described with reference to **FIGS. 3 and 4**, which show graphically the way in which embossing unit **1** is restabilized automatically when destabilized by any anomaly—e.g. sideslip of, or a crease in, strip **2**—capable of moving a reaction force R application point A—originally located along reference axis **17**—laterally along pitch line **8** to a point A' which, by way of example, is located to the right of point A.

[0028] It should be pointed out that, for reasons of clarity, oscillation of embossing roller **4** is greatly amplified in **FIGS. 3 and 4**. In actual fact, oscillation is normally in the order of fractions of a degree (not illustratable graphically) and to all intents and purposes may be considered "infinitesimal".

[0029] Theoretically, if a system—in this case, driven embossing roller **4**—subjected to a compression force F and a reaction force R, both acting parallel to the same fixed plane, rotates-translates generically in this fixed plane, and oscillates infinitesimally as a result of a point A of application of reaction force R moving along a fixed line—in this case, pitch line **8**—extending in the fixed plane, it is always possible to determine an instantaneous centre of rotation C movable in the fixed plane both in absolute terms and relative to the system; and an instantaneous centre of stability SC, which by analogy with boats may be defined as a pseudo-metacentre, which is the point which lies in the fixed plane, is integral with the system, and, following infinitesimal oscillation of the system, moves, in the fixed plane and parallel to the fixed line (pitch line **8**), by the same amount as instantaneous centre of rotation C.

[0030] Graphically, the pseudo-metacentre or instantaneous centre of stability SC is the point through which compression force F passes before and after said rotation-translation. In other words, and with reference to **FIGS. 3 and 4**, the instantaneous centre of stability SC is the point defined by the intersection of two lines along which force F is assumed to be applied after each of the two movements into which rotation-translation of driven embossing roller **4** may be divided: a line through C and A' and which infinitesimal oscillation rotates about C with respect to reference axis **17**; and a line through point C' and translated parallel to reference axis **17** by displacement of C to C'. By definition, therefore, in a fixed-pivot system, instantaneous centre of rotation C and pseudo-metacentre or instantaneous centre of stability SC are fixed and coincide.

[0031] Since, as stated in the introduction, to stabilize the system, it is not enough that driven embossing roller **4** be mounted to oscillate about a fixed pivot or hinge (in this case, C and SC coincide) located on the opposite side of pitch line **8** to driven embossing roller **4**, the only way of achieving a permanently stable system, in which translation of driven embossing roller **4** may be rendered less important, is to support driven embossing roller **4** on a supporting unit, e.g. articulated or articulated rocking supporting unit **12**, which allows driven embossing roller **4** to oscillate about an instantaneous centre of rotation C detached from pseudo-metacentre or instantaneous centre of stability SC, i.e. an instantaneous centre of rotation C movable in said fixed plane.

[**0032**] In fact, only using a supporting unit of this type, can the average engineer determine the countless physical-geometric variables of embossing unit **1** to ensure permanent stability of the embossing unit (pseudo-metacentre or instantaneous centre of stability SC on the opposite side of pitch line **8** to driven embossing roller **4**) and that the instantaneous centre of rotation C remains permanently at an acceptable distance from driven embossing roller **4**.

[**0033**] As shown in **FIGS. 3 and 4**, embossing unit **1** responds to displacement of point A to A' by rotation-translation (clockwise rotation and leftward translation) of axis **7** in said fixed plane, i.e. in the **FIG. 3, 4** plane, and by displacement of instantaneous centre of rotation or hinge C in the same direction as point A.

[**0034**] As shown in **FIGS. 3 and 4**, however, instantaneous centre of rotation or hinge C moves in the same direction as point A (rightwards in the example shown) but further (i.e. faster) than point A, thus generating a torque which tends to restore the system as a whole to its original equilibrium condition (both forces F and R located opposite each other along reference axis **17**) which is therefore shown to be the stable equilibrium condition.

[**0035**] To determine the theoretical position assumed by pseudo-metacentre or instantaneous centre of stability SC—originally located along axis **17**—of embossing unit **1** following response of embossing unit **1** to an anomaly capable of moving from A to A' the point of application of reaction force R (indicated R'), the response is shown graphically as though it were performed in two successive movements.

[**0036**] During the first of the two movements, driven embossing roller **4** (only axis **7** is shown in **FIG. 3**, and only surface **24**, parallel to and integral with axis **7**, of cross member **19** is shown in **FIG. 4**) rotates about instantaneous centre of rotation or hinge C, which is considered fixed, taking with it reference axis **17**, which assumes a new configuration **17'** through A'. Since pseudo-metacentre or instantaneous centre of stability SC is originally located along axis **17** and, as stated, is integral with the oscillating system, rotation of axis **17** to **17'** draws pseudo-metacentre or instantaneous centre of stability SC into a new position along axis **17'**.

[**0037**] During the second of the two movements, instantaneous centre of rotation or hinge C moves to C', and compression force F (indicated F') assumes the correct position through C' and perpendicular to pitch line **8**, thus compensating reaction force R' and normally generating a moment.

[**0038**] Since, as stated, pseudo-metacentre or instantaneous centre of stability SC is located along axis **17'** and, by definition, is the point, integral with the oscillating system, which moves parallel to pitch line **8** like instantaneous centre of rotation or hinge C, the position along axis **17'** of pseudo-metacentre or instantaneous centre of stability SC is defined by the intersection of reference axis **17'** and the line of action of compression force F'.

[**0039**] Since the **FIGS. 3 and 4** graphs apply to finite oscillation a theory which can only be applied to infinitesimal oscillation, the graphic result does not exactly correspond to reality, but serves to show clearly the tendency of the system, in response to an anomaly moving point A, to move instantaneous centre of rotation or hinge C in the same direction as point A and to simultaneously produce a stabilizing torque.

[**0040**] As regards the physical-geometric characteristics of the supporting units **12** shown, it should be pointed out that, in the case of the **FIG. 1** supporting unit **12**, the main stability condition (pitch line **8** located between driven embossing roller **4** and pseudo-metacentre or instantaneous centre of stability SC) is normally achieved by operating connecting rods **21** as ties and never as push-rods. In the latter case, in fact, the system would be unstable. In the case of the **FIG. 2** supporting unit **12**, on the other hand, it is important to bear in mind that the smaller is the radius of curvature of the curved surface—in the example shown, surface **25**—on which driven embossing roller **4**"rocks", the closer the system comes to instability (fixed pivot, i.e. fixed SC and C, both located on the same side of pitch line **8** as driven embossing roller **4**). Said radius of curvature should therefore be fairly ample, e.g. equal to at least twice the distance between instantaneous centre of rotation or hinge C and pitch line **8**. If both surfaces **24** and **25** are curved (as referred to previously but not shown), the above consideration applies to the one with the smaller radius of curvature.

[**0041**] Given the above considerations, a number of variations (not shown) may be made to embossing unit **1**. For example, driven embossing roller **4** may be fixed, and drive embossing roller **3** oscillating. This solution would involve no theoretical complications, only a certain amount of difficulty—resolvable in known manner—as regards drive torque transmission.

[**0042**] Alternatively, both embossing rollers **3** and **4** may be oscillating. In an embossing unit of this sort, there would still be difficulty in transmitting the drive torque, and oscillation of the two embossing rollers, not being limited by a fixed-rotation-axis embossing roller, may be fairly considerable. Nevertheless, the above theory, relative to an embossing unit in which the pitch line of contact between the two embossing rollers is fixed, would clearly indicate the possibility of producing, and relatively easily, an embossing unit with a movable pitch line of contact (with both embossing rollers oscillating).

[**0043**] The above theory relates to a two-roller embossing unit. It should be pointed out that, in an embossing unit comprising more than two rollers, the same also applies to all or some of the pairs of rollers.

1. An embossing unit comprising a first and a second embossing roller (**3**, **4**) counter-rotating respectively about a first and a second axis (**6**, **7**) of rotation defining a plane, the embossing rollers (**3**, **4**) being tangent to each other along a pitch line (**8**) lying in said plane; and a push assembly (**16**) for pressing the embossing rollers (**3**, **4**) against each other to grip, in use, sheet material (**2**) for embossing between the embossing rollers (**3**, **4**) with a given compression force (F); at least one of the axes (**6**, **7**) of rotation being an oscillating axis (**7**) oscillating about a third axis (**15**) perpendicular to said plane and defining, in said plane, a centre of rotation (C); characterized in that the centre of rotation (C) is an instantaneous centre of rotation (C), which is movable in said plane in response to displacement, along the pitch line (**8**) of tangency between the embossing rollers (**3**, **4**), of a point (A) of application of a reaction force (R) to the compression force (F).

2. An embossing unit as claimed in claim 1, wherein said first embossing roller (**3**) is a drive embossing roller, and said second embossing roller (**4**) is a driven embossing roller.

3. An embossing unit as claimed in claim 1, wherein said oscillating axis (**7**) is the second axis (**7**); the first axis (**6**) is a fixed axis; and the push assembly (**16**) is connected to the second embossing roller (**4**).

4. An embossing unit as claimed in claim 1, wherein, of the embossing rollers (**3**, **4**), the one coaxial with said oscillating axis (**7**) is an oscillating embossing roller (**4**) oscillating about the third axis (**15**); a supporting unit (**12**) being provided to support the oscillating embossing roller (**4**); and said supporting unit (**12**) being interposed between the oscillating embossing roller (**4**) and the push assembly (**16**).

5. An embossing unit as claimed in claim 4, wherein the supporting unit (**12**) is an articulated unit.

6. An embossing unit as claimed in claim 5, wherein the supporting unit (**12**) comprises an articulated quadrilateral.

7. An embossing unit as claimed in claim 6, wherein said articulated quadrilateral comprises a frame (**18**) movable parallel to said compression force (F) by the push assembly (**16**); a cross member defined by a shaft (**11**) coaxial with said oscillating axis (**7**) and supporting for rotation said oscillating embossing roller (**4**); and two connecting rods (**21**) perpendicular to the third axis (**15**) and having respective lines of action intersecting at said instantaneous centre of rotation (C).

8. An embossing unit as claimed in claim 7, wherein each connecting rod (**21**) is a tie.

9. An embossing unit as claimed in claim 4, wherein the supporting unit (**12**) is an articulated “rocking” unit.

10. An embossing unit as claimed in claim 9, wherein the supporting unit (**12**) comprises a base (**26**) having a first surface (**25**); a fork (**18**) comprising a cross member (**19**) and two arms (**20**), the cross member (**19**) having a second surface (**24**); and a shaft (**11**) coaxial with said oscillating axis (**7**) and supporting said oscillating embossing roller (**4**); at least one of said first and said second surface (**25**, **24**) being a curved surface (**24**) contacting the other of said first and said second surface (**25**, **24**) at a point defining the instantaneous centre of rotation (C).

11. An embossing unit as claimed in claim 10, wherein said push assembly (**16**) is connected to the base (**26**).

12. An embossing unit as claimed in claim 11, wherein said curved surface (**24**) has a radius of curvature equal to at least twice the distance between the instantaneous centre of rotation (C) and the pitch line (**8**).

13. An embossing unit as claimed in claim 1, the embossing unit (**1**) having, at any instant and in use, an instantaneous centre of stability (SC) defined as the point which lies in said plane, is integral with said oscillating axis (**7**), and, following infinitesimal oscillation of said oscillating axis (**7**), moves, in said plane and parallel to the pitch line (**8**), by the same amount as the instantaneous centre of rotation (C); the pitch line (**8**) being located, in use, between the instantaneous centre of stability (SC) and the oscillating axis (**7**).

* * * * *