(12) UK Patent Application (19) GB (11) 2 040 208 A

(21) Application No **7944341**
(22) Date of filing **24 Dec 1979**
(30) Priority data
(31) **54/000815**
(32) **8 Jan 1979**
(33) **Japan (JP)**
(43) Application published
28 Aug 1980
(51) **INT CL³**
B26F 1/38
(52) Domestic classification
B4B 5A 5D 5P 5S
(56) Documents cited
None
(58) Field of search
B4B
(71) Applicants
Mitsubishi Jukogyo Kabushiki Kaisha
5-1, Marunouchi 2-chome, Chiyoda-ku, Tokyo, Japan.
(72) Inventors
Tadao Otomaru
(74) Agents
Ronald Rushton - John H. Sommerville.

(54) **Rotary die cutter**

(57) A rotary die cutter for punching out shaped pieces from sheet material such as corrugated cardboard comprises a knife cylinder 1, an anvil cylinder 2, a pair of driving gears 9, 13 having different numbers of teeth and coupled to said respective cylinders, a pair of helical gears 11, 12 meshed with each other and interposed between the driving gears 9, 13 and an hydraulic ram 8 provided for sliding the anvil cylinder in its axial direction. Upon actuation of the ram the anvil cylinder is displaced not only in the axial direction but also in the circumferential direction via the helical gears to disturb the regular rotational phase relationship between the anvil cylinder and the knife cylinder thereby avoiding repeated impressions on the anvil cylinder.

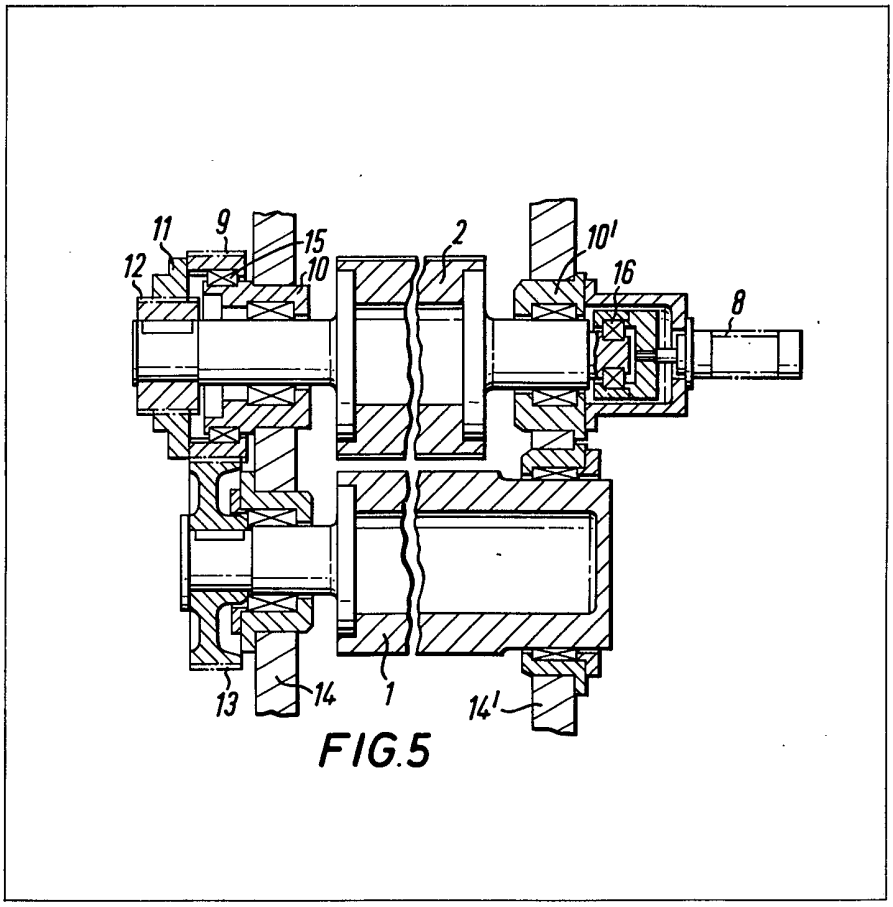

FIG.5

The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

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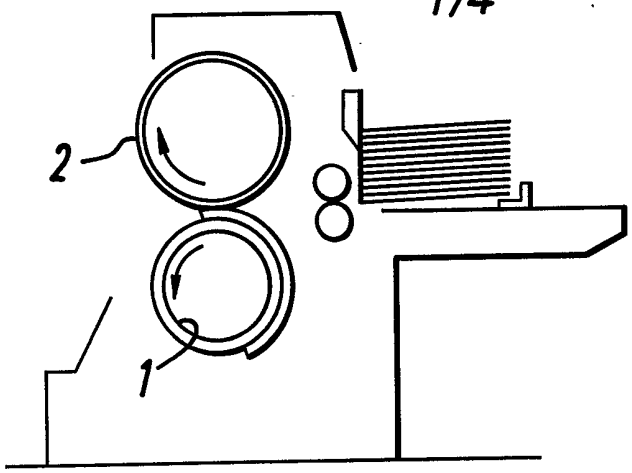

FIG.1

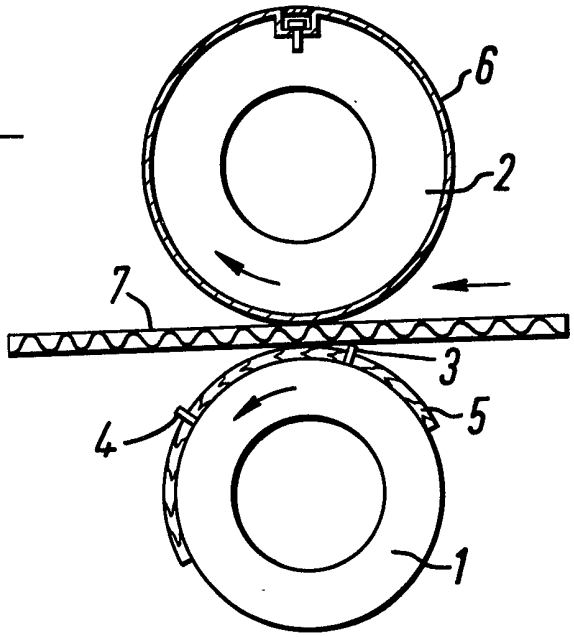

FIG.2

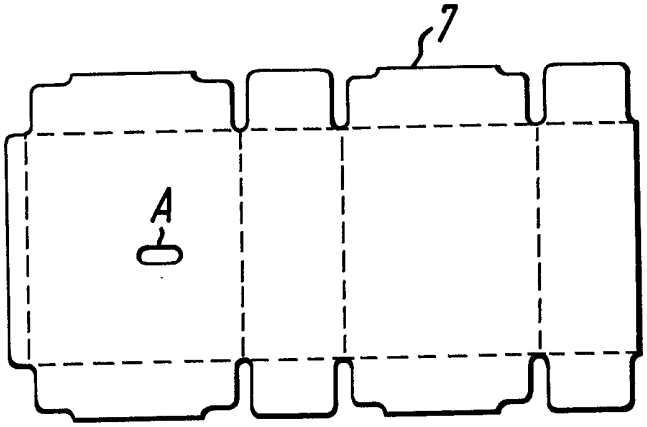

FIG.3

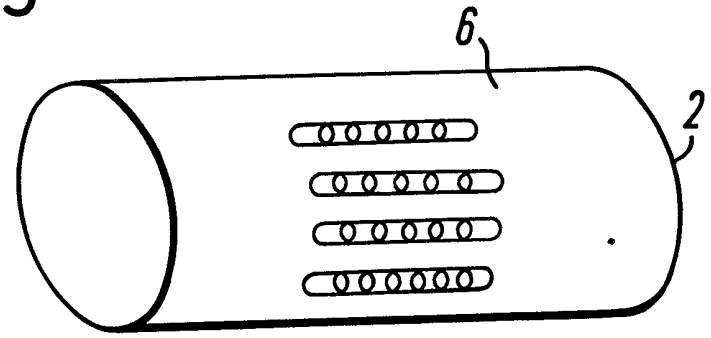

FIG.4

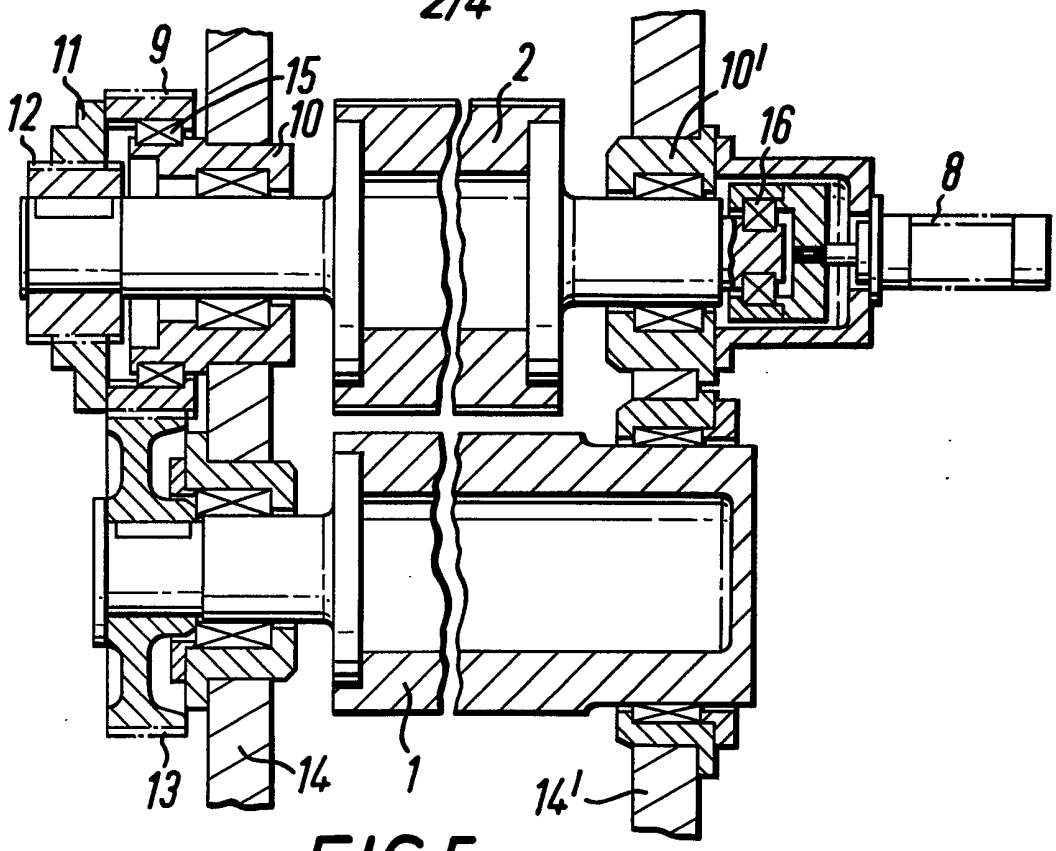

FIG.5

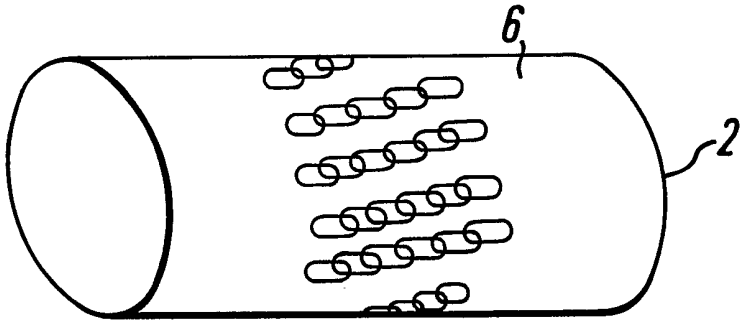

FIG.7

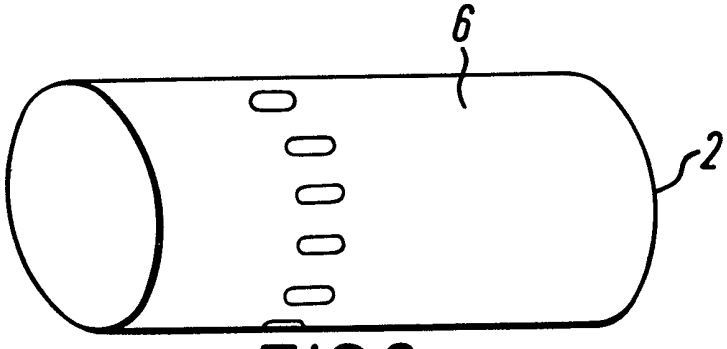

FIG.8

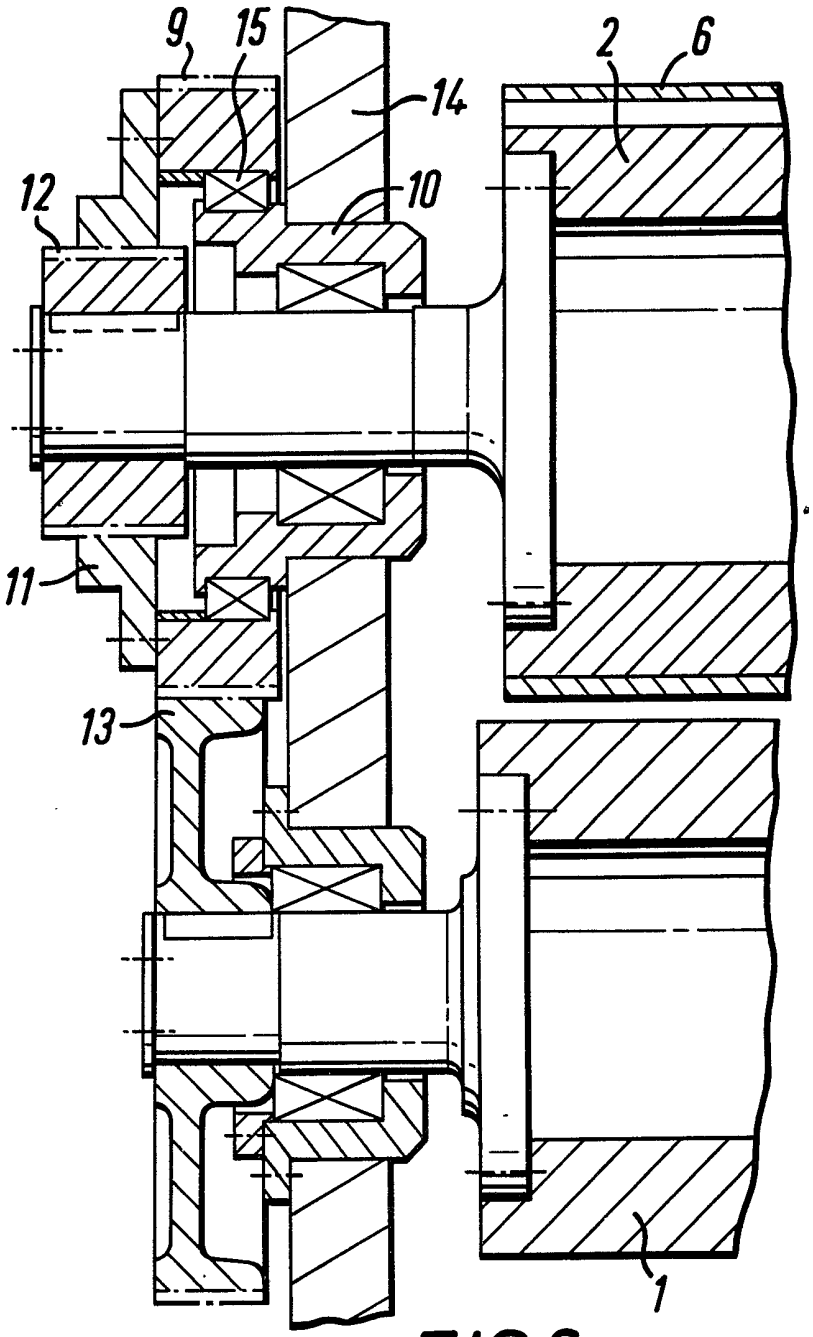

FIG.6

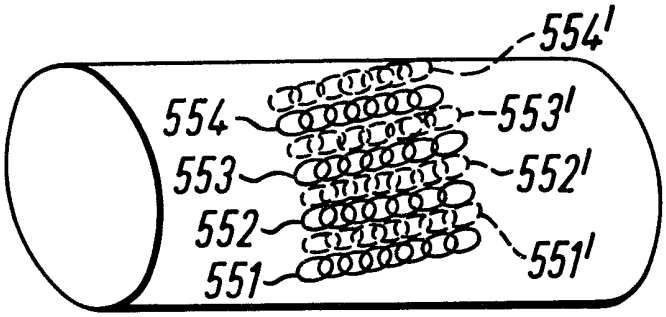

FIG.10

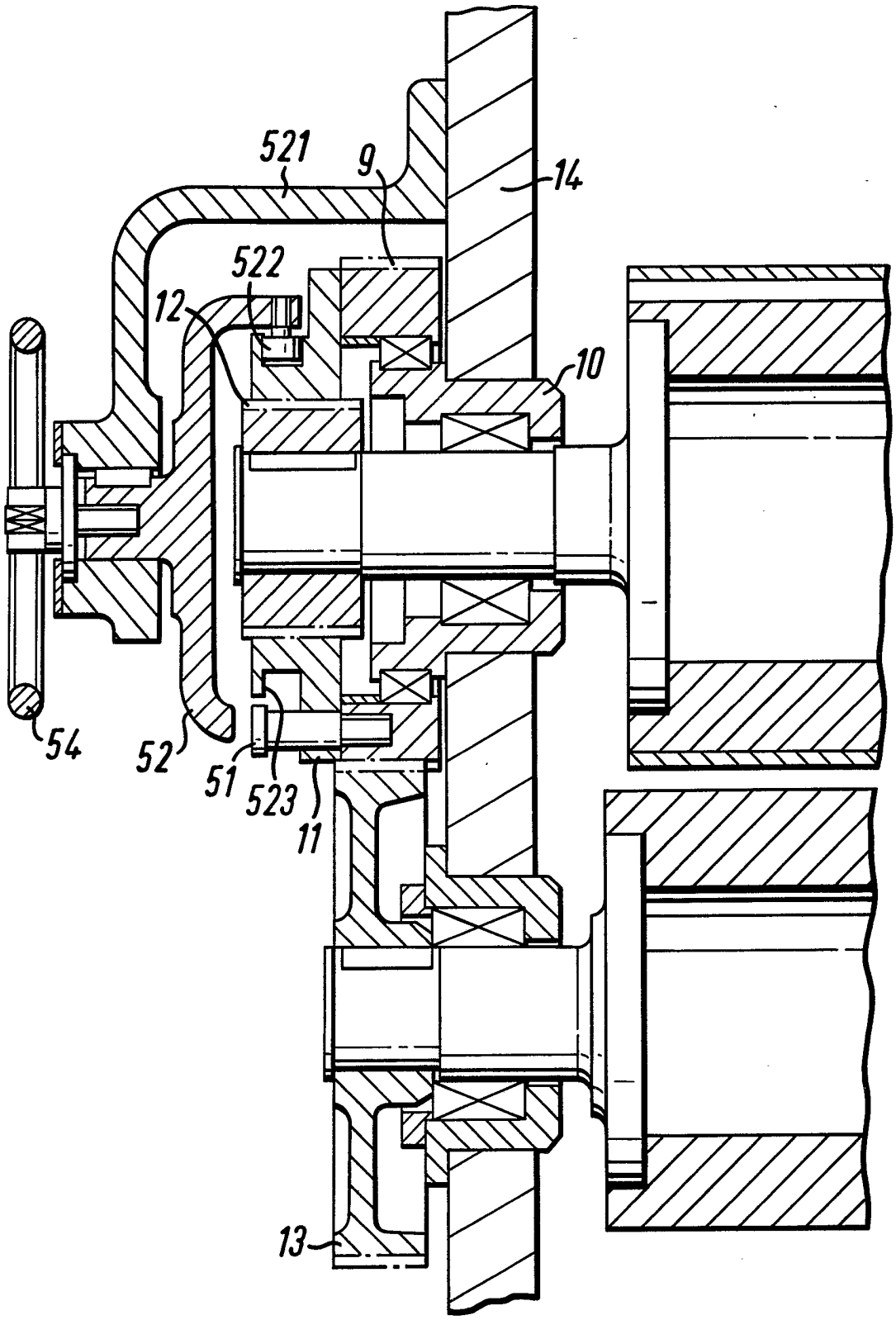

FIG.9

SPECIFICATION

Rotary die cutter

The present invention relates to improvements in a rotary die cutter for punching out a predetermined shaped piece from sheet material such as corrugated cardboard with a punching knife.

Heretofore, a rotary die cutter has been known, which is of the type including a knife cylinder provided with a punching knife on its outer peripheral surface, an anvil cylinder having an anvil sheet for receiving said punching knife wrapped around its outer peripheral surface, and driving gears having different numbers of teeth which are coupled to the axial end portions of said cylinders and meshed with each other, said knife and said anvil cylinder being adapted to cooperate with each other for punching out a corrugated carboard sheet inserted therebetween.

More particularly, one example of the known rotary die cutters is shown in Figures 1 and 2 of the accompanying drawings. Thus, the die cutter comprises a knife cylinder 1 and an anvil cylinder 2 disposed in parallel and opposed relationship. On the knife cylinder 1 are mounted a punching knife 3 for punching out a predetermined shaped piece of corrugated cardboard sheet fed therethrough and/or a scriber 4 for scribing a line on the sheet via a die lumber or backing board 5. Around the outer peripheral surface of the anvil cylinder 2 and anvil sheet 6 is wrapped, which is made of urethane. These respective cylinders 1 and 2 are rotationally driven by an externally mounted driving motor via a pair of spur gears coupled to the axial end portions of the respective cylinders and meshed with each other. In order to prevent the punching knife 3 from striking against the anvil sheet 6 at the same position for every revolution, the numbers of teeth of the respective spur gears are different, and also the anvil cylinder 2 is moved somewhat in the axial direction. Thus, when the corrugated cardboard sheet 7, which is fed from a cardboard feeder, is inserted between the respective cylinders, a predetermined shape of cardboard piece is punched out by the punching knife 3 from the corrugated cardboard sheet 7 and, if used, a fold line is scribed by the scriber 4 on the punched cardboard piece. It will be appreciated that the punching knife 3 and the scriber 4, in use, bite into the anvil sheet 6 and the punched cardboard piece, respectively. One example of a corrugated cardboard piece which has been punched out from the corrugated cardboard sheet 7 and scribed with fold lines, is shown in Figure 3. The punching impressions left in the anvil sheet 6 by the repeated punching out of a hole A in the cardboard pieces (see Figure 3) is illustrated in Figure 4. From this Figure, it can be seen that, owing to the selection of different numbers of teeth for the spur gears for the two cylinders and the axial movement of the anvil cylinder 2, the punching impressions for the hole A do not overlap at the same position, but they are distributed along a number of line segments extending axially on said anvil cylinder. However, since the line segments of punching impressions is a finite number, determined as a function of the gear ratio of the meshed spur gears, the punching impressions caused by the punching knife 3 are concentrated in a limited surface region of the anvil cylinder 2. Hence, such rotary die cutters still have the disadvantage that the cutting capability of the punching knife is degraded in the concentrated regions; thereby the time interval between repolishing or replacement of the surface of the anvil cylinder is shortened.

An object of the present invention is to provide an improved rotary die cutter which is free from the above-described disadvantage, and in which provision is made such that the punching knife may strike against the surface of the anvil cylinder more uniformly and hence enable the useful life of the anvil surface to be extended to improve its maintanence and economy.

According to the present invention, there is provided a rotary die cutter including a machine frame, a knife cylinder provided with a punching knife on its outer peripheral surface, an anvil cylinder providing a surface for receiving said punching knife, and driving gears having different numbers of teeth which are coupled to respective cylinders and meshed with each other, said knife cylinder and said anvil cylinder being adapted to cooperate with each other for punching sheet material inserted therebetween, characterised in that said knife cylinder is rotatably supported by said machine frame in an axially constrained manner and is fixedly secured to one of said driving gears, in that said anvil cylinder is rotatably and axially slidably supported by said machine frame and is coupled to the other of said driving gears through a pair of helical gears, one of said helical gears being axially fixed to said anvil cylinder, while the other helical gear is mounted on said other driving gear which is in turn rotatably supported by said machine frame in an axially constrained manner, and in that sliding means are provided for sliding said anvil cylinder in its axial direction.

In such a construction of rotary die cutter, sliding movement in the axial direction of the anvil cylinder caused by the sliding means would simultaneously generate a certain extend of rotation of the anvil cylinder due to the intermediary of said pair of helical gears, and so, during the operation of said sliding means, the relative positioning between the outer peripheral surfaces of the knife cylinder and the anvil cylinder would vary both in the axial direction and in the circumferential direction. Thus, points of repeated punching impressions corresponding to a given point on the punching knife aligns on the outer peripheral surface of the anvil cylinder along a straight line in an oblique direction rather than in the axial direction. Therefore, punching impressions generated by an axial segment of the punching knife would not concentrate on an axial straight line on the anvil cylinder as is the case with known rotary die cutters, so that the life of the anvil sheet is extended, resulting in a prolongation of the time intervals between repolishings and replacements of the anvil sheet which provides the anvil surface, and thereby the maintenance, management and economy for the punching operations can be

improved.

According to a feature of the present invention, said other helical gear is coaxially mounted on said other driving gear in an axially displaceable but angularly fixed manner, and adjusting means are provided for adjustable varying and constraining the relative axial positioning between said other helical gear and said other driving gear.

This feature enables the rotational phase relationship between the anvil cylinder and the knife cylinder to be arbitrarily and continously varied independently of the axial displacement of the anvil cylinder, and thereby the punching impressions generated on the anvil surface by the punching knife can be more uniformly distributed over the entire outer peripheral surface of the anvil cylinder without any restriction, so that the life of the anvil sheet can be further extended and the maintenance, management and economy of the punching operations can be still further improved.

The above-mentioned and other features and advantages of the present invention will become more apparent by reference to the following description of two preferred embodiments taken in conjunction with the accompanying drawings, in which:-

Figure 1 is a general schematic view of one example of rotary die cutter in the prior art,

Figure 2 is a vertical cross-section of a central portion of the knife and anvil cylinders of the cutter of Figure 1,

Figure 3 is a plan view of one example of a corrugated cardboard piece punched out by means of a rotary die cutter,

Figure 4 is a schematic view showing punching impressions left on the anvil cylinder after repreated use of a rotary die cutter in the prior art,

Figures 5 to *8* show a rotary die cutter according to a first preferred embodiment of the present invention, Figure 5 being a vertical cross-section view taken along a plane including the axes of the knife and anvil cylinders, Figure 6 being an enlarged cross-sectional view of axial end portions of said anvil and knife cylinders, Figure 7 being a schematic view showing punching impressions left on the anvil cylinder after repeated use, and Figure 8 being a schematic view similar to Figure 7 when a hydraulic cylinder for axially sliding the anvil cylinder is not operated,

Figure 9 is an enlarged partial cross-section view showing a part similar to that shown in Figure 6 of the second preferred embodiment of rotary die cutter, and,

Figure 10 is a schematic view showing punching impressions left on the anvil cylinder after repeated use of the second preferred embodiment of rotary die cutter.

Referring now to the first preferred embodiment of cutter illustrated in Figures 5 to 8, a knife cylinder 1 is rotatably supported at its opposite ends via bearings by machine frames 14 and 14', and an anvil cylinder 2 is rotatably supported at its opposite ends via bearings 10 and 10', also by said machine frames 14 and 14'. One end of the knife cylinder 1 is fixedly secured to a spur gear 13. On an outer periperal surface of the bearing 10 of said anvil cylinder a spur gear 9 is rotatably mounted via a bearing 15, and said spur gears 13 and 9, which have different numbers of teeth are meshed with each other. An annular ring providing an inwardly directed helical rack 11 is concentrically and fixedly secured to the spur gear 9, and a further annular ring providing an externally directed helical gear 12 is fixedly secured to the end portion of the anvil cylinder 2, which portion projects through a central opening in the spur gear 9. The helical rack 11 and helical gear 12 are meshed with each other. The length of the helical gear 12 is made larger than the length of the helical rack 11 by an amount corresponding to a required amount of axial movement of the anvil cylinder 2 in use. Alternatively, the length of the helical rack 11 could be made larger than the helical gear 12 by the same amount. The cylinder of a hydraulic piston and cylinder unit 8 is mounted on the frame 14' with its piston connected with the anvil cylinder 2 via a bearing 16. Accordingly, by actuating the hydraulic unit 8, the anvil cylinder 2 can be made to slide in the axial direction independently of its rotation.

In operation of the rotary die cutter, driving power is transmitted from a suitable motor or other power source (not shown) to the spur gear 13 through a transmission device (not shown) to rotate the knife cylinder 1, and is further transmitted to the anvil cylinder 2 through the spur gear 9, helical rack 11 and helical gear 12 to rotate said anvil cylinder. During rotation of the knife cylinder 1 and the anvil cylinder 2, if the hydraulic unit 8 is actuated, then the anvil cylinder 2 slides in the axial direction and the helical gear 12 is also moved in the axial direction jointly with the anvil cylinder 2, so that the meshing position between the helical rack 11 and helical gear 12 is changed, resulting in rotation of the helical rack 11. Consequently, the position of the punching impression on the anvil cylinder 2 caused by the punching knife (not shown) on the knife cylinder 1 is displaced obliquely relative to the axial direction of the anvil cylinder 2. One example of an array of repreated punching impressions for the holes A of cardboard pieces as shown in Figure 3 on the anvil cylinder 2 is shown in Figure 7. If the actuation of the hydraulic unit 8 is stopped, the repeated punching impressions on the anvil cylinder 2 caused by the punching knife appear as shown in Figure 8, the punching impressions being arrayed along one circumference at a regular interval determined as a function of the particular gear ratio of the spur gears 9 and 13.

As described above, since the anvil cylinder of this embodiment is displaced both in the axial direction and in the rotational direction by actuating the hydraulic unit 8 and thus the repeated punching impressions on said anvil cylinder are arrayed along a plurality of lines which are oblique to the axial direction, the areas where the punching impressions overlap with each other are reduced, resulting in a more uniform wear of the anvil surface. Thus, the necessity for repolishing or replacement of the anvil surface is reduced, the life of said surface is extended, and also since the amount of biting of the punching knife is made more uniformly over the entire surface of the anvil cylinder, the cutting

capability of the punching knife can be stabilized and its punching precision can be extremely enhanced.

Referring to Figures 9 and 10 in respect of the second preferred embodiment, those component parts equivalent to component parts in the first preferred embodiment are given the same reference numerals.

In this embodiment, an inwardly directed helical rack 11 of an annular ring is mounted on a spur gear 9 via a slide shaft 51 so as to be freely slidable in the axial direction of an anvil cylinder 2. Reference numeral 521 designates a bearing fixedly secured to a machine frame 14, which slidably supports a phase adjusting shaft 52. At one end of the phase adjusting shaft 52 a roll 522 is rotatably supported, which roll engages within a groove 523 formed around the outer periphery of the annular ring for the helical rack 11. The other end of the phase adjusting shaft 52 is fixedly secured to a shaft of a rotatable handle 54, which is threadedly engaged with the bearing 521 so that the phase adjusting shaft 52 may be adjusted in the axial direction.

In operation of this embodiment, after a certain number of corrugated cardboard sheets have been punched, the handle 54 is rotated by a predetermined amount so as to adjust the position of the phase adjusting shaft 52 in the axial direction of the anvil cylinder 2, the movement being transmitted to the helical rack 11 via the roll 522. Thus, the helical rack 11 moves in the same direction, resulting in a phase shift in the rotational direction between the helical rack 11 and its meshing helical gear 12. Consequently, the locus of repeated punching impressions for the holes A of cardboard pieces as shown in Figure 3 on the surface of the anvil cylinder is displaced from a plurality of oblique lines 551 to 554 shown by solid lines in Figure 10 to similar oblique lines 551' to 554' shown by the dotted lines in said Figure.

Thus, by manipulating the handle for displacing the phase adjusting shaft 52 is described above, the positions of the repeated punching impressions on the surface of the anvil cylinder can be distributed continuously and even more uniformly over a broader area on said surface. Consequently, the life of the anvil surface is further extended and the cutting capability of the punching knife further stabilized.

While there have been described and illustrated specific preferred embodiments of the invention, it will be understood that variations or modifications of details of said embodiments may be made without departing from the true spirit and scope of the invention.

CLAIMS

1. A rotary die cutter including a machine frame, a knife cylinder provided with a punching knife on its outer peripheral surface, an anvil cylinder providing a surface for receiving said punching knife, and driving gears having different numbers of teeth which are coupled to respective cylinders and meshed with each other, said knife cylinder and said anvil cylinder being adapted to cooperate with each other for punching sheet material inserted therebetween; characterized in that said knife cylinder is rotatably supported by said machine frame in an axially constrained manner and is fixedly secured to one of said driving gears, in that said anvil cylinder is rotatably and axially slidably supported by said machine frame and is coupled to the other of said driving gears through a pair of helical gears, one of said helical gears being axially fixed to said anvil cylinder, while the other helical gear is mounted on said other driving gear which is in turn rotatably supported by said machine frame in an axially constrained manner, and in that sliding means are provided for sliding said anvil cylinder in its axial direction.

2. A rotary die cutter as claimed in Claim 1, further characterized in that said other helical gear is coaxially mounted on said other driving gear in an axially displaceable but angularly fixed manner, and in that adjusting means are provided for adjustably varying and constraining the relative axial positioning between said other helical gear and said other driving gear.

3. A rotary die cutter constructed, arranged and adapted to operate substantially as hereinbefore described with reference to Figures 5 to 8, or 9 and 10.

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Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.