Feb. 9, 1960 J. K. RUSSELL ET AL 2,924,154

METHOD AND APPARATUS FOR CRUMPLING PAPER

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FIG. 1.

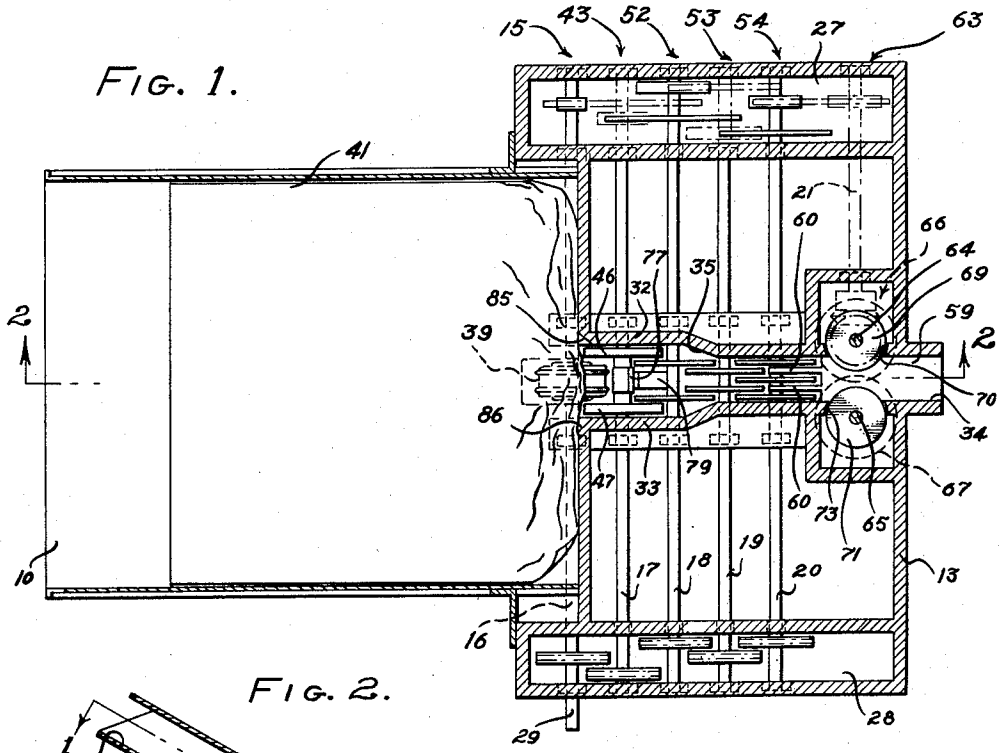

FIG. 2.

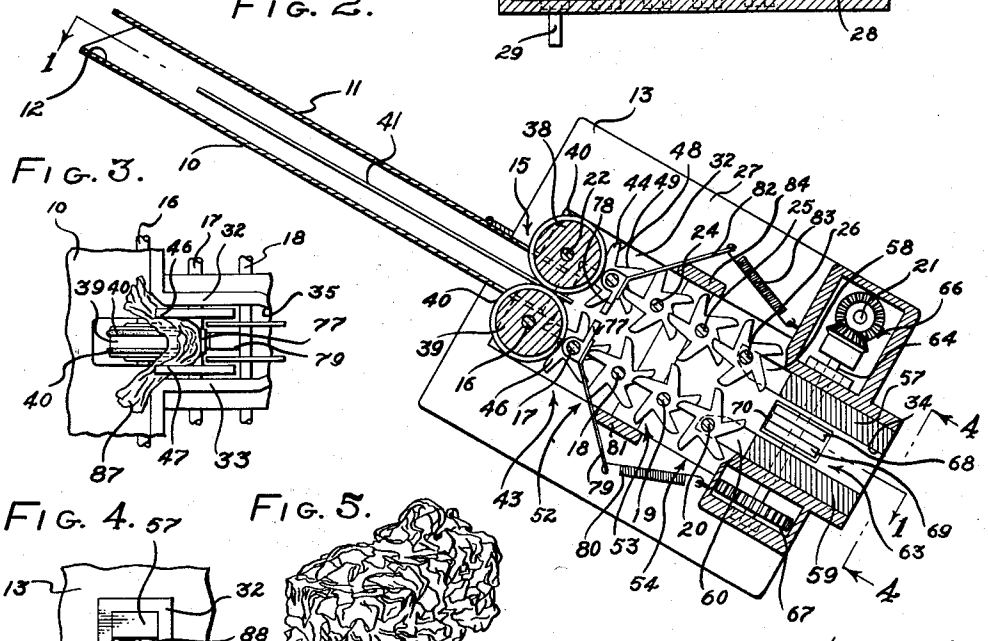

FIG. 3.

FIG. 4.

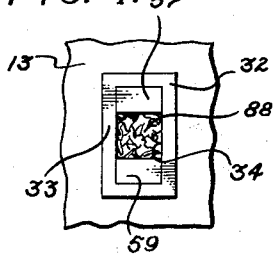

FIG. 5.

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METHOD AND APPARATUS FOR CRUMPLING PAPER

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This invention relates to methods for crumpling sheets of material, such as paper or the like, into compact wads having numerous sharply folded edges and corresponding voids along all axes of the crumpled wad. The invention also relates to apparatus suitable for carrying out the methods described herein.

It has been known for some time that crumpled wads of paper, either chemically treated or untreated, are suitable for use in filtering engine oils. It has now been determined that an important factor in the efficiency of filters containing such crumpled wads of paper is the manner in which the paper is wrinkled. It is highly desirable that the paper have folds and voids extending in all directions with substantially no through channels existing in each wad so that the orientation of the individual wads in the filter relative to each other is of no significance. The wads should be approximately square so that they can be packed into a suitable container completely at random. Oil flows through the container along the interstices in the wads rather than through the paper of the rods, the dirt from the oil being deposited on the paper which is wetted by the oil.

Another important factor in the production of oil filters is the cost of the raw material used for filtering. While the methods and the apparatus to be described herein may be used with any type of sheet material, they are especially adapted for use with used newsprint which is an abundant and cheap raw material and provides a very successful crumpled wad for use in oil filtering.

Therefore, it is an object of the invention to provide a method of crumpling sheets of paper or the like to produce a compact, wrinkled wad which is not easily opened, has substantially no loose tails or wings and no passages extending therethrough, and has a plurality of sharp folds and associated voids oriented along different axes to obstruct fluid flow in all directions.

It is another object of the invention to provide a method of crumpling paper or the like to produce deep wrinkles in the crumpled mass by penetrating the mass substantially to the center thereof from opposed sides without tearing the material. Another object of the invention is to provide a method of crumpling a sheet of paper or the like by moving the sheet along a path against a stop to crumple the entire sheet against the stop and then removing the stop, permitting the crumpled sheet to continue moving along the path. A further object of the invention is to provide such a method in which the trailing edges of the sheet normally extending backward from the stop are crumpled and folded into the mass of paper at the stop.

It is a further object of the invention to provide a method of crumpling paper or the like in which the material is advanced along a path at a plurality of stations and simultaneously acted on at each station to crumple the material. Another object of the invention is to provide such a method in which the rate of advance of the paper is less at each successive station so as to crumple the paper along its longitudinal as well as its lateral axes.

A further object of the invention is to provide such a method in which the action providing lateral crumpling at one of the stations is substantially transverse to the action providing lateral crumpling at the preceding station.

It is an object of the invention to provide apparatus for carrying out the above methods. Another object of the invention is to provide such apparatus having a plurality of sets of crumpling wheels successively positioned along a path with adjacent sets of wheels over-lapping each other, providing increased crumpling action along a shortened path and permitting a wad to be engaged by at least one set of wheels at all times so that a single wad may be formed without requiring following wads to push the first wad along. A further object of the invention is to provide such apparatus in which some of the wheels have teeth or spikes extending therefrom for more than half the radius thereof to provide deep wrinkles in the crumpled paper. Another object of the invention is to provide toothed wheels having particularly shaped teeth which eliminate tearing of the sheet material while being crumpled.

It is a further object of the invention to provide apparatus for crumpling paper having means for advancing the paper along a path and having a gate or trigger for blocking the path so that the sheet of material is crumpled into a compact mass against the gate before the gate is opened or removed. It is a further object of the invention to provide new and improved methods and apparatus for crumpling paper or the like which produce a superior product at a higher production rate and lower cost than previously known methods and equipment.

The invention also comprises novel details of construction and novel combinations and arrangements of parts, which will more fully appear in the course of the following description. The drawing merely shows and the description merely describes a preferred embodiment of the present invention which is given by way of illustration or example.

In practicing the method of the invention, the sheet of material to be crumpled is moved along a path, the material, which may be paper or other suitable sheet stock, being contacted at successive stations along the path to impart the movement to the material. The movement of the paper is blocked adjacent one of the stations, preferably after the second station for reasons to be pointed out, to permit the entire sheet to be crumpled together and to create both longitudinal and lateral wrinkles, after which movement of the crumpled mass along the path is permitted to continue.

It is preferred in carrying out the method of the invention to have the sheet contacted at approximately its center line at the first station to crumple the central portion of the sheet and to have the resulting wings or trailing edges contacted at the second station to force the wings into the central portion. This can be accomplished since movement of the mass has been blocked, permitting the trailing edges to catch up with the main body of the paper wad and to have additional wrinkles formed therein. This method of crumpling prevents the formation of a loose, V-shaped wad that has an unobstructed path between the arms of the V and does not remain compact, the wings or trailing edges previously referred to corresponding to the arms of the V.

The method of the invention includes acting on the paper at the stations along the path to also laterally compress and crumple the mass. This action preferably includes forming deep voids and wrinkles in the mass by deeply penetrating the mass at one or more of the stations. Such deep penetration should, of course, be performed without tearing the sheet. The deep voids and wrinkles provide a finished product far superior in filter-

ing ability to crumpled wads having only superficial surface voids and wrinkles.

It is desirable for oil filter use that the finished wad of crumpled paper be approximately square in cross-section. This may be achieved in the method above described by providing the lateral action at the last station along an axis substantially perpendicular to that of the next preceding station and regulating the magnitude of compression and crumpling to give the desired shape.

The paper may also be compressed and crumpled along the axis of the path by having the movement imparted to the paper at successive stations become slower as the paper progresses along the path. The shape of the finished product can be varied by controlling the relative speeds at the stations, thereby controlling the longitudinal compression and crumpling.

An apparatus suitable for performing the above described methods is shown in the drawings, where:

Fig. 1 is a sectional view of a preferred embodiment of the apparatus, taken along the line **1—1** of Fig. 2;

Fig. 2 is a sectional view taken along the line **2—2** of Fig. 1;

Fig. 3 is a view of a portion of the apparatus shown in Fig. 1 with the paper in another position;

Fig. 4 is a view of a portion of the apparatus taken along the line **4—4** of Fig. 2; and

Fig. 5 is an isometric view of a crumpled wad of paper produced by the apparatus of the invention.

A paper chute **10** having a hinged access lid **11** defining a sheet entrance slot **12** is fixed to and extends outward from a main frame **13**. The apparatus is preferably operated in conjunction with a sheet-feeding device, not shown, which will feed sheets singly into the chute **10** with sufficient velocity and at the proper angle to cause the sheet to float down the chute and into a first set of driven rolls **15** without contacting the lower side of the chute. This mode of operation eliminates sliding friction due to contact of the sheet with the chute which merely serves to restrain errant sheets. However, the sheets of material may be fed into the first set of rolls **15** by any sheet transporting mechanism or by hand, irrespective of the orientation of the apparatus.

Shafts **16** through **26** are rotatably mounted in the main frame **13**, the shafts being coupled together in driving relationship by gear trains contained in gear boxes **27** and **28** positioned at each end of the main frame **13**. A drive motor, not shown, may be coupled to an end **29** of the shaft **16** for rotating all of the shafts, shafts **16** through **21** being rotated clockwise as seen in Fig. 2 and shafts **22** through **26** being rotated counterclockwise. In the embodiment shown herein, the gear box **28** provides the counterrotation between the two shafts of a set and the gear box **27** provides different rates of rotation for each counterrotating pair of shafts. Of course, other means, such as pulleys and belts or the like, may be used for driving the shafts if desired.

Wall members **32, 33** are centrally positioned in the main frame **13** and define a passage from the paper chute **10** to an exit opening **34**. In the embodiment of the invention disclosed herein, a tapered section **35** is provided in the passage defined by the wall members **32, 33** to reduce the spacing between the wall members at an intermediate position. However, such a tapered section is not essential in the apparatus, the particular size of the passage defined by the wall members being dependent upon the initial size of the sheet of the material being crumpled, the desired size of the finished product, the length of the passage and the speed at which the wad moves along the passage.

The first set of driven rolls **15** may consist of a cylindrical roller **38** mounted on and driven by the shaft **22** and an opposed cylindrical roller **39** mounted on and driven by the shaft **16** and each of the rollers may be provided with rubber rims **40** to increase the friction thereof. The peripheries between the rims are spaced apart a distance sufficient to permit the counterrotating rollers to pull a sheet of material **41** between the rollers without tearing or puncturing the sheet.

Another set **43** of driven rolls or wheels, four in number, is positioned between the wall members **32** and **33** in overlapping relation with the rollers **38** and **39**. This set may include a pair of toothed wheels **46, 47** mounted on and driven by the shaft **17**, being spaced thereon to lie in planes on opposite sides of the roller **39**. The set **43** may also include a second pair of toothed wheels mounted on and driven by the shaft **23** to lie in these same planes but being disposed on opposite sides of the roller **38**. Only toothed wheel **44** of this second pair is shown. The shafts **16** and **17** are spaced apart a distance less than the sum of the radii of the roller **39** and the wheel **46** so that the wheel overlaps the roller as shown in the drawing, the roller **38** and wheel **44** being similarly positioned. The shafts **17** and **23** are spaced apart so as to provide a slight clearance between the peripheries of the wheels **44** and **46**, this spacing providing optimum crumpling action.

The wheels of the set **43** may have various shapes, a preferred form being shown in Fig. 2. Referring to the wheel **44** in particular, it is provided with a plurality of radially extending teeth or spokes which have a height greater than one-half the maximum radius of the wheel. Such a spoked wheel design is much more effective in crumpling paper for use in oil filters and the like than conventional flat rollers or spur gears. Each tooth on the wheel has a leading edge **48** which follows a chord of the wheel and a trailing edge **49** which follow substantially a radius of the wheel, the junction of the leading edge and the circumference of the wheel being rounded. This particular shape for the teeth on the wheels permits the teeth to penetrate deeply into the crumpled mass of paper, to move the paper along the passage without perforating it and to withdraw from the crumpled mass without tearing the material.

A third set of driven rolls **52**, which may be toothed wheels similar to those of the second set of rolls **43**, is mounted on the counterrotating shafts **18** and **24**, the shafts being positioned so that the wheels overlap the wheels of the next preceding set. A fourth set of driven rolls **53** is mounted on the shafts **19** and **25**, the fourth set being similar in construction and spacing to the second and third sets. The wheels in the fourth set which have a common shaft are spaced from each other and both are positioned between the corresponding wheels of the third set.

A fifth set of driven rolls **54** is mounted on the shafts **20** and **26**, the fifth set being similar to the second, third and fourth sets with the exception that three wheels are mounted on each shaft, the center of the three wheels being positioned between the corresponding wheels of the fourth set and the outer two wheels being positioned outwardly of the corresponding wheels of the fourth set. The particular number of sets of driven rolls and the particular number and spacing of wheels which are used in any embodiment of the invention are dependent upon the size of the sheet material and the desired size of the crumpled wad. In the particular embodiment described and illustrated herein, a sheet of used newsprint approximately 14 inches by 20 inches is crumpled into a wad approximately 1¼ inch by 1½ inch by 2 inches.

An upper guide plate **57** is positioned between the parallel wall members **32, 33** with guide fingers **58** extending along the passage between the central and side wheels on the shaft **26**, the shaft **26** passing through openings in the ends of the guide fingers **58**. A lower guide plate **59** corresponding to the upper guide plate **57** is also positioned between the parallel wall members **32, 33** with guide fingers **60** extending along the passage between the central and side wheels mounted on the shaft **20**. The wall members **32, 33** and the guide plates **57, 59** define the exit opening **34**.

Another set of driven rolls 63 is mounted on counterrotating shafts 64, 65, the shaft 64 being driven by the shaft 21 through a pair of bevel gears 66 and the shaft 65 being driven from the shaft 64 through a pair of spur gears 67. The set of driven rolls 63 may consist of a pair of cylindrical rollers such as the rollers 38 and 39 or may consist of one or more pairs of toothed wheels such as the wheels 44 and 46. In the embodiment described herein, cylindrical wheels 68, 69, each having a corrugated periphery, are mounted on the shaft 64 with a portion of the wheels extending through an opening 70 in the wall member 32. A similar pair of cylindrical wheels of which only the wheel 71 is shown, each having a corrugated periphery, is mounted on the shaft 65, the wheels extending through an opening 73 in the wall member 33 opposite the wheels 68, 69.

A gate 77 is rotatably mounted on the shaft 17 between the wheels 46, 47, the gate extending inward toward the center of the passage. A similar gate 78 is rotatably mounted on the shaft 23 between the wheels 44, 45 and extends into the passage toward the gate 77, there preferably being a small gap between the adjacent ends of the gates. One end of a lever 79 is fixed to the gate 77 and the other end of the lever is coupled to the frame 13 by a spring 80, the spring urging the gate 77 to move in a counterclockwise direction as viewed in Fig. 2 until the lever 79 rests against a stop 81 with the gate 77 substantially transverse of the passage between the wall members. A lever 82 fixed to the gate 78 and a spring 83 coupling the lever to the frame coact in the same manner to urge the lever against a stop 84 and position the gate 78 transverse of the passage.

In the operation of the apparatus described above, the sheet of material 41 is fed into the paper chute 10 by suitable means. The sheet moves down the chute, is engaged by the rim of the roller 39 and carried between the rollers 38 and 39 as shown in Figs. 1 and 2. The rollers 38 and 39 engage the sheet at approximately its center line, drawing the central portion of the sheet into the passage between the wall members 32, 33 and crumpling it into the space between the rollers and the gates 77, 78. The corners of the wall members 32, 33 may be beveled as shown at 85, 86 of Fig. 1 to eliminate the possibility of tearing the material at this point. The crumpled sheet is now substantially V-shaped as shown by the numeral 87 in Fig. 3. By this time, the second set of driven rolls 43 engages the extending arms of the V-shaped paper 87 and moves the extending arms forward along the passage thereby compressing the arms toward the center of the mass of crumpled paper in the cavity beyond the rollers 38, 39 bounded by the wheels of the set 43 and the gates 77, 78. The mass of paper is compressed against the boundaries of such cavity by the wheels of the set 43, filling the voids initially formed at the apex of the V-shaped sheet. The various components of the apparatus are so dimensioned that at about the time that the ends of the arms of the V-shaped piece of paper 87 are passing into the wheels of the second set of driven rolls, the wad of paper being restrained by the gates will be large enough and rigid enough to force the gates to swing open against the action of the springs 80, 83 and the wad of paper will be moved along the passage to be engaged by the third set of driven rolls. Each successive set of driven rolls engages the wad of paper and moves it along the passage to the next set with the last set of rolls pushing the completed product 88 outward through the exit opening 34.

As the mass of crumpled paper passes between each set of rolls, it is further compressed and wrinkled, especially by the deep penetration of the wheels which produce deep wrinkles and voids in the mass. After passing between several sets of rolls, the mass tends to become rectangular in cross-section and the last set of rolls 63 serves to compress the mass in a direction transverse to the action of the previous sets thus changing the

shape of the finished product and also setting the folds created in the previous operations, i.e., making the creases sharp. The setting is aided by making the spacing between the peripheries of the wheels of the last set 63 approximately one-half the spacing between wall members at this point.

Longitudinal wrinkling and compression of the mass may also be accomplished in the apparatus by having one or more of the sets of driven rolls rotate at a speed to move the mass of paper through the rolls at a slower rate than the mass was moved through the next preceding set of rolls. If desired, each succeeding set of rolls may be operated at a slower rate to provide longitudinal compression and crumpling between each set of rolls as the paper moves along the passage or two or more sets of rolls may be operated to move the paper therethrough at the same rate.

The preferred location for the gates 77, 78 is as employed in the embodiment described herein; however, the gates may be positioned at other points along the passage and similar results will be achieved. The opening of the gates in the embodiment disclosed herein is controlled by balancing the force produced by the crumpled mass of paper pushing against the gate and the force of the springs 80, 83. Other suitable means for controlling the gates may be used, such as synchronizing the opening of the gates with the feeding of paper into the chute so that the gates open at a particular time interval after the paper enters the first set of driven rolls.

We claim as our invention:

1. In an apparatus for crumpling a sheet of paper, the combination of: guide means providing a passage which restricts movement of the sheet of paper; feed means positioned adjacent one end of said passage for moving the sheet of paper into said passage; displaceable gate means means obstructing said passage and preventing movement of the paper along said passage, said feed means crumpling the sheet of paper against said gate means for urging said gate means out of said passage; and resilient means for urging said gate means into said passage against the action of said feed means with said crumpled sheet overpowering said resilient means to displace said gate means and clear said passage when the crumpled mass of paper attains a predetermined size and density.

2. In an apparatus for crumpling a sheet of paper, the combination of: guide means providing a passage which restricts movement of the sheet of paper; a set of opposed feed rolls positioned adjacent one end of said passage; means for driving the opposed rolls of said set counterrotatingly to move a sheet of paper through said set of rolls and into said passage; a set of opposed crumpling wheels positioned in said passage; means for driving the opposed wheels of said set counterrotatingly to move the paper through said passage past said set of wheels; a set of opposed gates positioned in said passage for preventing movement of paper therethrough, the opposed gates of said set being movable away from each other to permit movement of the paper therebetween; and spring means coupled to each of said gates for urging said gates toward each other.

3. In an apparatus for crumpling a sheet of paper, the combination of: guide means providing a passage which restricts movement of the sheet of paper; a set of opposed feed rolls positioned adjacent one end of said passage; means for driving opposed rolls of said set counterrotatingly to move a sheet of paper through said set of rolls into said passage; a set of opposed toothed wheels positioned in said passage, each of said wheels having a hub and a plurality of teeth extending therefrom, the height of each of said teeth being greater than one-half the maximum radius of the wheel with said teeth extending more than half-way to the center of said passage when disposed perpendicular to the longitudinal axis of said passage; means for driving the opposed wheels of said set counterrotatingly to move a sheet of paper

through said passage past said set of wheels with teeth of opposed wheels being aligned when disposed perpendicular to said longitudinal axis; gate means positionable in said passage for preventing movement of the paper along said passage; and control means for maintaining said gate means in said passage for a predetermined period to crumple the paper against said gate means.

4. In an apparatus for crumpling a sheet of paper, the combination of: guide means providing a passage which restricts movement of the sheet of paper; a set of opposed feed rolls positioned adjacent one end of said passage and disposed along a lateral centerline of said passage; means for driving the opposed rolls of said set counterrotatingly to move a sheet of paper through said set of rolls into said passage; first and second sets of opposed crumpling wheels positioned in said passage, said sets being disposed on each side of said set of feed rolls respectively; means for driving the opposed wheels of said sets counterrotatingly to move the paper through said passage past said sets of wheels, the rate of movement of the paper past said wheels being less than the rate of movement through said set of rolls, the axes of rotation of the corresponding wheels and rolls which rotate in the same direction being spaced along said passage a distance less than the sum of the maximum radii of a wheel and roll; gate means positionable in said passage between said first and second sets of wheels for preventing movement of the paper along said passage; and control means for maintaining said gate means in said passage for a predetermined period to crumple the paper against said gate means.

5. In an apparatus for crumpling a sheet of paper, the combination of: guide means providing a passage which restricts movement of the sheet of paper; a plurality of sets of opposed wheels successively positioned along said passage; means for driving the opposed wheels of each of said sets counterrotatingly to move the paper through said passage, the axes of rotation of said wheels being substantially parallel, the axes of rotation of adjacent wheels which rotate in the same direction being spaced less than the sum of the maximum radii of said spaced wheels; gate means mounted adjacent the side of said passage, said gate means being pivotable from a first position for preventing movement of the paper along said passage to a second position for permitting movement of the paper along said passage; and spring means urging said gate means to said first position for crumpling the sheet of paper into a wad between the preceding sets of wheels and said gate means, said wad moving said gate means to said second position on attaining a predetermined size and density.

6. In an apparatus for crumpling a sheet of paper, the combination of: guide means providing a passage which restricts the movement of the sheet of paper; feed means positioned adjacent one end of said passage for forcing the sheet of paper into said passage; gate means mounted adjacent the side of said passage, said gate means being pivotable from a first position for preventing movement of the paper along said passage to a second position for permitting movement of the paper along said passage; and spring means urging said gate means to said first position for crumpling the sheet of paper into a wad between said feed means and said gate means, said wad moving said gate means to said second position on attaining a predetermined size and density.

7. In an apparatus for crumpling a sheet of paper, the combination of: guide means providing a passage which restricts the movement of the sheet of paper; first feed means positioned adjacent one end of said passage for advancing a sheet of paper into said passage; a plurality of additional feed means successively positioned along said passage for advancing the paper along said passage and for laterally crumpling the paper, at least one of said additional feed means crumpling the paper along a lateral axis substantially transverse to the lateral axis along which other of said additional feed means function; gate means mounted adjacent the side of said passage, said gate means being pivotable from a first posititon for preventing movement of the paper along said passage to a second position for permitting movement of the paper along said passage; spring means urging said gate means to said first position for crumpling the sheet of paper into a wad between the preceding feed means and the gate means, said wad moving said gate means to said second position on attaining a predetermined size and density; and drive means for actuating each of said feed means, with the rate of advance of the paper past at least one of said feed means being faster than past the next succeeding feed means.

8. In an apparatus for crumpling a sheet of paper, the combination of: guide means providing a passage which restricts movement of the sheet of paper; first feed means positioned adjacent one end of said passage for advancing the sheet of paper into said passage; second feed means positioned in said passage for advancing the paper along said passage, said second feed means including two spaced sets of opposed wheels positioned at opposite sides of said passage; gate means mounted adjacent said second feed means, said gate means being pivotable from a first position for preventing movement of the paper along said passage to a second position for permitting movement of the paper along said passage, said gate means, said sets of wheels and said first feed means defining a cavity into which the sheet of paper is crumpled into a wad by the combined action of said first and second feed means; and spring means urging said gate means to said first position for maintaining said cavity closed, said wad moving said gate means to said second position on attaining a predetermined size and density.

9. In an apparatus for moving sheets of paper along a path while crumpling the sheets, the combination of: a first set of counterrotating wheels for driving a sheet of paper therebetween; a second set of wheels comprising pairs of counterrotating wheels positioned on each side of said first set with the axes of said second set spaced from the axes of said first set along said path; gate means swingingly mounted for positioning between said pairs of wheels blocking said path, said sets of wheels and said gate means defining a cavity into which a sheet of paper is driven by said first set for crumpling against said gate means by both of said sets; and spring means for urging said gate means into said position blocking said path.

10. In an apparatus for moving sheets of paper along a path while crumpling the sheets, the combination of: spaced wall members defining two opposite sides of a passage; a plurality of sets of opposed toothed wheels successively positioned along said passage with the axes of rotation of said wheels substantially perpendicular to said wall members and with the wheels of successive sets overlapping the corresponding wheels of the preceding sets, each of said wheels having a hub and a plurality of teeth extending therefrom, each tooth having a chord of the wheel as a leading edge and a radius of the wheel as a trailing edge with a rounded junction at the extremity at the leading edge; and means for driving the oppised wheels of each of said sets counterrotatingly to move the paper through said passage past said sets of wheels with teeth of opposed wheels being aligned when disposed perpendicular to said longitudinal axis.

11. A method of crumpling successive sheets of paper to form separate wads, including the steps of: feeding the sheets into a passage; imparting movement along the passage to each succeeding sheet and simultaneously acting on the paper to partially crumple it; passing the partially crumpled sheet into a cavity; stopping movement by a yieldable stopping force of the partially crumpled sheet in the cavity; further crumpling the entire

sheet while stopped in the cavity to form a wad which overcomes the yieldable stopping force and restores movement of the crumpled sheet along the passage when the wad attains a predetermined size and density; then stopping movement by a yieldable stopping force of the next partially crumpled sheet in the cavity; and further crumpling the next entire sheet in the cavity while stopped to form another wad which overcomes the yieldable stopping force and restores movement of the crumpled sheet along the passage when the wad attains a predetermined size and density.

12. A method of crumpling successive sheets of paper to form separate wads, including the steps of: feeding the sheets into a passage; imparting movement along the passage to each succeeding sheet at substantially the center line of the passage and simultaneously acting on the paper to partially crumple it; passing the partially crumpled sheet into a cavity; stopping movement by a yieldable stopping force of the partially crumpled sheet in the cavity; crumpling the trailing edges of the sheet into the central portion thereof to wad the entire sheet into the cavity while stopped forming a wad which overcomes the yieldable stopping force and restores movement of the crumpled sheet along the passage when the wad attains a predetermined size and density; then stopping movement by a yieldable stopping force of the next partially crumpled sheet in the cavity; and crumpling the trailing edges of the next sheet into the central portion thereof to wad the entire sheet into the cavity while stopped forming another wad which overcomes the yieldable stopping force and restores movement of the crumpled sheet along the passage when the wad attains a predetermined size and density.

13. A method of crumpling successive sheets of paper to form separate wads, including the steps of: feeding the sheets into a passage; imparting movement along the passage to each succeeding sheet at substantially the center line of the passage and simultaneously acting on the paper to partially crumple it; passing the partially crumpled sheet into a cavity; stopping movement by a yieldable stopping force of the partially crumpled sheet in the cavity; crumpling the trailing edges of the sheet into the central portion thereof to wad the entire sheet into the cavity while stopped forming a wad which overcomes the yieldable stopping force and restores movement of the crumpled sheet along the passage when the wad attains a predetermined size and density; then stopping movement by a yieldable stopping force of the next partially crumpled sheet in the cavity; crumpling the trailing edges of the next sheet into the central portion thereof to wad the entire sheet into the cavity while stopped forming another wad which overcomes the yieldable stopping force and restores movement of the crumpled sheet along the passage when the wad attains a predetermined size and density; and after movement has been restored, forming deep wrinkles in each wad at at least one point along the passage by penetrating the crumpled mass substantially to the center thereof from opposing sides simultaneously.

14. In an apparatus for crumpling a sheet of paper, the combination of: guide means providing a passage which restricts movement of the sheet of paper, with the outlet of said passage being narrower than its inlet for laterally crumpling the paper along a first transverse axis; feed means positioned adjacent one end of said passage for moving the sheet of paper into said passage; displaceable gate means obstructing said passage and preventing movement of the paper along said passage, said feed means crumpling the sheet of paper against said gate means for urging said gate means out of said passage; resilient means for urging said gate means into said passage against the action of said feed means with said crumpled sheet overpowering said resilient means to displace said gate means and clear said passage when the crumpled mass of paper attains a predetermined size and density; a set of opposed crumpling wheels positioned in said passage, with the axis of rotation of said wheels disposed substantially parallel to said first transverse axis for laterally crumpling the paper along a second transverse axis substantially perpendicular to said first axis; and means for driving the opposed wheels of said set counterrotatingly to move the paper through said passage past said set of wheels.

15. In an apparatus for crumpling a sheet of paper, the combination of: guide means providing a passage which restricts movement of the sheet of paper; a plurality of sets of opposed wheels successively positioned along said passage for lateral crumpling of the sheet; means for driving the opposed wheels of each of said sets counterrotatingly to move the paper through said passage, the axes of rotation of said wheels being substantially parallel with the wheels of each set rotating at a lesser rate than the wheels of the preceding set for longitudinal crumpling of the sheet; gate means mounted adjacent the side of said passage, said gate means being pivotal from a first position for preventing movement of the paper along said passage to a second position for permitting movement of the paper along said passage; and spring means urging said gate means to said first position for crumpling the sheet of paper into a wad between the preceding set of wheels and said gate means, said wad moving said gate means to said second position on attaining a predetermined size and density.

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