Aug. 13, 1968 A. J. LIEBMAN 3,396,914

MACHINE FOR DISINTEGRATING PAPER AND OTHER WASTE MATERIALS

Filed March 15, 1966 3 Sheets-Sheet 1

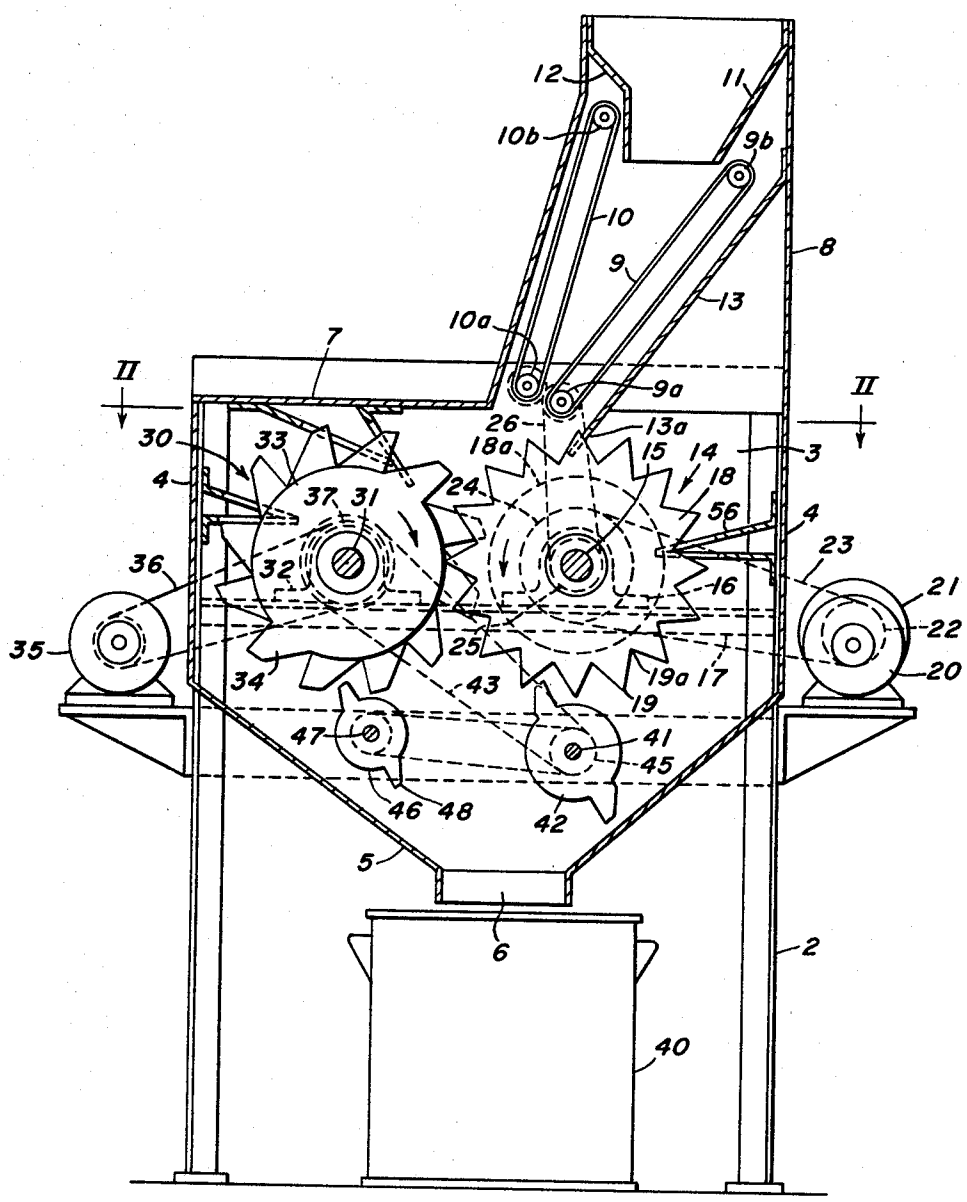


FIG. 1.

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Filed March 15, 1966 3 Sheets-Sheet 2

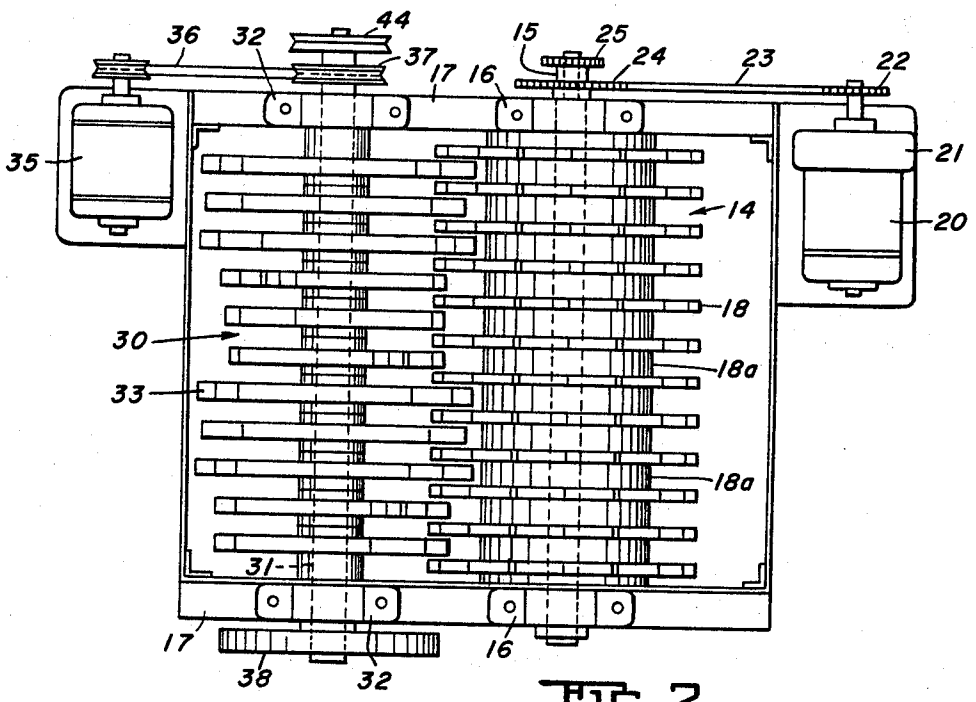


FIG. 2.

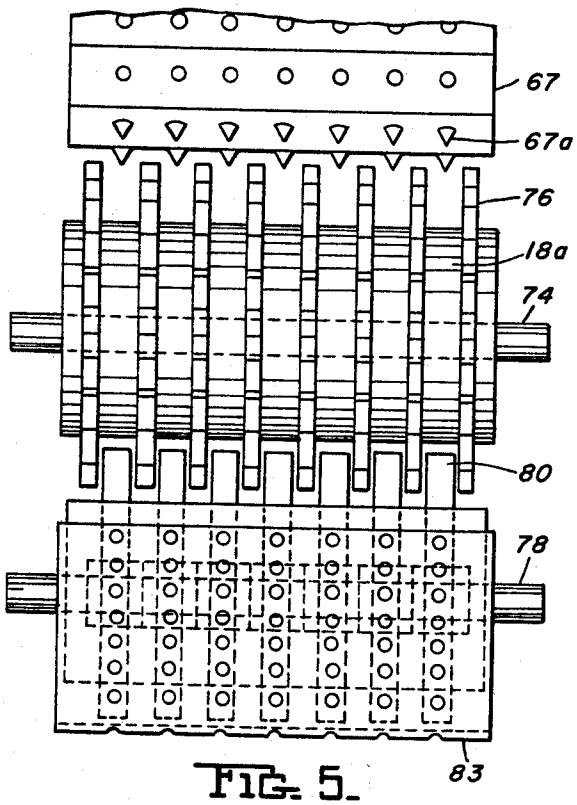


FIG. 5.

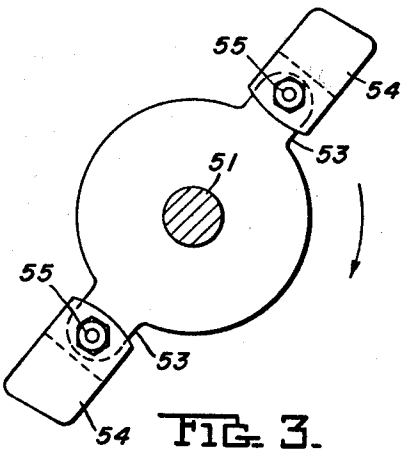


FIG. 3.

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MACHINE FOR DISINTEGRATING PAPER AND OTHER WASTE MATERIALS

Filed March 15, 1966 3 Sheets-Sheet 3

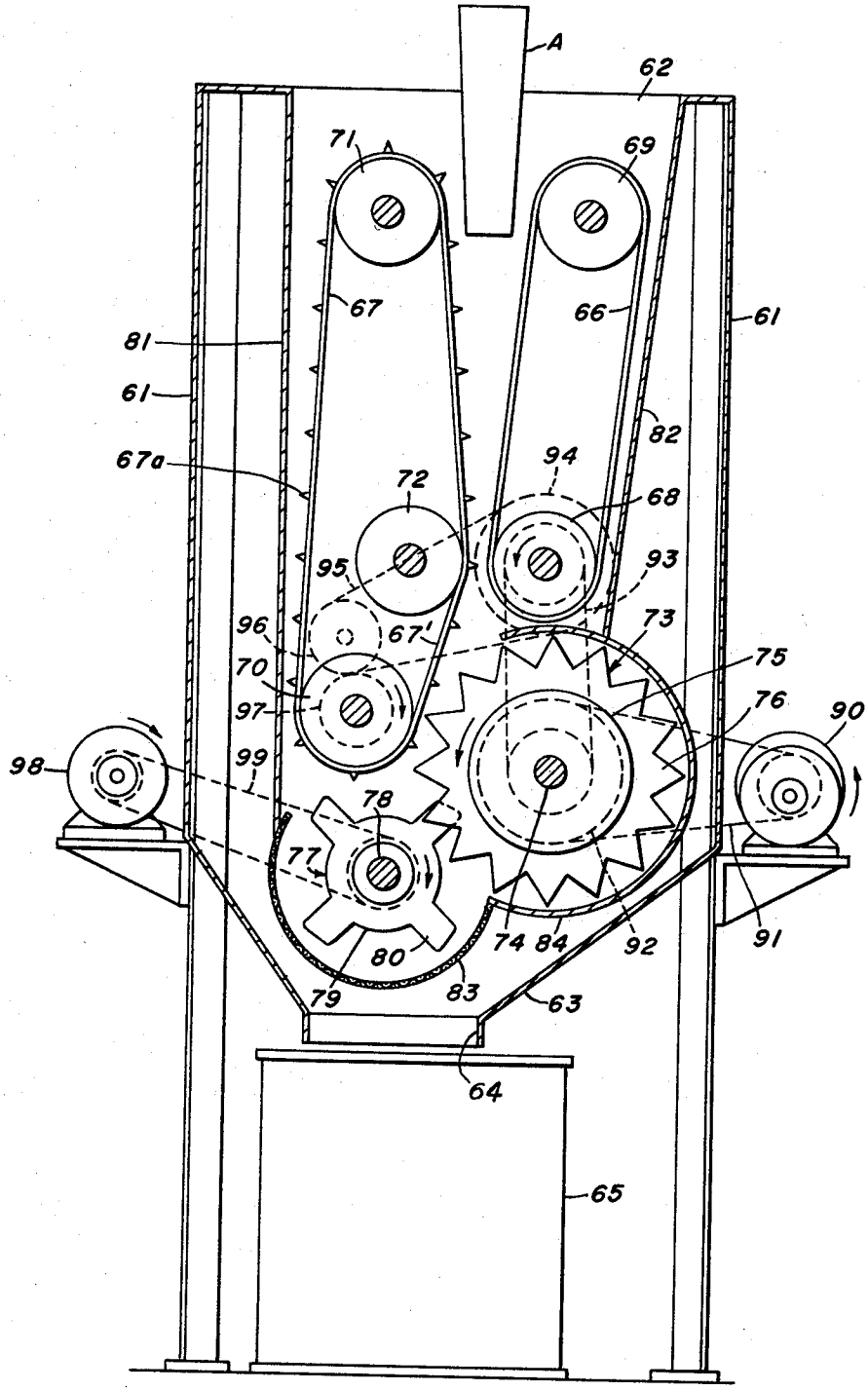


FIG. 4.

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3,396,914

MACHINE FOR DISINTEGRATING PAPER AND OTHER WASTE MATERIALS

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Continuation-in-part of application Ser. No. 381,702, July 10, 1964. This application Mar. 15, 1966, Ser. No. 534,506

22 Claims. (Cl. 241—63)

This application is a continuation-in-part of my application Ser. No. 381,702, filed July 10, 1964, now abandoned, and assigned to the assignee of the present application.

This invention is for a machine primarily for reducing papers, confidential documents, drawings, etc., to small, readily burnable condition, but it may at the same time destroy other refuse which may be included with the papers or separately introduced, including such materials as sheet metal "skeletons" from metal stamping operations, defective rubber gloves at the place of manufacture, imperfectly formed plastic articles or sheet material, chip-board, leather, etc.

Since one important use for the invention is the disintegration of papers, it will be specifically described in this connection for purposes of illustration and not by way of limitation. In many offices, both government and private, it is desirable to so disintegrate the contents of waste baskets, old or current files, blueprints, etc. as well as newspapers, magazines, paper books and the like, that they cannot be pieced together or their contents deciphered, so that they can be readily incinerated or used as scrap paper, or even merely used for a packing material in shipments to be protected from damage. It is not unusual that the contents of waste baskets may contain bottles or vials or small metal pill boxes, plastic containers, etc. which cannot be separated out prior to disintegration of the paper. Also, in many cases there may be books such as telephone books, directories, and thick sheafs of paper.

According to the present invention there is provided a machine which will rend papers, as well as other materials mentioned above, into small, mutilated fragments, disintegrate books, crush objects such as bottles, shred plastic, leather or chip-board sheet to bits, and not be impaired by paper clips, staples, metal pill boxes, etc. To this end the machine embodies a pair of belts which converge toward each other, and which may travel at the same or different speeds. These serve to move the material to a toothed feed drum comprised of a series of spaced disks having toothed peripheries that feed and hold the papers while another drum, comprised of choppers or projections arranged along a shaft in staggered relation to the disks of the feed drum, is revolved at high speed with the choppers passing between the toothed disks of the feed drum, beating and chopping the edges of the refuse as it feeds forward into small fragments. Glass objects are smashed to small pieces, plastic objects shredded, and thin metal objects bent or sheared.

Additional mechanism may be provided for giving a secondary fragmenting operation to the material leaving the first; for combing out particles from the revolving elements to prevent the build-up of compacted fragments in or on the drum, and in some cases the converging belts may be arranged by their different speeds and the use of teeth on the belts to produce a preliminary shredding of the feed material. The invention further contemplates screening the fragments to assure that they do not exceed a maximum size with the recycling of oversize fragments to the disintegrating operation.

The invention has for its object to provide a unique machine for effecting thorough disintegration of materials to be destroyed.

A further object of the invention is to provide a machine of this character of rugged and simple construction which is capable of disintegrating various materials, including glass, metal, plastic, wood, paper and others.

These and other objects and advantages are secured by my invention as may be more fully understood by reference to the accompanying drawings illustrating certain embodiments thereof in conjunction with the detailed description thereof.

In the drawings:

FIG. 1 is a more or less schematic illustration showing a vertical section through one form of machine embodying my invention;

FIG. 2 is a top view of the feed drum and disintegrator drum, the view being a horizontal section in the approximate plane of line II—II of FIG. 1, with certain parts omitted for clarity of illustration;

FIG. 3 is an end view of a modified form of disintegrator drum;

FIG. 4 is a view similar to FIG. 1 of a modified form of machine; and

FIG. 5 is a fragmentary view showing in a somewhat distorted projection the cooperating parts of the mechanism.

Referring first to FIGS. 1 and 2, **2** designates generally a structural supporting frame on which are sheet metal sides **3** and **4** defining the four walls of a main enclosure. The bottom **5** of the enclosure is hopper-shaped with sloping walls inclined toward a discharge opening **6**. There is a top cover sheet **7**, and at one side of the top there is a vertically-extending chute-like enclosure **8**.

Within the vertical chute-like enclosure are two endless belts **9** and **10** which converge downwardly, the belt **9** passing over rollers **9***a* and **9***b*, and the belt **10** passing over rollers **10***a* and **10***b*. The belts terminate below the top of the enclosure **8**, and within the enclosure are deflector plates **11** and **12**, these plates extending downwardly and inwardly to guide refuse material to be disintegrated into the space between the two belts and prevent it from getting in behind them. The belt **10** is more nearly vertical than belt **9**, and under belt **9** there is a downwardly-inclined sheet metal apron **13**. As here shown, the lower ends of the belts terminate near the level of the top of the main enclosure.

The narrow space between the lower ends of the two belts is located just above a feed drum, designated generally as **14**. It comprises a shaft **15** supported in bearings **16** on structural frame members **17**, and on the shaft are a series of spaced disks **18** fixed to rotate with the shaft and having teeth **19** about their peripheries. These teeth may be pointed as shown, flat or rounded, and preferably the apex-to-apex chord distance between adjacent teeth is in the range of about 1–5 inches. Between the disks **18** are spacing fillers **18***a* also in the form of circular disks. The disks **18** are spaced according to how fine the paper is to be fragmented, but typically they may be about ¼ to 1¼ inch thick and about ⅝ to 2½ inches apart.

Any suitable drive for rotating the drum in a counterclockwise direction as viewed in FIG. 1 may be provided. In the drawings I have shown a motor **20** with an associated speed reducing gear **21** that drives a sprocket wheel **22**. A chain **23** passes around this sprocket wheel and a similar wheel **24** on the end of the shaft **15**. The drum is

rotated at a relatively low speed, typically about 5 to 95 r.p.m., but this may vary according again to the size of the fragments to be produced, the slower the speed, the smaller the fragments. I have shown form purposes of illustration a second sprocket wheel **25** on the shaft **15** to drive a chain **26** passing around a sprocket wheel on the shaft of roller **9***a* for the belt **9**, and a spur gear alongside of its drives roller **10***a* of belt **10**. In this way the speed of the belts may be regulated relative to the speed of the feed drum. The peripheral linear speed of the disks or star wheels **18** is preferably in the range of about 50 in./min. to about 5000 in./min. and the linear speed of the feed belt **9** is preferably about 5–15% less than the peripheral linear speed of the star wheels whereby the material is kept under some tension for presentation to the hammer members later described. The material is first contacted by the star wheels and advanced toward the hammers.

Parallel with the feed drum there is a disintegrator drum, designated generally as **30**. It comprises a shaft **31** mounted in bearing **32** on the frame members **17**. On it are a series of spaced disks **33** which rotate with the shaft, and which have one or more, preferably two, projections **34** extending beyond the periphery. With two such projections they are separated 180°. These disks **33** are staggered with reference to the toothed disks **18** of the feed drum, and are so positioned that the bladed or beaters **34** pass between adjacent disks **18** with ordinarily little clearance between the ends of the beaters and the filler disks **18***a*. The lateral clearance between the hammers **34** and the star wheel disks **18** may be about 1/64 in. to about 3/8 in. on either side of the hammer. The clearance will vary for different materials, but generally, resilient materials such as rubber require small clearance for the most effective disintegrating action, while greater lateral clearance is preferred for coarser materials, materials which fracture easily, such as wood, glass and metals. The circles of revolution of the hammers **34** and the teeth **19** overlap, and the relation of the hammers and teeth should be such that the hammers extend at least to the root, indicated at **19***a*, of the teeth. The clearance between the ends or peripheries of the hammers and the filler disks **18***a* should be about 1/16 in. to about 3/8 in., again, as in the case of lateral clearances, there should be small clearance for resilient or stretchable materials and more for more frangible materials. This slight clearance between hammers **34** and disks **18***a* provides a self-cleaning characteristic for the machine whereby materials are prevented from jamming or clogging on the feed drum hindering the functioning of the machine and escaping disintegration. In all cases the width or thickness of the hammers should be greater than the width of the star wheels **18**. This greater width exposes more material to the action of the hammers and is important to prevent strips of material from progressing through the machine between the hammers. One suitable ratio would be a hammer width about 1.5 times the width of the star wheels, but other ratios may be suitable, depending on the materials to be disintegrated. Moreover, it is desirable in some cases that the projections **34** of adjacent disks **33** be arcuately displaced as shown from one another so that along the length of the drum they describe a helical curve rather than being aligned. In this way the projections of the several disks pass progressively between the several toothed rollers, and not all at one time. However, it is also desirable in many cases that the projections of all the disks be aligned to pass in a row between the disks **18**.

The disintegrator drum **30** rotates at relatively high peripheral speed as compared to the feed drum. With the feed drum and disintegrator of roughly comparable overall diameters, as shown, the speed of rotation of the disintegrator is typically 2250 r.p.m., but this may be varied, as a larger diameter disintegrator could have a greater peripheral speed at a slower rotational speed than a smaller one at a higher rotational speed. The peripheral linear speed of the hammers is preferably in the range of about 15,000 in./min. to about 100,000 in./min., but the ratio of linear peripheral speed of the disintegrator hammers to that of the star wheel should not be less than about 20:1.

This ratio is important in that a peripheral linear hammer speed substantially less than about 15,000 in./min. will not produce effective disintegration, while the feed drum and feed belt speeds should be high enough so that materials can be economically processed. It is of course desirable to process the materials as rapidly as possible consistent with the desired degree of disintegration. The above ratio of 20:1 within the speed ranges given, is a desirable ratio, in that materials can progress rapidly enough for economic treatment, while at the same time a given portion of material can be fragmented by a plurality of blows from the hammers while progressing over the star wheels. Too, the slower speed of the star wheels and the inherent slippage between some or most materials being processed and the star wheels means that a given portion of material will be resident in the impact zone of the hammers for a period sufficient to afford the hammers time to break or "bite" off fragments of that portion several times at this speed ratio. The impact zone of the hammers is defined generally as the area of overlap between hammers and star wheels. It is of course possible that the hammers may contact the material outside that zone, but within that zone the most effective disintegration takes place principally because the star wheel teeth provide a sort of anvil against which the hammers can operate upon the material. A given portion of material, therefore, can be divided into smaller fragments because the material is advanced only slightly before a hammer again contacts it. In one sense the hammers only "nibble" or "gnaw" at the material rather than biting off large chunks. Paradoxically less power is required and the machine is less apt to stall, while at the same time better fragmentation is achieved.

For simplicity of illustration I have shown a separate motor **35** which drives a V-belt **36** passing around a pulley **37** on the shaft **31** for driving the drum at high speed, but it will be apparent that various other driving arrangements using one motor may be used. It is desirable also that a flywheel **38** be secured to the shaft **31**.

In operation, papers or other material to be destroyed are dumped into the top of the upwardly-extending enclosure. They are moved by gravity and the downwardly-traveling confronting reaches of the belts **9** and **10** toward the feed roll, and at the same time they are pressed together and emerge as a more or less flattened sheaf or web which is projected against the teeth of the feed drum. The feed drum supports the web of paper and moves it gradually toward the path of travel of the projections **34** of the disintegrator drum. With the paper supported at intervals across its width on the teeth of the feed drum, the choppers or projections on the disintegrator strike the unsupported paper between the teeth with high speed and force, ripping, beating or tearing it out in small fragments. For each increment of forward travel of the paper it will be struck several times. The fragments fall to the hopper bottom and out the opening **6** into a receptacle **40**.

While this will produce a satisfactory disintegration for most purposes, for highly confidential papers there may be one or more secondary beaters. In FIG. 1 there is shown a third shaft **41** directly below shaft **15** with a second disintegrator **42** similar to **33** but smaller. Should any large fragments be impacted on the points of the feed drum, this secondary disintegrator will tear it to fragments. It is also in the trajectory of fragments being propelled downwardly by the disintegrator **33**. It will catch the large fragments and carry them between the points of the feed drum, producing a secondary reduction. It may be driven by a belt **43** passing around a pulley **44** on shaft **31** and a pulley **45** on shaft **41**. It will be noted that disintegrator **33** and also disintegrator **42** rotate in a

direction opposite the direction of rotation of the feed drum.

There may be a third disintegrator drum **46** on shaft **47**. It is similar to **42**, but with its teeth or projections **48** staggered with respect to the disks and projections **34** on the primary disintegrator, and with its circles of revolution overlapping the circles described by projections **34**. It is below the primary disintegrator. If large fragments should by any chance be swept by the disintegrator around past the feed wheel, any such fragment will be struck by the projections **48** of this third drum.

As a further precaution there is a baffle **49** under the cover **7** having a notch or comb-like edge **50** through the open space of which the projections **34** of the disintegrator pass so that any fragment that may escape satisfactory reduction would be torn apart at this point. Similarly the plate **13** has a notched or comb-like lower edge through the spaces of which the teeth of the feed wheels pass.

If there are particularly heavy papers, bottles, vials, etc., the flywheel has sufficient momentum to effect disintegration, crushing or bending without stalling the machine.

As a modification, the machine may be constructed as above described, but as shown in FIG. 3 the projections or impactors on the disintegrator drum may be hinged to swing out under centrifugal force, but hinge backward upon contacting the material to be destroyed. In this figure **51** is a shaft corresponding to shaft **31**, and **52** is a disk similar to **33**, but on its periphery it has lugs **53** with holes passing therethrough. There are choppers or hammers **54** with bifurcated ends straddling the lugs, and a pivot **55** passing through registering holes in the lug and hammer pivotally attaches the hammer to the lug, so that these movable choppers or projections pivot about an axis parallel with the axis of the disintegrator drum.

With either form of disintegrator drum, further precaution against fragments being lodged between the disks can be taken by providing fixed combs with long fingers projecting between the disks of the disintegrator and feed drums to adjacent the hubs of the disks. In FIG. 1 **56** is such a comb having fingers extending between the feed wheel disks **18**. Both of these combs have long, stiff fingers that dislodge fragments close in toward spacers **18***a*. With such combs the combs **13***a* and **49** may or may not be provided.

In FIGS. 4 and 5 there is shown a modification which is especially useful where a smaller capacity of machine is desired, and where it is necessary to exercise special precaution against any fragments being above a predetermined size. In these figures **60** designates generally a supporting frame on which is formed an enclosure having side walls **61** and **62**. The enclosure as here shown has an open top and has a hopper-like bottom **63** with a discharge opening **64** through which fragments of paper may be delivered to a receptacle **65**.

Within the enclosure are two endless belts **66** and **67**. These belts are arranged at a slight angle from a vertical plane so that their confronting reaches converge downwardly. The belt **66** passes around the lower pulley **68**, and an upper pulley **69**. The belt **67** passes around a lower pulley **70**, an upper pulley **71**, and over a third idler **72** which presses the descending reach of the belt **67** toward the discharge throat between the two belts. There is a short reach of the belt **67** at **67'** between the pulley **72** and the pulley **70** where the belt slopes reversely from its inclination above the pulley **72**.

There is a feed drum designated generally as **73**, and which is of the general form previously described. It has a shaft **74** and a hub **75** with spiked toothed disks **76** at spaced intervals along the hub.

The belt **67** is provided with short spikes or pins **67***a* which are arranged in parallel rows along the surface of the belt as most clearly seen in FIG. 5. These rows of pins are staggered with reference to the toothed disks **76** so that as best seen in FIG. 5 the spikes or teeth on the portion of the belt **67'** pass between the teeth of the feed roll.

Below the pulley **70** there is a disintegrator drum designated generally as **77** which may be of the construction previously described in FIGS. 1 and 2, or in FIG. 3. It has a shaft **78** along which are a series of disks **79** as previously described, these disks having projections **80** thereon similar to the projections described on the disintegrator drum of either FIGS. 1 and 2, or FIG. 3. These projections are also staggered with reference to the disks **76** of the feed wheel so that the circles defined by their rotation overlap the circles defined by the teeth on the feed drum with the projections **80** passing through the spaces between the disks **76**. The drum **77** is positioned low enough so that the projections **80** thereof do not interfere with the spikes or projections on the belt **67** where it passes around the belt **70**, but there is very slight clearance between them.

Behind the upwardly-traveling reach of the belt **67** there is a guard plate **81** that is close to the upwardly-traveling reach of the belt **67**. There is a similar guard plate **82** back of the upwardly-traveling reach of the belt **66**. The guard plates **81** and **82** extend up to the top of the enclosure so as to form a hopper which confines any material that is dumped into the top of the enclosure in the space between the two guard plates.

Partly encircling the lower half of the disintegrator drum is a heavy screen **83** which is curved concentrically about the disintegrator drum and its inner surface has only a working clearance with the projections **80** of the disintegrator drum. At the edge of the screen **83** near the center of the machine and just below the point where the projections **80** of the disintegrator drum emerge from between the disks of the feed drum there is a circularly curved enclosure **84** which extends around the periphery of the feed drum to a point just past the center of the roller **68** and its inner surface has only a working clearance with respect to the teeth on the feed drum.

Any suitable arrangement may be provided for driving the disintegrator drum, the feed drum and the two belts. It is desirable that the belt **66** travel at a relatively low linear speed while the belt **67** travels at a much higher linear speed. In a machine of the approximate proportions shown in FIG. 4, the roller **69**, for example, may rotate at about 15 r.p.m. while the roller **71** rotates at a speed of approximately 95 r.p.m. It will thus be seen that there is a substantial differential speed between the confronting reaches of the two belts. Likewise the feed drum is driven at a much lower speed than the disintegrator drum, as in the constructions previously described. As showing one driving arrangement,, there is a motor indicated at **90** which drives a sprocket chain **91** passing around a sprocket wheel **92** on the end of the shaft **74**. The motor **90** operates through a reducing gear to drive the sprocket as in the machine previously described. The shaft **74** has a second sprocket wheel which drives a chain **93** that passes around a sprocket wheel on the end of the roller **68**. The direction of drive of both the roller **68** and the feed drum **73** is the same, this being a counterclockwise direction as shown in FIG. 4. There is a sprocket wheel **94** on the end of the roller **68** of larger diameter that drives a chain **95** passing around a smaller wheel **96** on a stub shaft. There is a gear attached to this sprocket engaging a gear **97** on the end of the roller **70** so that the roller **70** is rotated at a higher speed than the roller **68** and in the opposite direction.

I have shown a second motor **98** which drives a belt **99** passing around a pulley on the end of the disintegrator drum shaft **78** for rotating the disintegrator drum at high speed, i.e., desirably several thousand r.p.m. as in the construction previously described.

In this machine sheafs of papers, books or the like, indicated generally at A, are entered into the open space between the two belt tops. These are squeezed together

by the converging belts and because of the differential speed between the two belts, the spikes or teeth **67***a* on the belt **67** shred or rip through the papers, books, etc. These shreds emerge from between the two belts and enter the space where the spikes on the belt are traveling between the teeth of the feed roller. Here again the feed roller is moving at a relatively low peripheral speed with the belt moving at a higher speed, and further shredding takes place and the fragments are reduced in size. These fragments passing from between the portion of the belt **67'** and the feeder roll move into the area between the feeder roll and the disintegrator where the fragments and shreds of paper being supported on the slow-moving teeth of the feed roll are chopped or beaten into fragments by the projections **80** of the disintegrator drum. The fragments so formed fall onto the screen **83**. If they are small enough they will blow through the screen and fall through the hopper into the receptacle **65**, but if they are too large to pass through the screen they will be carried around by the disintegrator drum and first pass through the area between the projections **80** of the disintegrator drum and the spikes on the belt **67** where it is passing around the lower pulley, and then recycled to the area between the disintegrator drum and the feed drum and further comminuted. It is impossible with this arrangement for any fragment that will not pass through the screen to be discharged from the machine. The screens themselves act as fragmentation members as the paper particles pass therethrough at high speeds and are further torn on the screen mesh. These fragments are so torn, beaten and multilated that they cannot be pieced together. The paper fragments can be compressed into a small space for storage, if necessary, until such time as they are to be incinerated or otherwise disposed of. The fragments can be readily burned in a proper incinerator.

As indicated in FIG. 5, the belt **67** (and if desired the belt **66**) may be of a character having jointed transverse strips so that the belts are rigid in a transverse plane. Bottles or vials which may be included with the papers will be crushed and thoroughly disintegrated; plastic articles will be shredded, and things like staples and paper clips will in no way interfere with the operation of the machine since these will be deformed and bent and pass through the screen along with the fragments of paper.

If desirable, both belts may have spikes on them, although the belt **66** is here shown without such spikes. The belts of FIGS. 1 and 2 may, if desired, be constructed like the belts shown in FIG. 4. Also, if necessary, the combs described in connection with FIGS. 1 and 2 for dislodging fragments from between the disks of the feed and disintegrator drums may be employed in the arrangement shown in FIG. 4, and of course a screen could be used with the arrangement shown in FIGS. 1 and 2.

The invention provides a machine wherein the papers or other materials are first confined between moving belts, and then carried into engagement with a feed roll moving at relatively slow speed, and having teeth which engage and support the paper at intervals across the width of the machine while a disintegrator revolving at high speed has projections or cutters that pass between the teeth of the feed roll and chop and tear the material into small fragments. In the arrangement shown in FIG. 4 the belts not only serve to feed the material to the feed roll, but their joint action effects an initial tearing or shredding, so that less power is required for the disintegrator roll to effect the final comminution of the paper.

As hereinbefore pointed out, the machine may be used, and even specially designed, for destroying or chopping materials other than paper or paper articles, including sheet metal "skeletons" produced in stamping tin plate to reduce the bulk and enable such material to be more readily detinned. Fragments of tin plate so chopped are of irregular non-planar shapes so that they are superior for introducion into detinning solution to sheared sheet fragments, because the pieces will not lie flat in face-to-face contact and the solution will flow around the fragments. The waste plastic from molding thermoplastic articles can be disintegrated into low bulk fragments for remelting. Defective rubber goods, such as rubber gloves, can be effectively chopped up and destroyed to keep them from getting into unauthorized trade channels. These are but some of the many applications for the machine.

In many cases it is desirable to arrange the machine in a generally horizontal configuration wherein the materials progress through the machine in a generally horizontal path rather than in a generally vertical path as shown. In either case the essential parts retain the same cooperative relation.

While I have shown and described certain specific embodiments of my invention, it will be understood that various changes and modifications may be made by those skilled in the art within the contemplation of my invention and under the scope of the following claims.

I claim:

1. Apparatus for disintegrating materials of various kinds into small fragments, comprising,

(a) a supporting structure,

(b) a feed drum mounted in said structure for rotation about a horizontal axis,

(c) a disintegrator drum mounted in said structure for rotation about a horizontal axis,

(d) the feed drum having material engaging and supporting teeth projecting therefrom arranged in axially and angularly spaced rows on the drum,

(e) the disintegrator drum having material impacting teeth extending therefrom, the impacting teeth and disintegrating drum being so disposed with respect to the feed drum that the impacting teeth pass between the teeth of the feed drum with their circles of revolution overlapping, the width of the impacting teeth being greater than the width of the feed drum teeth,

(f) means for rotating the drums in opposite directions with the disintegrator drum being rotated at a higher speed than the feed drum by a ratio of at least 20 to 1 and the linear peripheral speed of the feed drum teeth is in the range of 50 to 5000 inches per minute, and

(g) means for feeding material toward the drums such that the material is engaged by the feed drum teeth before engagement with the impacting teeth.

2. Apparatus as defined in claim **1**, wherein the feeding means comprise,

(a) a pair of endless belts with confronting reaches converging toward the feed drum and

(b) means for driving the belts.

3. Apparatus as defined in claim **2**, wherein the belts are driven at a linear speed less than the linear peripheral speed of the feed drum teeth.

4. Apparatus as defined in claim **1**, wherein the linear peripheral speed of the disintegrator drum impacting teeth is in the range of about 15,000 to 100,000 inches per minute, the linear peripheral speed of the feed drum teeth is in the range of about 50 to 5000 inches per minute and wherein the ratio of the last two mentioned speeds is at least 20:1.

5. Apparatus as defined in claim **4**, wherein the feeding means comprises,

(a) a pair of endless belts with confronting reaches converging toward the feed drum,

(b) means for driving the belts and

(c) wherein the linear speed of the feed belts is approximately 5 to 15% less than the linear peripheral speed of the feed drum teeth.

6. Apparatus as defined in claim **1**, wherein the apex-to-apex chord distance between any two adjacent feed drum teeth is in the range of about 1 to 5 inches.

7. Apparatus as defined in claim 1, wherein the feed drum has fixed thereon a plurality of axially spaced discs, each disc having a plurality of equi-spaced teeth projecting radially therefrom, the root of each tooth being radially spaced from the periphery of the drum, the disintegrator drum being so disposed in relation to the feed drum that the circles of revolution defined by the impacting teeth overlap the circles of revolution defined by the disc teeth roots.

8. Apparatus as defined in claim 7, wherein the radial clearance between the impacting teeth and the feed drum at their closest points is on the order of about 1/16 to 3/8 inch.

9. Apparatus as defined in claim 1, wherein the lateral spacing between the impacting teeth and feed drum teeth at their points of closest approach is in the range of about 1/64 to 3/8 inch.

10. Apparatus as defined in claim 1, wherein the disintegrator drum is formed with a plurality of axially spaced discs, each disc having two teeth spaced 180° apart on the disc, the discs being so arranged on the drum that the teeth on adjacent discs are angularly spaced from each other.

11. Apparatus for disintegrating materials of various kinds into small fragments comprising a rotary feed drum having a spaced annular series of teeth about its periphery, a rotary disintegrator drum having projections on its periphery staggered to pass between the annular series of teeth on the feed drum, the teeth of the feed drum and the projections of the disintegrator drum defining overlapping circles of revolution, means driving the disintegrator drum at a higher speed of rotation than the feed drum, in a ratio of at least 20 to 1 with the feed drum operating at a linear peripheral tooth speed of between 50 and 5000 inches per minute, a pair of downwardly-converging endless belts having confronting reaches moving downward, said belts being positioned to feed paper introduced between them onto the feed roll adjacent the place where the two circles of revolution overlap, means for driving the belts, and a screen concentric with the disintegrator drum and having only a working clearance with its projections arranged to catch fragments of paper discharged from between the two drums and retain fragments of a size too large to pass through the screen for movement by the disintegrator back to the place of overlap of the two circles of revolution at the side toward which the paper is initially fed.

12. Apparatus for disintegrating materials of various kinds into small fragments comprising a rotary feed drum having a spaced annular series of teeth about its periphery, a rotary disintegrator drum having projections on its periphery staggered to pass between the annular series of teeth on the feed drum, the teeth of the feed drum and the projections of the disintegrator drum defining overlapping circles of revolution and driving the disintegrator drum at a higher speed of rotation than the feed drum, with the linear peripheral speed of the feed drum teeth in the range of 50 to 5000 inches per minute and the ratio of the linear peripheral speed of the impacting teeth to that of the feed drum teeth in a ratio of at least 20 to 1, a pair of downwardly-converging endless belts having confronting reaches moving downward, said belts being positioned to feed paper introduced between them onto the feed roll adjacent the place where the two circles of revolution overlap, means for driving the belts, an enclosure about the belts for confining papers in the space between the belts, an enclosure about the feed and disintegrator drums, a second disintegrator drum in the enclosure below the feed drum similar to the first and in the path of fragments discharged from between the feed drum and the first disintegrator drum, and means for rotating the second disintegrator drum at a speed higher than the speed of the feed roll.

13. Apparatus for disintegrating materials of various kinds as defined in claim 12 wherein the projections of the second disintegrator pass between the annular series of teeth on the feed roll.

14. Apparatus for disintegrating materials of various kinds as defined in claim 12 wherein the projections of the second disintegrator pass between the annular series of teeth on the feed roll, and wherein there is a third disintegrator drum in the enclosure below the first one with its projections arranged to pass between the projections of the first.

15. Apparatus for disintegrating materials of various kinds into small fragments comprising a rotary feed drum having a spaced annular series of teeth about its periphery, a rotary disintegrator drum having projections on its periphery staggered to pass between the annular series of teeth on the feed drum, the teeth of the feed drum and the projections of the disintegrator drum defining overlapping circles of revolution and driving the disintegrator drum at a substantially higher speed of rotation than the feed drum, a pair of downwardly-converging endless belts having confronting reaches moving downward, said belts being positioned to feed paper introduced between them onto the feed roll adjacent the place where the two circles of revolution overlap, means for driving the belts, the disintegrator drum comprising a shaft with spaced disks therealong, the projections being on the periphery of the disks and being pivoted to swing about axes parallel with the axis of rotation of the drum.

16. Apparatus for fragmenting severable materials comprising; a rotary feed drum having an axially spaced series of annular sets of teeth on its periphery, a rotary disintegrator drum having projections on its periphery axially spaced to pass between the annular sets of teeth on the feed drum, the tips of said teeth being movable in circular paths and the tips of the projections on the disintegrator drum movable in closed orbital paths overlapping said circular paths, each of said orbital paths having a portion closer to the periphery of said feed drum than to those of said circular paths adjacent said orbital path, said projections having an axial dimension substantially greater than the axial dimension of said teeth, means for rotating the drums in opposite directions, and means for guiding material to be fragmented onto the feed drum and toward said portions of said orbital paths in the same direction as the approach of the projections on the disintegrator drum to the teeth of the feed drum when the drums are rotated in opposite directions.

17. Apparatus for fragmenting severable materials as specified in claim 16 wherein; said axial dimension of said projections is about one and one-half times as great as said axial dimension of said teeth, respectively.

18. Apparatus for fragmenting severable materials comprising; a rotary feed drum having an axially spaced series of annular sets of teeth on its periphery, a rotary disintegrator drum having projections on its periphery axially spaced to pass between the annular sets of teeth on the feed drum, said teeth and said projections having the free ends thereof movable in closed overlapping orbital paths with the free ends of said projections being spaced from the outer surface of said feed drum during movement thereby a distance less than one-half the distance from the free ends of said teeth to said surface, each of said projections having a substantially greater axial extent than the axial extent of any of said teeth, means for rotating the drums in opposite directions, and means for guiding material to be fragmented onto the feed drum and toward the point of initial overlap when the drums are rotated in opposite directions.

19. Apparatus for fragmenting severable materials as specified in claim 18 wherein; said means for guiding is a pair of downwardly converging endless belts having confronting reaches moving downwardly said belts being positioned to feed severable material introduced between them onto the feed roll adjacent the place where the orbited paths overlap.

20. Apparatus for fragmenting severable materials as defined in claim 19 in which the driving means for the

disintegrator drum rotates said drum at a substantially higher peripheral speed than the feed drum, said driving means for the disintegrator drum rotating it at several thousand revolutions per minute and the feed drum at less than a hundred revolutions per minute.

21. An apparatus for fragmenting severable materials as defined in claim **19** in which said driving means operates one belt at a higher speed than the other.

22. An apparatus for fragmenting severable materials as defined in claim **20** in which said driving means operates one belt at a higher speed than the other and spikes on the surface of the faster moving belt which project into the space between the downwardly-traveling reaches of the two belts.

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