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CRIMPING OF YARN

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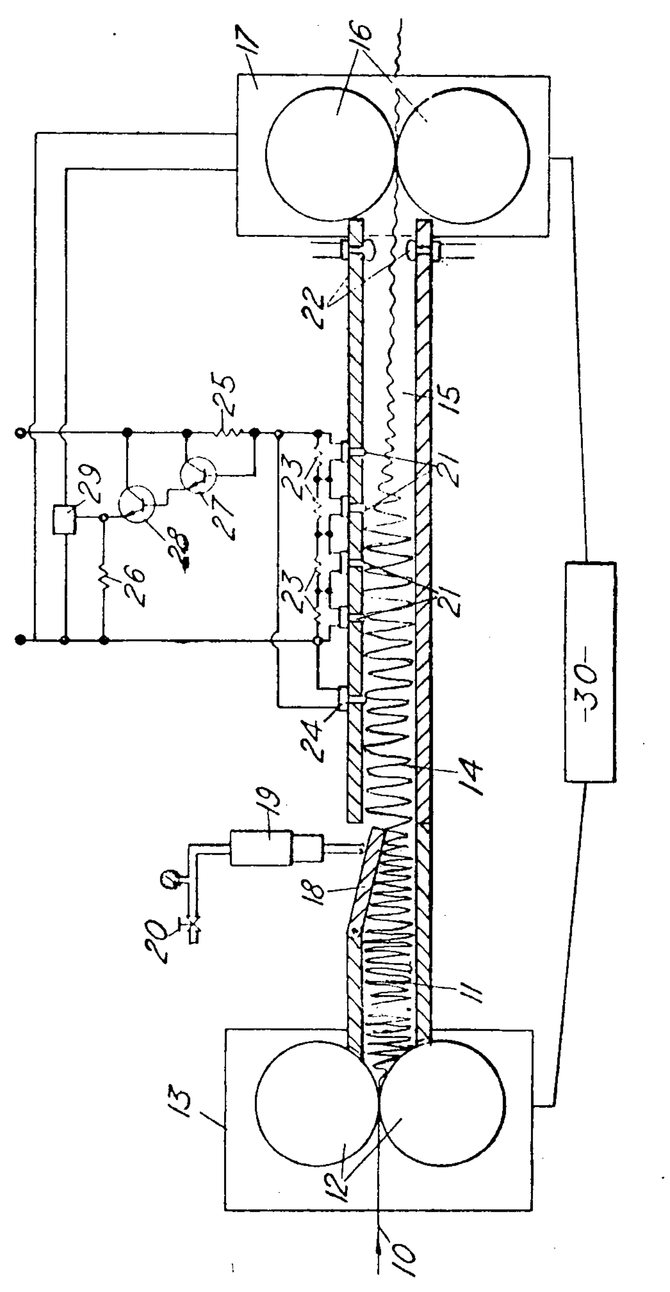

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CRIMPING OF YARN

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ABSTRACT OF THE DISCLOSURE

The improvement in methods and apparatus for controlling stuffing box crimping comprising photocell measuring means arranged to provide a signal smoothly related to the amount of yarn in the buffer chamber. The ratio of withdrawal to delivery of the yarn is controlled thereby maintaining the amount of yarn in the buffer chamber constant with the counter-pressure measurement regulator maintaining the controlled ratio at a constant value.

This is a continuation-in-part of application Ser. No. 718,266, filed Apr. 2, 1968, now abandoned.

The present invention concerns improvements in or relating to the crimping of yarn by the so-called stuffer-box process. In this specification, "yarn" is used as the generic term to include any textile fibre or filament or assemblies of fibres and filaments and is not to be read as being restricted to fibres, filaments and assemblies of any particular thickness.

The use of stuffer-box crimpers in the production of crimped yarns is well known. Generally, uncrimped yarn is conveyed by delivery rollers into a stuffer-box which is restricted at a suitable point by a moveable counter-pressure means, for instance a flap or a plunger. The yarn is compressed inside the stuffer-box until the internal pressure is sufficient to force open the counter-pressure means when crimped yarn exits the stuffer-box and may then advance or be advanced to subsequent operating stages, and a state of equilibrium upon which the crimping effect depends will be reached between the pressure exerted by the yarn and the pressure exerted by the counter-pressure means.

In practice, the crimping effect may not be constant owing to various influences such as, for example, variations in denier, moisture content or frictional properties of the yarn fed to the crimper and it is necessary to measure regularly some crimp characterising parameter and adjust the pressure exerted by the counter pressure means if necessary to keep the crimp characteristics within limits, the limits which may be tolerated for the particular crimped yarn which is being manufactured.

A suitable and commonly used parameter for characterising crimp is that of crimp ratio which I define herein as the ratio of the length of sample the uncrimped yarn to the crimped length of such sample. The measurement of the crimp characterizing parameter generally has to be performed by hand, however, and this is a tedious process and long delays may occur before corrective action if necessary can be taken.

I have discovered a method of producing stuffer-box crimped yarn having crimp characteristics (as determined by the ratio of rate of delivery of yarn to the stuffer box to the rate of withdrawal of yarn therefrom) lying between small arbitrary limits without the necessity of performing tedious hand tests and accordingly the invention comprises, in one of its aspects, a method of producing stuffer-box crimped yarn which comprises feeding yarn into a stuffer-box crimper having adjustable counter-pressure means, collecting a mass of crimped yarn from

said crimper in a buffer chamber and withdrawing yarn from said buffer chamber, measuring the amount of yarn in said buffer chamber by photoelectric means arranged to provide a signal substantially smoothly related to the amount of yarn in said buffer chamber, controlling the ratio of the rate of withdrawal of yarn from said chamber to the rate of delivery of yarn to the crimper in response to said signal so as to maintain the amount of yarn in said buffer chamber substantially constant, monitoring said ratio and adjusting said counterpressure means to maintain said controlled ratio at a substantially constant value.

By "the amount of yarn" in the buffer chamber I mean that length of the wad of crimped yarn passed from the crimper into the buffer chamber. When the crimping effect, delivery rate and withdrawal rate are all constant, an equilibrium will be set up so that the amount of yarn in the chamber will also remain constant.

In another of its aspects the invention comprises apparatus for producing stuffer box crimped yarn which comprises a stuffer-box provided with adjustable counter-pressure means and delivery means for feeding yarn into said stuffer-box, a buffer chamber situated so as to collect yarn exiting said stuffer-box, photoeletcric means for measuring the amount of yarn in said chamber arranged to provide a signal substantially smoothly related to the amount of yarn in said chamber, means for withdrawing the yarn from said buffer chamber and means for controlling the ratio of the rate of withdrawal of yarn from said chamber to the rate of delivery of yarn to the crimper in response to said signal as to maintain the amount of yarn in the chamber substantially constant, means for monitoring said controlled ratio and means for regulating the counter-pressure means in order to maintain said controlled ratio at a substantially constant value.

The method is based on the fact that an uncrimped length of yarn fed to the crimper is longer than its crimped length. If the yarn delivery and yarn withdrawal means are running continuously, the take-up means should therefore run more slowly than the delivery means, the ratio of the rate of delivery to the rate of withdrawal being related to the crimp ratio. If the crimping effect remains constant, the control system ensures that there is always the same amount of yarn between the crimper and the withdrawal means. If the crimping effect varies and if the control system is not used then the amount of yarn between the crimper and the withdrawal means will vary. If the crimp ratio decreases, yarn will build up between the crimper and the withdrawal means and vice versa.

The control system of the invention will detect the variation in the amount of yarn contained between crimper and withdrawal means and will vary the ratio of rate of yarn delivery to rate of yarn withdrawal to cause the amount of yarn to remain constant. By monitoring the change in the controlled ratio it is possible to observe drifts in the crimping effect and to correct the counterpressure means to ensure that the crimping effect is maintained between limits which may be tolerated in the particular crimping process.

The ratio of rate of yarn delivery to rate of yarn withdrawal may be varied by variation of the rate of delivery, or by variation of the rate of withdrawal, whilst maintaining the non-varied rate at a constant value. The choice of which rate is to be varied will be determined by the nature of subsequent or preceding processes acting on the yarn. For example, it may be desired to keep the rate of delivery constant if yarn is supplied to the crimper assembly from a spinning or drawing machine. For ease of description the following discussions will relate to systems in which the rate of delivery of yarn to the crimper is constant and the withdrawal rate is controlled by the signal from the photoelectric means although it is to be understood that the scope of the invention is not limited in this way.

Thus, in one process of the present invention, under conditions of constant crimping effect, the withdrawal rate will be controlled at a certain rate depending on the amount of yarn in the chamber, the amount of yarn in the chamber will remain substantially constant and the ratio of the rate of yarn delivery to the stuffer box to the rate of withdrawal of yarn from the chamber will be related to the crimp ratio. If, for instance, a decrease in the crimp ratio then occurs, yarn will commence to build up in the chamber, and the withdrawal rate will be increased by the control system.

The change in the amount of yarn in the buffer chamber will be detected so that the build-up is controlled. The ratio of yarn delivery rate to the new withdrawal rate will be related to the new crimp ratio and action can be taken if necessary to restore the original crimp ratio by suitable adjustment of the counter-pressure means after which adjustment the withdrawal rate will decrease by the action of the control mechanism, to the original value.

In practice it is impossible to withdraw the crimped yarn from the buffer chamber without imposing some tension on the crimped yarn and hence the ratio of rate of yarn delivery to rate of withdrawal of yarn measured in the process of this invention will not generally be identical to the crimp ratio, measured by hand. I have found, however, that the values bear a constant relationship to each other for particular sets of running conditions, providing that care is taken to prevent undue tension variations in the crimped yarn being delivered to the yarn withdrawal means, and hence the ratio values measured in the process of this invention can be used as a crimp characterising parameter. Ideally the path of travel of the crimped yarn from the buffer chamber to the yarn withdrawal means should be as short as possible and be as free as possible from changes of direction and contact with guides etc.

The buffer chamber should preferably have the same cross-sectional dimensions as the stuffer box, may be of any desired length and is preferably oriented so that yarn exiting the stuffer box does not substantially change direction. The stuffer box and buffer chamber should be fabricated of hard wearing material and stainless steel is preferred for its hard wearing and anti-corrosion properties.

The photoelectric means may comprise for instance, a plurality photoelectric cells arranged in the chamber and illuminating means either at the opposite side of the chamber from the photoelectric cells so that yarn can interpose between them. Alternatively, the illuminating means, in a preferred embodiment is situated, say, at one end of the chamber so as to illuminate the chamber with diffuse light. If the latter arrangement is used, the inside of the chamber may be polished to assist in light distribution. The cells and/or the illuminating means are preferably situated inside the chamber, i.e. let into the walls of the chamber so that they may be wiped by the yarn in its passage past them, and so may be cleansed of light masking deposits, or, alternatively may be situated outside the chamber and able to detect the amount of yarn in the chamber through slots, holes or transparent windows.

The only limitation as to the arrangement of the photoelectric means is that it should be arranged to produce a signal substantially smoothly related to the amount of yarn in the chamber. By a substantially smoothly related signal I mean one in which for every amount of yarn in the chamber there is a unique signal produced in contradistinction to a stepped signal, for example, one in which two photo-electric cells are spaced apart and a signal of a value is produced when the amount is below the level of one photo-electric cell a signal of a different value is produced when the amount is between the two photo-electric cells and a signal of a third value is produced when the amount is above the second photo-electric cell. The use of a step signal of this sort would not be useful in the process of this invention since the ratio of yarn delivery speed to yarn withdrawal speed would not be closely and continuously related to the amount of yarn within the buffer chamber.

I have found that one arrangement for achieving a signal which is substantially smoothly related to the amount of yarn in the chamber is to arrange a number of photo-electric cells, illuminated by direct or diffuse light, along the chamber each shunted with a suitable resistor to give a smooth characteristic from one cell to the next, connected in series and giving an electrical signal which is suitably amplified and fed to a motor controller which controls the speed of the yarn withdrawal means. The yarn in the chamber transmits a certain amount of light so that the intensity of light falling on the cells is not suddenly reduced by interposition of yarn, and consequently each cell is sensitive to the amount of yarn between it and the source and does not have a sharp switching action and a smooth related signal results. The number of cells required to produce a suitable signal will of course depend on the particular circuitry, the type of cell and the optical arrangement chosen. The relationship between the electrical signal and the amount of yarn in the chamber can be made to have any desired form by suitable choice of cell positions and types and shunting resistance and the overall response can be tuned to provide a smooth, preferably linear characteristic, by choice of suitable values of shunting resistances.

The delivery and/or yarn withdrawal means may conveniently be pairs of nip rolls driven by variable speed motors, although especially in the case of the withdrawal means care is necessary in choosing material for the nip rolls to prevent yarn lapping and one or both of the nip rolls may conveniently be part of a conveyor system.

The control means can comprise any means for producing any desired control signal from the signal from the photo-cells and may include conventional circuitry providing proportional control or proportional plus integral control. The feed and/or withdrawal rate monitoring means may conveniently be speed transducers arranged to measure the speed of the nip rolls although of course any other means for measuring the rates may be used. The withdrawal rate measuring means may be linked with the means to measure the rate of yarn delivery measuring means via a rate comparator to indicate the ratio of the two rates of some related value, which ratio or value will, as explained above, be related to the crimp ratio of the yarn. The crimper counter-pressure may be adjusted, if necessary, according to the variation of the withdrawal rate measurement (or if measured the ratio of the rate of delivery to rate of withdrawal or related value) from its desired value by any convenient relay proportionally to the error signal, or, if necessary, by hand.

My invention will now be described, by way of a specific example, with reference to the accompanying drawing which is a schematic part-sectional view of apparatus according to the invention. The reader will understand that my invention is in no way limited to the following description and that the specific values mentioned are solely by way of example. It will also be understood that the specific values may be altered to give response characteristics which may provide a more or less critically controlled process depending on the end use of the yarn being treated.

The drawing shows a stuffier-box **11**, which has a rectangular cross-section of 2 sq. in., and fabricated of stainless steel. Extending contiguously and coaxially of stuffer-box **11** is buffer chamber **15**, having substantially the same dimensions as stuffer-box **11** and having a length of about 24″. The buffer chamber **15** is also fabricated of stainless steel and the internal walls thereof are highly polished. Stuffer-box **11** is provided with counter-pressure means **18** consisting of a pivoted flap in a side wall, acted upon by an air pressure cylinder and piston **19**. The counter-pressure may be adjusted by adjustment of valve **20**. The yarn delivery means consist of nip rolls **12** situated at the open mouth of stuffer-box **11** in a conventional manner, and similarly yarn withdrawal means consists of nip rolls **16** situated at the open end of buffer chamber **15**. Nip rolls **12** are driven at a constant rate of 900 ft./min. through a motor and gearbox shown generally as **13**. Nip rolls **16**, however, are driven through a variable speed D.C. motor and gearbox shown generally as **17**. Buffer chamber **15** is provided with four photoresistive cells **21** (Type NSL 453 supplied by National Semiconductors Limited) which have high resistance at low light intensities and low resistance at high light intensities situated at 2 inch intervals along chamber **15** and projecting into chamber **15**, and four 6 watt bulbs **22** situated in chamber **15** at a position remote from cells **21** and at the opposite end to stuffer-box **11**. The use of diffuse light from bulbs **22** to illuminate cells **21** is preferred to direct light from bulbs situated diametrically opposite cells **21**, since the false response from the cells caused by yarn being withdrawn from the chamber interrupting the direct illumination of the latter case is prevented. Cells **21** are shunted with 12 kilo-ohms resistors and are connected in series across a 12 volt D.C. power source. The photocell and shunt resistor assembly thus acts as a variable resistance, having a minimum resistance of about 1 kilo-ohm when light is falling on all photocells, and a maximum resistance of about 50 kilo-ohms when not illuminated. A 50 kilo-ohm resistance **25** is connected in series with the photo-cell and the voltage drop across the cell and shunt resistance assembly is thus in the range ½ v.–5½ v. Transistors **27**, **28** and resistors **25**, **26** are connected to form a Darlington pair circuit which acts as an impedance matching device to pass the control signal from the cell and shunt resistance assembly to a standard commercially available closed-loop, thyristor D.C. motor controller shown generally as **29**, which receives a signal of between 0–5 volts depending on the response of the photocells and shunts assembly. The controller **29** adjusts the voltage applied to the variable speed motor in **17**, such that when the signal is 0 volts the speed of the motor is zero, and when the signal is 5 volts the speed of the motor in **17** is such that nip rolls **16** travel at the same rate as input nip rolls **12**, namely 900 ft./min.

One small disadvantage encountered with the use of diffuse light illumination of photocells **21** is that the intensity of the illumination falling on the cell furthest from the light source is less than that falling on the cell nearest to the light source, which means that the voltage across the photocell assembly when all cells are illuminated is not the required ½ volt but say 1–1.5 volts. This residual signal when fed via to the motor controller to the withdrawal motor means that the withdrawal means do not stop when all cells are illuminated. This problem is readily overcome by using an additional photo resistive cell **24** situated near the inlet end of chamber **15** and connected in parallel with the photo-cell-shunt assembly.

In operation an uncrimped 500 kilodenier tow, **10**, composed of 12 d.p.f. nylon 6.6 continuous filaments is fed at 900 ft./min. by nip rolls **12** into stuffer-box **11**. Crimped tow is forced from stuffer-box **11** into buffer chamber **15** and an end is brought into contact with nip rolls **16**. Buffer chamber **15**, photoresistive cells **21**, motor speed controller and yarn withdrawal means **16** form a closed loop control system. The photo-resistive cells **21** detect the amount of tow in buffer chamber **15** and the detector signal is fed to motor controller **29**. The signal received by the motor controller is typically zero volts when buffer chamber **15** is empty and 5 volts when buffer chamber **15** is full. The motor controller **29** is set so that the yarn withdrawal means is stationary when the control signal is zero, and equal to the speed of the yarn delivery means **12** (in this example 900 ft./min.), when the amplified signal is at its maximum value of 5 volts.

The crimp ratio of the yarn is measured manually in order to correlate crimp ratio and rate of yarn withdrawal i.e. the apparatus is calibrated and the crimp ratio is adjusted as necessary by adjusting the counter-pressure in stuffer-box **11** to obtain the desired crimp ratio of 25%. Once the correct crimp ratio has been established, there is no need for further manual measurement of the value of crimp ratio, apart from a check at, say, three monthly intervals. Even if the process is halted, on recommencement the value of crimp ratio will be unchanged at the selected value. In this example the counter-pressure necessary was about 33 lbs. per sq. inch and the rate of withdrawal of crimped tow was 640 ft./min.

The speeds of the pairs of nip rolls **16** are measured by a speed transducer (not shown), the output of which is fed to a printing device **30** which prints out the speed of rolls **16** at short intervals. If the value of the ratio drifts outside the 1% tolerance limits chosen for the process, the pressure on the movable flap **18** is adjusted by adjusting valve **20** manually, or by means of a suitable relay (not shown) so as to maintain the speed of nip rolls **16** at the value corresponding to the selected crimp ratio of 25%±1%, that is the withdrawal speed is maintained between 635–645 ft./min. Alternatively printing device **30** may be coupled with a comparator which compares the speeds of rolls **12** and **16** and prints out the ratio of the difference in speeds of rolls **16** and **12**, to speed of nip rolls **12**.

If the supply of uncrimped tow to the stuffer-box is interrupted, the amount of crimped yarn in the buffer will fall until it reaches the vicinity of photo-cell **24**. The signal then fed to the withdrawal motor speed controller will be 0 volts and the withdrawal of yarn will cease. On recommencement of the supply the control system will operate as before to bring the withdrawal nip rolls **16** up to speed and the yarn will have a crimp ratio of 25%±1% at all points if the withdrawal rate is maintained between 635–645 ft./min.

In an alternative design photo-cells **21** are illuminated by direct light from light sources situated diametrically opposite. In this case photo-cell **24** becomes redundant.

What I claim is:

1. A method of producing stuffer-box crimped yarn which comprises feeding yarn into a stuffer-box crimper having adjustable counter-pressure means, collecting a mass of crimped yarn from said crimper in a buffer chamber and withdrawing yarn from said buffer chamber, measuring the amount of yarn in said buffer chamber by photoelectric means arranged to provide a signal substantially smoothly related to the amount of yarn in said buffer chamber, controlling the ratio of the rate of withdrawal of yarn from said chamber to the rate of delivery of yarn to the crimper in response to said signal so as to maintain the amount of yarn in said buffer chamber substantially constant monitoring measuring said ratio, and adjusting said counter-pressure means to maintain said controlled ratio at a substantially constant value.

2. A method as claimed in claim **1** in which the rate of delivery of yarn to the crimper is substantially constant and the rate of withdrawal of crimped yarn from the said buffer chamber is controlled by said signal.

3. A method as claimed in claim **1** in which the rate of withdrawal of yarn from the said buffer chamber is substantially constant and the rate of delivery of yarn to the crimper is controlled by said signal.

4. Apparatus for producing stuffer-box crimped yarn which comprises a stuffer box provided with adjustable counter-pressure means and delivery means for feeding yarn into said stuffer-box, a buffer chamber situated so as to collect yarn exiting said stuffer-box, photoelectric means for measuring the amount of yarn in said chamber arranged to provide a signal substantially smoothly related to the amount of yarn in said chamber, means for withdrawing the yarn from said buffer chamber and means for controlling the ratio of the rate of withdrawal of yarn from said chamber to the rate of delivery of yarn to the crimper in response to said signal so as to maintain the amount of yarn in said buffer chamber, substantially constant means for measuring said ratio and means for regulating the counter-pressure means in order to maintain said controlled ratio at a substantially constant value.

5. Apparatus as claimed in claim **4** which the delivery means operates at a substantially constant rate and the withdrawal means is controlled in response to said signal.

6. Apparatus as claimed in claim **4** in which the withdrawal means operates at a substantially constant rate and the delivery means is controlled in response to said signal.

7. Apparatus as claimed in claim **4** in which the photo-electric means comprises photo-electric cell means and illuminating means.

8. Apparatus as claimed in claim **7** in which the photo-electric cell means is housed in the walls of the chamber.

9. Apparatus as claimed in claim **8** in which the photo-electric cell means projects into the interior of the chamber.

10. Apparatus as claimed in claim **7** in which the photo-electric cell means is situated outside the walls of the chamber and the walls are provided with light transmitting means.

11. Apparatus as claimed in claim **7** in which the illuminating means is situated at the end of the chamber from which the yarn is withdrawn.

12. Apparatus as claimed in claim **11** in which the interior of the chamber is reflecting.

13. Apparatus as claimed in claim **7** in which the illuminating means is situated opposite and across the chamber from the photo-electric cell means.

14. Apparatus as claimed in claim **11** in which the illuminating means is housed in the walls of the chamber.

15. Apparatus as claimed in claim **13** in which the illuminating means is housed in the walls of the chamber.

16. Apparatus as claimed in claim **11** in which the illuminating means projects into the interior of the chamber.

17. Apparatus as claimed in claim **13** in which the illuminating projects into the interior of the chamber.

18. Apparatus as claimed in claim **7** in which the illuminating means is situated outside the walls of the chamber and the walls are provided with light transmitting means.

19. Apparatus as claimed in claim **7** in which the photo-electric cell means comprises a plurality of cells arranged along the chamber, and connected in series to a source of electricity so as to produce a signal substantially smoothly related to the amount of yarn in the chamber.

20. Apparatus as claimed in claim **19** in which each photo-electric cell is shunted with a resistor.

21. Apparatus as claimed in claim **20** in which the photo-electric cell means comprises four cells arranged along the chamber and connected in series.

22. Apparatus as claimed in claim **19** in which a further photo-electric cell is connected across the series of photo-electric cells and situated nearer the crimper than the series of photo-electric cells.

23. Apparatus as claimed in claim **4** in which the related signal is amplified.

24. Apparatus as claimed in claim **4** in which the delivery means and withdrawal means are pairs of driven nip rolls, the drive for the withdrawal means is equipped with a controller and the related signal is fed to said controller.

25. Apparatus as claimed in claim **4** in which the delivery means and advancing means are pairs of driven nip rolls, the drive for the delivery nip rolls is equipped with a controller and the related signal is fed to said controller.

26. Apparatus as claimed in claim **4** in which the stuffer box and the chamber are continuously arranged.

27. Apparatus as claimed in claim **26** in which the stuffer box and the chamber are arranged in abutting relationship along a common axis.

References Cited

UNITED STATES PATENTS

2,820,988	1/1958	Wegener	28—72.14
3,126,431	3/1964	Harder	264—40
3,261,155	7/1966	Kunzle	264—168 X
3,398,224	8/1968	Schatz	264—282
3,417,447	12/1968	Trifunovic	28—72.14 X

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