

SCREEN BASKET OPTIMIZED FOR REMOVAL OF STICKIES
FROM ADHESIVES-CONTAMINATED RECYCLABLE FIBER

CLAIM FOR PRIORITY

- 5 This non-provisional application is based upon U.S. Provisional Patent Application No. 61/461,117, of the same title, filed January 13, 2011. The priority of U.S. Provisional Patent Application No. 61/461,117 is hereby claimed and the disclosure thereof is incorporated into this application by reference.

10 TECHNICAL FIELD

- Recycling is fast becoming essential for almost every recyclable commodity, yet differences between prices for commodities obtained from nature and those obtained from waste often do not economically justify use of recyclable materials. In the case of fiber obtained from recycle streams of waste paper, it is often quite
15 difficult to render the fiber equivalent in quality to fiber obtained from virgin pulp without incurring costs exceeding the price differential between virgin fiber and the recyclable fiber contained in readily available waste streams.

BACKGROUND

- 20 Achieving virgin equivalent quality from recycled paper is increasingly difficult as fiber from lower and lower grade sources is used. Curbside recycled paper is usually considered just about the lowest possible grade of paper being recycled today. One factor which seems to contribute to the difficulty of obtaining fiber having quality equivalent to virgin fiber from curbside recycled paper is the
25 presence of large amounts of "stickies" and other contaminants in the paper; but industrial/commercial waste papers are also becoming increasingly contaminated, especially with troublesome adhesives. Stickies commonly result from pressure sensitive labels in the waste paper but can be created by other adhesives, plastic window envelopes and the like. During the papermaking process, stickies in the
30 furnish cause problems both by precipitating out of the furnish onto machine parts as well as by remaining in the web where they contribute to dense spots of

- adhesive, ink, plastic, fiber and a host of other contaminants. Stickies are especially problematic when recycle fiber is being used for tissue products as, in bath and facial tissue, each ply of tissue may only have a thickness equivalent to perhaps seven to ten layers of fiber, so the dark dense spot resulting from a stickie which finds its way into the finished sheet detracts both from the aesthetic appearance of the sheet and its functional integrity. Stickies that deposit out on machine clothing interfere with the proper movement of water and/or air through the fabric, again potentially contributing to defects in the finished product.
- 10 As waste paper is converted into pulp which is usable in making tissue and towel products, it is subjected to many of the same processes used with virgin pulp. In fact many mills will use a combination of virgin and recycle pulp to “dial-in” quality. This can lead to difficulties in fiber processing as many of these procedures are relatively sensitive to throughput variations. An especially
- 15 important process is “screening” in which pulp is fed through a “screen” to remove dirt and other contaminants. Virtually all of the pulp fed to a papermachine will pass through a series of screens, each configured to remove contaminants progressively smaller in size than the screen before. Each screen will typically also have some means for removing contaminants lodged on the
- 20 screen so that the screen does not become blocked. The term “screen” is often used both to refer to the overall apparatus used for removing impurities from pulp and for the actual perforate structure which forms the heart of that apparatus. In this application, the aggregate of those structures that form the removable perforate structure are typically referred to as the screen basket. This application
- 25 relates to the perforate screen structure and more particularly to the shape of the surface of the screen structure which contacts the fiber suspension from which impurities are to be removed. Typically, foils moving relative to the screen basket are used for this purpose. These foils are hypothesized to induce negative pressure pulses that clear debris off of the screen basket so that it can pass out of
- 30 the screen through a reject line.

SUMMARY OF THE INVENTION

This invention relates to a screen structure which is unusually effective at removing stickies from recyclable fiber but is tolerant of substantial swings in throughput which result in variations in the flow velocity through the screen – slot
5 velocity.

In modern screens, a great deal of attention is paid both to the hydrodynamics of the flow system as it passes over the screen structure but also to the stresses imposed on the screen as it is subjected to alternating pressure pulses which
10 temporarily induce backflow through the openings in the screen which ideally remove debris which might otherwise occlude the screen and thereby reduce the screening systems capacity. There are two primary techniques used for constructing screens. In the first, a web structure, typically a sheet of stainless steel, has a variety of inter-cooperating grooves, channels, perforations and slits
15 formed in both of its surfaces. The sheet is then rolled into a cylindrical shape and incorporated into the screen system. In the second, a plurality of vanes are formed, often each vane will have a quite complex shape possibly including tapers, grooves, lands, relieved regions and dressed away areas so that when the vanes are assembled into a cylindrical array, precisely shaped slits are formed
20 through the resulting cylindrical shell formed by the multitude of vanes.

There are advantages to each method of construction; but, in screens formed by either technique, the goal is to precisely form a surface joined to slits in parallel in which the flow of water will efficiently conduct fibers through the slits while
25 rejecting contaminants without occluding the surface of the screen. The present invention is thought to be most easily practiced by forming a very large number of similarly shaped vanes then locking them into a ring structure to form a cylindrical screen basket but equivalent surface configurations can also be formed into sheet stock although the manufacturing cost may be higher due to the

difficulties involved in forming precise slits, channels, grooves and contours in the required size.

While large stickies are especially problematic when they find their way into the sheet and the effect of very small stickies in the sheet itself can be difficult to detect, it is not sufficient to remove only the larger stickies at the screens as the adhesives, particularly the pressure sensitive adhesives, tend to aggregate during the papermaking process and grow into larger stickies. Accordingly, one common way of measuring the effectiveness of screening is to separately measure the total area of stickies removed in several size ranges. We prefer to analyze stickies contents in terms of the stickies content by total area in the ranges of $0.001 - 0.04 \text{ mm}^2$, $0.04 - 0.3 \text{ mm}^2$ and over 0.3 mm^2 . In addition, it is sometimes useful to aggregate the 0.04 to 0.3 mm^2 and over 0.3 mm^2 ranges into a single category of over 0.04 mm^2 . Typically, most well designed screens are reasonably effective for stickies over $\sim 0.3 \text{ mm}^2$ in area but will have more difficulty with stickies in the two smaller ranges of $0.001 - 0.04 \text{ mm}^2$ and $0.04 - 0.3 \text{ mm}^2$. Further, it is generally thought that there is a tradeoff between designing screens to be effective on the smaller size ranges of stickies and the amount of fiber that can be effectively cleaned by that screen in a given period. We have found that the screens of the present invention have surprising effectiveness with smaller stickies removal coupled with the ability to process large quantities of fiber over a wide range of slot velocities. It is considered quite surprising that these screens could combine the ability to both remove large fractions of the smaller stickies and process large amounts of fiber over a wide range of slot velocities. Effective removal of large stickies is, however, the *sine qua non* of screen design. A screen design which is not extremely effective in removing large stickies can only be employed in special circumstances.

We have found that surprisingly effective removal of stickies from recyclable waste can be achieved by passing pulp derived from industrial, commercial and

post-consumer waste through a metallic screen basket having an accepts
 contacting surface approximating that of a right circular cylinder having an axis
 "A", a circumference "C" and a diameter "D", said surface comprising a plurality
 of sequences of facets, each sequence comprising a generally circumferentially
 5 extending facet, an upstream generally diametrically extending facet adjacent
 thereto, and a downstream generally diametrically extending facet adjacent thereto,
 each said generally circumferential facet being generally parallel to the axis "A"
 of the cylinder and having a leading edge and a trailing edge, each said leading
 edge and trailing edge as well as each said upstream generally diametrically
 10 extending facet and each said downstream generally diametrically extending facet
 being generally parallel to the axis "A" of the cylinder, each said leading edge
 being located upon a cylindrical surface S_1 , and each said trailing edge being
 located upon a cylindrical surface S_2 , the diametral difference " δ " between the
 distance from the axis "A" of the cylindrical surface S_1 from the diametral
 15 distance from the axis "A" of the cylindrical surface S_2 being between about 0.4
 mm to about 0.6 mm, the normal direction to the surface of each said generally
 circumferential facet in each sequence of facets having a component directed
 toward the adjacent trailing edge of an adjacent generally circumferential facet in
 an adjacent sequence of facets, the angle " α " between each said
 20 generally circumferential facet and the diametral direction of said right circular
 cylinder being between about 80° and 76° , the distance "t" from the leading edge
 to the trailing edge of each said generally circumferential facet being between
 about 2.3 mm and 2.5 mm, the upstream generally diametrically extending facet of
 each sequence adjoining the leading edge of a generally circumferential facet and
 25 the downstream generally diametrically extending facet of each sequence adjoining
 the trailing edge, the distance between the upstream generally diametrically
 extending facet of each sequence and the downstream generally diametrically
 extending facet of the next adjacent sequence "w" being between about 0.11 and
 0.14 mm, a relieved channel leading from the accepts side to the rejects side of
 30 said screen being defined between the upstream generally diametrically extending

facet of each sequence and the downstream generally diametrically extending facet of the next adjacent sequence.

5 In some embodiments, the screen basket is formed from at least one unitary metallic sheet, usually of stainless steel, each sheet having a plurality of trenches formed into its surfaces and a plurality of slits formed therethrough.

10 In other embodiments, a corrosion resistant hardened surface is disposed upon said screen basket; preferably said corrosion resistant hardened surface comprises a major proportion of chromium having hardness of at least about 65 on the Rockwell C scale in a thickness of at least 0.2 mils up to about 1.0 mils.

Still yet other features and advantages of the invention will become apparent from the following description and appended **Figures**.

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BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described in detail below with reference to the drawings wherein like numerals designate similar parts and wherein:

20 **Figure 1** is a partially cut away perspective of a known construction of a screen basket which is suitable to be adapted for practice of the present invention by replacement of the vanes therein by vanes having the configuration described herein.

25 **Figure 2** is a schematic illustration of the geometry of the supply side of a screen basket constructed from a large number of vanes.

Figure 3 is a schematic illustration of a foil in relation to several vanes of a screen basket.

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Figure 4 is a schematic illustration of the theorized flow pattern in the neighborhood of the slits in a screen basket of the present invention.

Figure 5 illustrates the distribution of stickies by size in the supply streams used
5 in experiments conducted to determine the effectiveness of several screen baskets.

Figure 6 illustrates the distribution of stickies by size in the accepts streams
obtained in experiments conducted to determine the effectiveness of several
screen baskets.
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Figure 7 illustrates the Average Cleanliness Efficiencies obtained for the various
size ranges of stickies obtained in experiments conducted to determine the
effectiveness of several screen baskets.

15 **Figure 8** illustrates the relationship between the Average Cleanliness Efficiencies
obtained for the various size ranges of stickies and the slot widths of the screens
used in experiments conducted to determine the effectiveness of several screen
baskets.

20 **Figure 9** illustrates the relationship between the Average Cleanliness Efficiencies
obtained for the various size ranges of stickies and the profile heights of the
screens used in experiments conducted to determine the effectiveness of several
screen baskets.

25 **Figure 10** illustrates the relationship between the Overall Average Cleanliness
Efficiencies obtained and the slot width of the screens used in experiments
conducted to determine the effectiveness of several screen baskets.

Figure 11 illustrates the correlation obtained between the Overall Average Cleanliness Efficiencies and the slot widths and profile heights of the screens used in experiments conducted to determine the effectiveness of several screen baskets.

- 5 **Figure 12** sets forth both the Area % of total stickies removed and the total mass flow of the accepts streams for each of the screens evaluated with profile height being indicated for each data point.

- 10 **Figure 13** sets forth both the Area % of total stickies removed and the total mass flow of the accepts streams for each of the screens evaluated with accepts tonnage being indicated for each data point.

- 15 **Figure 14** sets forth the Area % of total stickies removed in the size range of 0.001 to 0.04 mm² on a grid of the slot width and profile height for each of the screens evaluated.

- 20 **Figure 15** sets forth the Area % of total stickies removed in the size range of 0.04 to 0.3 mm² on a grid of the slot width and profile height for each of the screens evaluated.

- 25 **Figure 16** sets forth the Area % of total stickies removed in the size range of greater than 0.04 mm² on a grid of the slot width and profile height for each of the screens evaluated.

- 30 **Figure 17** sets forth the Area % of total stickies removed in the size range of greater than 0.3 mm² on a grid of the slot width and profile height for each of the screens evaluated.

Figure 18 illustrates the wide variations in Cleanliness Efficiencies resulting for each of the several size ranges of stickies as slot velocity was varied for a screen basket with 0.19 mm slots and a profile height of 0.6 mm.

- 5 **Figure 19** illustrates the significant reductions in the variations in Cleanliness Efficiencies resulting for each of the several size ranges of stickies as slot velocity was varied for a screen basket with 0.14 mm slots and a profile height of 0.51 mm.

- 10 **Figures 20-24** illustrate the performance of a variety of screen designs on various size ranges of stickies as slot velocity is varied.

DETAILED DESCRIPTION

- The invention is described below with reference to a preferred embodiment. Such discussion is for purposes of illustration only. Modifications to particular
15 examples within the spirit and scope of the present invention, set forth in the appended claims, will be readily apparent to one of skill in the art.

Terminology used herein is given its ordinary meaning unless otherwise indicated.

- 20 **Figure 1** illustrates a screen basket **30** comprised of a very large number of longitudinally extending vanes **32** defining longitudinally extending slits **34** therebetween, vanes **32** being held between flanges **36** joined by longitudinally extending rods **38**. Vanes **32** are reinforced by circumferential ribs **40**. This overall method of construction is known from United States Patent No. RE 38,738
25 E and is well suited to receive and retain vanes **32** as described herein.

- Figure 2** (with periodic reference to Figures 1 and 3) illustrates the cross-section of several vanes **32** of the present invention. Each vane **32** has three facets: downstream generally diametrically extending facet **42**, generally circumferentially
30 extending facet **44** and upstream generally diametrically extending facet **46**.

Upstream generally diametrically extending facet **46** adjoins generally circumferentially extending facet **44** at leading edge **48** while downstream generally diametrically extending facet **42** adjoins generally circumferentially extending facet **44** at trailing edge **50** which preferably has a radius of curvature of about 0.6 mm. On each vane **32**, centerline **C** extends toward geometrical axis “A” of screen basket **30**. Leading edge **48** of each vane **32** lies upon imaginary cylindrical surface **S₁** while each trailing edge **50** lies upon imaginary cylindrical surface **S₂**, spaced a distance “**δ**” of between 0.4 mm and 0.6 mm from imaginary cylindrical surface **S₁**, this distance being referred to as the profile height. Each generally circumferentially extending facet **44** has a thickness “**t**” of between about 2.3 and 2.5 mm and is inclined toward the upstream at an angle “**α**” of between about 76° and 80° its respective diametrically extending centerline **C**. Slit **52** having a width “**w**” of between about 0.11 mm and 0.145 mm is defined between upstream generally diametrically extending facet **46** of each vane **32** and downstream generally diametrically extending facet **42** of the next vane upstream therefrom. Together the downstream generally diametrically extending facet **42**, trailing edge **50**, generally circumferentially extending facet **44** and upstream generally diametrically extending facet **46** collectively define the supply contacting surface **54** of screen basket **30**.

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Figure 3 illustrates foil **56** having leading edge **58** and trailing edge **60** defined thereupon. As leading edge **58** of foil **56** passes over each slit **52**, it is theorized that it introduces a negative pressure upon the slit it is passing over tending to clear the slit of stickies and other debris that may be deposited there, while the positive pressure resulting after trailing edge **60** of foil **56** passes over slit **52** tends to drag fiber therethrough while incidentally forcing stickies and other debris against rejects supply contacting surface **54** of screen basket **30** (Figure 1), there to remain until passage of a successive foil **56** induces negative pressure to dislodge stickies and debris. In conventional practice, the clearance between the

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supply contacting surface **54** and foil **56** is a small fraction of an inch or just a few millimeters.

- Figure 4** illustrates the hypothetical formation of vortices **62** as flow passes over trailing edge **50** of each vane **32**. Some have theorized that proper formation of vortices **62** helps to align fibers with slit **52** easing the passage of longer fibers through slit **52**. Others have hypothesized that proper formation of vortices ameliorates the formation of deposits between the slits of the screen.
- 10 Six different screen baskets having the general configuration illustrated in **Figure 1** were evaluated with recycled fiber samples collected from industrial, commercial and post-consumer waste pulp recycling operations. The slot width and profile height for each of the screen baskets, as reported by the manufacturers, are set forth in Table 1. Upon microscopic inspection, it was determined that the
- 15 geometry of the screen baskets varied considerably from that stated by the manufacturer in several cases. Table 1 compares the Actual Screen Basket Geometry to that reported by the manufacturers.

Table 1

Screen Basket Label	Reported Screen Basket Specifications		Actual Screen Basket Geometry	
	Slot Width, mm	Profile Height, mm	Slot Width, mm	Profile Height, mm
A	0.10	0.9	0.11	0.90
V-1	0.11	0.7	0.11	0.70
V-2	0.12	0.5	0.13	0.50
V-3	0.15	0.7	0.16	0.67
V-4	0.15	0.7	0.14	0.51
V-5	0.15	0.7	0.19	0.62

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Over a period of several months, the screen baskets were evaluated with pulp samples having average stickies contents and size variations as set forth in Table 2.

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Table 2
Supply Stickies (per 100 OD g basis)

	Supply Stickies (per 100 OD g basis)							
	0.001-0.04 mm ²		>0.04 mm ²		0.04-0.3 mm ²		>0.3 mm ²	
	Count	Area	Count	Area	Count	Area	Count	Area
A	3,571	28.5	1,859	474.7	1,494	185.3	365	289.4
V-1	2,076	16.9	1,152	305.6	936	117.3	216	188.3
V-2	4,674	40.0	2,830	739.2	2,262	282.1	568	457.1
V-3	2,650	43.2	2,957	680.2	2,448	305.5	509	374.7
V-4	3,805	30.6	1,997	473.2	1,672	208.2	325	265.0
V-5	5,090	20.5	1,355	381.5	1,064	135.5	291	246.0

On a gross basis the results obtained are set forth in the two parts of Table 3.

Table 3 (part 1)

	Reject Ratio	Supply			Accepts			Rejects				Mass Flow (ODSTPD)			Production	
		%	TSS	Ash	%	Cons	%	GPM	%	TSS	Ash	%	Cons	Accept		Rejects
A	0.16	1.10	6.88	1.02	3,466	0.99	7.39	0.94	565	1.51	5.66	1.40	213	50	263	373
V-1	0.14	1.08	6.95	1.01	3,527	1.01	7.42	0.94	494	1.41	5.67	1.33	214	42	256	366
V-2	0.20	1.17	7.41	1.09	3,536	1.10	7.58	1.02	704	1.51	5.98	1.42	235	64	299	393
V-3	0.14	1.05	5.82	0.99	3,665	1.00	6.07	0.94	512	1.49	4.64	1.42	220	46	266	386
V-4	0.14	1.09	7.29	1.01	3,716	1.03	7.45	0.95	520	1.45	6.06	1.36	230	45	275	393
V-5	0.14	1.08	7.39	1.00	3,574	1.04	7.52	0.96	501	1.35	6.26	1.26	224	41	265	375

Table 3 (part 2)

	Thickening Factor	Vol. Reject Rate, %	OD Reject Rate, %	Slot Vel. m/s
A	1.36	14.0	19.0	1.29
V-1	1.31	12.3	16.4	1.38
V-2	1.29	16.6	21.5	1.52
V-3	1.42	12.3	17.3	1.58
V-4	1.33	12.3	16.5	1.60
V-5	1.25	12.3	15.4	1.54

The accepts stream samples from the screen were evaluated for stickies content with average results as set forth in Table 4.

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Table 4

	Accepts Stickies (per 100 OD g basis)							
	0.001-0.04 mm ²		>0.04 mm ²		0.04-0.3 mm ²		>0.3 mm ²	
	Count	Area	Count	Area	Count	Area	Count	Area
A	1,973	16.7	969	123.7	927	105.2	42	18.5
V-1	1,388	10.2	493	59.1	476	52.2	17	6.8
V-2	1,734	16.4	896	103.0	876	91.2	20	11.8
V-3	2,717	24.9	1,520	172.0	1,490	160.5	30	11.5
V-4	1,537	12.1	632	72.5	619	66.4	12	6.1
V-5	1,595	13.0	854	120.6	801	98.1	54	22.5

From these results, cleanliness efficiencies were obtained on both a number basis and an area basis as set forth in the three parts of Table 5. These results are also presented graphically in **Figures 5-10** while **Figure 11** presents a correlation

10 between slot width, profile height and average cleanliness efficiency.

Table 5 (part 1)

	Cleanliness Efficiency (Area)			Cleanliness Efficiency (Count)		
	>0.04 mm ² , %	0.04-0.3 mm ² , %	>0.3 mm ² , %	>0.04 mm ² , %	0.04-0.3 mm ² , %	>0.3 mm ² , %
A	74.4	40	94	49.1	39	89
V-1	81.6	50	96	58.7	50	93
V-2	85.1	59	97	66.8	59	96
V-3	75.0	49	97	49.7	41	94
V-4	84.6	67	98	68.2	63	96
V-5	68.5	28	91	37.7	25	83

Table 5 (part 2)

Screen			Capacity		Stickies		Cleanliness Efficiency (Area)		
	Slot Width, mm	Profile Height, mm	Tons per day in Accept Stream	Tons per day in Supply Stream	Total area of Stickies in Supply	Area % Stickies Removal Efficiency	>0.04 mm ² , %	0.04-0.3 mm ² , %	>0.3 mm ² , %
A-1	0.11	0.90	213	263	688.6	61.7	74.4	40	94
V-1	0.11	0.70	214	256	439.7	70.8	81.6	50	96
V-2	0.13	0.50	235	299	1061.3	79.0	85.1	59	97
V-3	0.16	0.67	220	266	1028.9	64.1	75	49	97
V-4	0.14	0.51	230	275	712.0	77.9	84.6	67	98
V-5	0.19	0.62	224	265	537.4	52.7	68.5	28	91

Figures 12-17 graphically present relationships between slot width, profile height and stickies removal with tonnage production being noted for each case.

Table 5 (part 3)

Screen			Stickies		
	Slot Width, mm	Profile Height, mm	Total area of Stickies in Supply 0.001 – 0.04 mm ²	Total area of Stickies in Accepts 0.001 – 0.04 mm ²	Area % Stickies Removal Efficiency 0.001 – 0.04 mm ²
A-1	0.11	0.90	28.5	16.7	41.4%
V-1	0.11	0.70	16.9	10.2	39.6%
V-2	0.13	0.50	40.0	16.4	59%
V-3	0.16	0.67	43.2	24.9	42.4%
V-4	0.14	0.51	30.6	12.1	60.5%
V-5	0.19	0.62	20.5	13.0	36.6%

As the demand on the fiber processing lines typically varies from time to time depending upon the paper machine needs, it is quite advantageous for a screen design to be able to provide a relatively consistent output over a range of throughputs. To demonstrate the ability of screen designs of the present invention to handle variations in throughputs, during the series of trials above, the performance of the screen was recorded as the slot velocity was varied. The following tables (Tables 6 - 11) record the Cleanliness Efficiencies of the several screen designs set forth over a range of slot velocities.

Example 1 (Comparative)

Table 6 describes the performance of a screen, not of the present invention, in the above-described evaluation. **Figure 18** sets forth those results graphically. It can be appreciated that not only are the efficiencies rather low but that they vary widely as slot velocity is varied, making it quite difficult to reliably control the input to the papermaking process as demand for fiber is varied. (Throughout the Examples, where the last line of a table is separated from the lines above it by a

heavy horizontal line, the values in that last line are averages of the figures above in that table.)

Table 6

Screen Basket V-5 - Slot Width 0.19 mm/ Profile Height 0.62 mm			
Slot velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.28	67.3	33.3	91.7
1.27	69.5	35.3	95.4
1.28	68.7	5.2	95.1
1.29	75.5	24.1	93.9
1.28	74.6	40.0	90.2
1.28	77.3	38.7	93.8
1.16	76.5	44.3	93.3
1.16	58.5	16.4	86.0
1.19	43.6	-5.0	82.7
1.20	69.1	27.7	91.5
1.20	65.0	25.6	82.8
1.20	51.9	31.2	65.7
1.16	49.5	23.0	84.8
1.16	70.3	7.2	95.5
1.18	76.5	45.2	91.1
1.17	66.0	18.0	88.0
1.17	76.2	27.0	94.0
1.17	72.1	43.4	93.2
1.15	79.6	33.4	96.4
1.22	58.9	29.3	80.6
1.16	72.0	-2.3	95.4
1.16	68.2	13.8	92.6
1.19	75.1	37.2	91.8

Table 6 (continued)

Screen Basket V-5 - Slot width 0.19 mm/ Profile Height 0.62 mm			
Slot velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.19	80.5	43.3	92.9
1.29	71.1	45.3	97.1
1.28	68.2	33.9	90.3
1.15	62.1	8.9	92.9
1.16	56.0	16.7	87.0
1.23	47.9	4.3	81.2
1.22	52.5	7.4	87.2
1.19	68.6	48.7	90.8
1.20	52.1	32.5	79.9
1.22	79.3	56.0	93.3
1.22	79.0	45.7	96.6
1.28	83.8	23.5	98.4
1.29	75.2	44.9	89.5
1.16	62.3	7.8	96.2
1.16	86.0	42.9	98.3
1.18	78.0	57.4	92.7
1.17	74.0	19.8	95.3
1.32	78.3	39.3	95.1
1.33	69.1	46.2	93.9
1.34	66.7	23.9	91.5
1.35	59.5	9.7	88.9
1.22	68.5	28.4	90.8

Example 2

Table 7 sets forth results obtained with a screen which was found to be performing exceptionally well for unknown reasons. Upon close examination, it was determined that not only did it not match the specifications from the factory but it
5 appeared that it had most likely worn considerably from its initial configuration. As the slot width was narrower than manufacturer's specification, it was considered apparent however that not all of the variation could be due to wear. **Figure 19** presents the results obtained with this screen graphically. It can be appreciated that the average efficiencies are not only very high but the results
10 remain quite consistent over a wide range of slot velocities. These results led the present inventors to determine whether the outstanding and unexplained performance of this screen could be duplicated by manufacturing a screen with the same slot width and profile height.

Table 7

Screen Basket V-4 - Slot Width 0.14 mm/ Profile Height 0.51 mm			
Slot Velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.74	80.8	56.8	98.5
1.73	80.5	50.4	98.7
1.75	81.6	50.8	96.8
1.74	94.6	73.5	99.0
1.75	88.3	68.3	98.3
1.75	90.9	75.7	95.3
1.58	93.8	83.2	100.0
1.58	85.6	70.1	99.0
1.61	89.5	76.4	96.3
1.61	92.6	78.4	99.5
1.60	81.3	42.7	99.4
1.63	82.9	63.4	100.0
1.58	85.7	63.8	97.1
1.58	88.7	73.7	96.9
1.68	86.7	71.8	97.4
1.67	89.5	71.3	99.7
1.85	84.8	78.4	98.6
1.85	86.2	76.1	99.4
1.86	81.3	71.6	99.1
1.86	81.8	66.6	97.0
1.67	87.1	69.3	100.0
1.67	82.2	65.2	99.4
1.67	78.9	67.7	97.6

Table 7 (continued)

Screen Basket V-4 - Slot Width 0.14 mm/ Profile Height 0.51 mm			
Slot Velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.67	83.5	73.3	95.7
2.04	83.6	68.9	97.1
2.04	50.0	30.0	79.8
2.03	80.4	66.6	96.4
2.05	87.7	75.3	98.6
1.58	86.6	65.1	98.4
1.58	86.6	68.6	98.6
1.58	86.3	73.0	98.4
1.57	85.7	68.9	99.0
1.72	84.6	67.3	97.7

Example 3

- 5 Table 8 presents the results obtained with a screen of the present invention, V-2 which attempted to achieve the same slot width and profile as found in screen V-4. The results obtained are presented graphically in **Figure 20**. From these results, it can be appreciated that screen V-2 largely replicates the benefits of screen V-4.

Table 8			
Screen Basket V-2 - Slot Width 0.13 mm/ Profile Height 0.5 mm			
Slot Velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.34	88.3	65.6	98.6
1.35	84.1	65.5	99.4
1.38	75.5	35.1	98.9
1.44	80.2	36.0	100.0
1.35	88.7	57.9	98.7
1.35	91.7	74.4	98.4
1.45	77.6	40.2	97.3
1.48	86.0	67.1	99.2
1.42	82.9	57.8	90.1
1.41	85.1	62.9	92.6
1.40	87.0	71.3	99.5
1.30	89.9	71.6	98.5
1.44	88.0	61.6	98.8
1.45	91.0	65.8	100.0
1.44	78.5	46.4	95.2
1.55	88.8	73.7	97.9
1.35	89.6	62.3	98.1
1.35	79.5	54.4	92.0
1.40	85.1	59.4	97.4

Example 4 (Comparative)

Table 9 sets forth the results obtained with another screen V-1, not of the invention, while those results are presented graphically in **Figure 21**. While the results are somewhat consistent with slot velocity, it can be appreciated from

- 5 **Figure 21**, that the efficiency of Screen V-1 is far inferior to screens of the present invention.

Table 9

Screen Basket V-1 - Slot Width 0.11 mm/ Profile Height 0.7mm			
Slot Velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.33	80.5	47.9	96.6
1.33	74.6	37.1	90.3
1.40	73.4	49.9	92.2
1.41	64.3	36.6	89.0
1.37	91.0	66.2	100.0
1.38	73.8	45.9	96.0
1.41	85.5	55.4	97.1
1.41	84.1	55.0	96.1
1.47	88.7	62.5	96.9
1.47	88.5	52.8	100.0
1.33	92.5	59.5	100.0
1.33	78.7	30.1	98.8
1.36	80.4	50.1	96.1
1.34	86.1	52.9	98.9
1.38	81.6	50.1	96.3

Example 5 (Comparative)

Table 10 presents the results obtained on another screen, V-3 not of the invention,

- 10 while those results are presented graphically in **Figure 22**. While the results are

somewhat consistent with slot velocity, it can be appreciated from **Figure 22**, that the efficiency of Screen V-3 is inferior to screens of the present invention.

Table 10

Screen Basket V-3 - Slot Width 0.16 mm/ Profile Height 0.67 mm			
Slot Velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.53	79.1	63.3	96.0
1.52	80.0	47.1	98.0
1.52	74.0	52.1	93.9
1.53	75.9	56.4	98.0
1.45	82.3	58.9	96.9
1.45	75.7	52.6	96.1
1.45	72.2	48.0	95.5
1.45	65.7	41.2	92.5
1.62	75.8	38.3	97.8
1.62	69.3	40.2	97.0
1.61	78.8	53.4	95.9
1.61	73.2	48.6	95.1
1.38	75.5	46.0	97.3
1.39	72.2	41.6	97.1
1.39	73.2	49.3	96.1
1.39	70.3	40.0	97.2
1.44	75.2	46.0	98.8
1.43	81.3	52.6	99.0
1.44	74.8	47.0	98.5
1.43	76.0	53.3	98.7
1.48	75.0	48.8	96.8

Example 6 (Comparative)

Table 11 presents the results obtained on another screen, A-1 not of the invention, while those results are presented graphically in **Figure 23**. It can be appreciated that the results are somewhat inconsistent with slot velocity. It can also be

5 appreciated from **Figure 23**, that the efficiency of Screen A-1 is quite low for this type of fiber.

Table 11

Screen Basket A-1 - Slot Width 0.11 mm/ Profile Height 0.9 mm			
Slot Velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.16	80.4	46.1	97.3
1.15	77.6	39.0	96.8
1.18	63.8	29.1	82.9
1.19	62.2	32.0	87.1
1.20	78.7	37.2	96.4
1.20	70.9	32.2	94.8
1.15	65.7	50.0	88.2
1.15	87.0	54.9	99.2
1.17	83.3	53.2	95.4
1.17	76.8	51.0	95.0
1.16	75.3	52.5	96.1
1.16	88.0	64.6	98.0
1.15	84.6	61.1	98.7
1.22	80.6	45.6	97.1
1.15	84.2	63.3	98.2
1.15	65.9	41.3	85.2
1.18	83.0	62.4	93.9
1.18	87.1	53.7	99.1
1.28	73.8	38.2	95.4
1.27	80.3	56.2	95.6
0.98	86.7	56.0	100.0
0.98	83.0	65.7	96.5
0.98	81.2	41.1	97.1
0.98	75.6	33.2	98.5
1.15	83.8	67.7	97.7
1.15	75.4	44.4	96.4
1.17	84.3	63.9	98.7
1.18	81.3	42.7	99.4
1.17	74.9	38.8	98.8
1.18	66.5	38.1	95.4
1.15	67.9	27.4	92.9

Table 11 (Continued)

Screen Basket A-1 - Slot Width 0.11 mm/ Profile Height 0.9 mm			
Slot Velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.16	65.7	20.0	95.4
1.21	64.3	29.0	93.1
1.21	79.2	45.2	95.8
1.14	73.1	29.2	94.1
1.15	48.8	15.6	85.6
1.28	74.4	31.8	95.4
1.26	74.9	42.0	98.0
1.14	68.4	17.1	93.1
1.15	43.8	-32.1	77.4
1.24	64.7	26.9	94.8
1.23	68.1	34.6	95.9
1.27	76.5	40.4	92.6
1.27	81.7	46.2	96.6
1.22	72.5	43.5	96.0
1.16	76.1	27.6	96.4
1.14	74.1	22.4	94.4
1.28	83.0	51.6	97.1
1.28	65.9	27.0	88.6
1.26	73.8	45.5	91.1
1.15	76.2	35.1	92.4
1.16	55.6	3.4	81.7
1.17	74.4	40.1	94.4

The results of the preceding Examples 1-6 can be summarized in the following set of Tables 12-17 which are graphically represented in **Figure 24**.

Table 12 : Example 1 (Comparative)			
Averages from Table 6			
Screen Basket V-5 - Slot Width 0.19 mm/ Profile Height 0.62 mm			
Slot Velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.22	68.5	28.4	90.8

Table 13 : Example 2			
Averages from Table 7			
Screen Basket V-4 - Slot Width 0.14 mm/ Profile Height 0.51 mm			
Slot Velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.72	84.6	67.3	97.7

Table 14 : Example 3			
Averages from Table 8			
Screen Basket V-2 - Slot width 0.13 mm/ Profile Height 0.5 mm			
Slot velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.40	85.1	59.4	97.4

5

Table 15 : Example 4 (Comparative)			
Averages from Table 9			
Screen Basket V-1 - Slot Width 0.11 mm/ Profile Height 0.7mm			
Slot Velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.38	81.6	50.1	96.3

Table 16 : Example 5 (Comparative)			
Averages from Table 10			
Screen Basket V-3 - Slot Width 0.16 mm/ Profile Height 0.67 mm			
Slot Velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.48	75.0	48.8	96.8

Table 17 : Example 6 (Comparative)			
Averages from Table 11			
Screen Basket A-1 - Slot width 0.11 mm/ Profile Height 0.9 mm			
Slot velocity (m/s)	Cleanliness Efficiencies (%)		
	Stickies Area Size Ranges		
	>0.04 mm ²	0.04-0.3 mm ²	>0.3 mm ²
1.17	74.4	40.1	94.4

It can be appreciated from Tables 12-17 and **Figure 24** that the cleanliness efficiencies for stickies are quite sensitive to even small variations in slot width and profile height.

While the invention has been described in connection with several examples, modifications to those examples within the spirit and scope of the invention will be readily apparent to those of skill in the art. In view of the foregoing discussion, relevant knowledge in the art and references discussed above in connection with the Background and Detailed Description, the disclosures of which are all incorporated herein by reference, further description is deemed unnecessary.

WHAT IS CLAIMED IS:

1. A method for screening recycled pulp comprising the steps of:
 - 5 fiberizing and suspending the pulp in an aqueous liquid;

pressurizing said aqueous liquid;

passing said aqueous liquid containing said fiberized and suspended pulp
10 to one screen having:

a metallic screen basket for screening of stickies having a supply side
surface approximating that of a right circular cylinder having an axis
“A”, a circumference “C” and a diameter “D”, said surface comprising
15 a plurality of sequences of facets, each sequence comprising a
generally circumferentially extending facet, an upstream generally
diametrically extending facet adjacent thereto, and a downstream
generally diametrically extending facet adjacent thereto, each said
generally circumferential facet being generally parallel to the axis “A”
20 of the cylinder and having a leading edge and a trailing edge, each said
leading edge and trailing edge as well as each said upstream generally
diametrically extending facet and each said downstream generally
diametrically extending facet being generally parallel to the axis “A” of
the cylinder, each said leading edge being located upon a cylindrical
25 surface S1, and each said trailing edge being located upon a cylindrical
surface S2, the diametral difference “ δ ” between the distance from the
axis “A” to the cylindrical surface S1 and the diametral distance from
the axis “A” to the cylindrical surface S2 being between about 0.4 mm
to about 0.6 mm, the normal direction to the surface of each said
30 generally circumferential facet in each sequence of facets having a

component directed toward the adjacent trailing edge of an adjacent generally circumferential facet in an adjacent sequence of facets , the angle “ α ” between each said generally circumferential facet and the diametral direction of said right circular cylinder being between about 80° and 76°, the distance “t” from the leading edge to the trailing edge of each said generally circumferential facet being between about 2.3 mm and 2.5 mm, the upstream generally diametrically extending facet of each sequence adjoining the leading edge of a generally circumferential facet and the downstream generally diametrically extending facet of each sequence adjoining the trailing edge, the distance “w” between the upstream generally diametrically extending facet of each sequence and the downstream generally diametrically extending facet of the next adjacent sequence being between about 0.11 mm and 0.145 mm, a channel leading from the supply side to the accepts side of said screen being defined between the upstream generally diametrically extending facet of each sequence and the downstream generally diametrically extending facet of the next adjacent sequence;

a plurality of foils deployed adjacent said supply surface, each said foil being adapted to induce flow past said accepts surface of said screen basket and thereby periodically induce backflow through said channels against the pressure applied to said aqueous liquid, forward flow responsive to the pressure applied to said aqueous liquid occurring during periods between said periodic backflow;

conducting forward flow passing though said channels as an accepts flow to a papermaking operation;

passing rejects flow from said supply side of said screen basket to another screen; and

5 recycling accepts from said other screen back to the supply to said one stream.

2. The method of claim 1, wherein the screen basket is comprised of a plurality of metallic faceted vanes.
- 10 3. The method of claim 1, wherein the screen basket is formed from at least one unitary metallic sheet, each sheet having a plurality of trenches formed into its surfaces and a plurality of slits formed therethrough.
4. The method of claim 1 wherein the screen basket comprises stainless steel.
- 15 5. The method of any preceding claim wherein a corrosion resistant hardened surface is disposed upon the screen basket.
6. The method of claim 1 wherein the screen basket is plated with chromium.
- 20 7. The method of claim 6 wherein the screen basket bears a hard plating comprising a major proportion of chromium having hardness of at least about 65 on the Rockwell C scale in a thickness of at least 0.2 mils up to about 1.0 mils.
- 25 8. A metallic screen basket for screening of stickies containing recycled fibers, having a supply side surface approximating that of a right circular cylinder having an axis "A", a circumference "C" and a diameter "D", said surface comprising a plurality of sequences of facets, each sequence comprising a
- 30 generally circumferentially extending facet, an upstream generally diametrically

extending facet adjacent thereto, and a downstream generally diametrically
extending facet adjacent thereto, each said generally circumferential facet
being generally parallel to the axis "A" of the cylinder and having a leading
edge and a trailing edge, each said leading edge and trailing edge as well as
5 each said upstream generally diametrically extending facet and each said
downstream generally diametrically extending facet being generally parallel to
the axis "A" of the cylinder, each said leading edge being located upon a
cylindrical surface S1, and each said trailing edge being located upon a
cylindrical surface S2, the diametral difference "d" between the distance from
10 the axis "A" to the cylindrical surface S1 and the diametral distance from the
axis "A" to the cylindrical surface S2 being between about 0.35 mm to about
0.60 mm, the normal direction to the surface of each said generally
circumferential facet in each sequence of facets having a component directed
toward the adjacent trailing edge of an adjacent generally circumferential facet
15 in an adjacent sequence of facets, the angle " α " between each
said generally circumferential facet and the diametral direction of said right
circular cylinder being between about 80° and 76° , the distance "t" from the
leading edge to the trailing edge of each said generally circumferential facet
being between about 2.30 mm and 2.5 mm, the upstream generally diametrically
20 extending facet of each sequence adjoining the leading edge of a generally
circumferential facet and the downstream generally diametrically extending
facet of each sequence adjoining the trailing edge, the distance between the
upstream generally diametrically extending facet of each sequence and the
downstream generally diametrically extending facet of the next adjacent
25 sequence being between about 0.11 mm and 0.145 mm, a channel leading
from the supply side to the accepts side of said screen being defined between
the upstream generally diametrically extending facet of each sequence and the
downstream generally diametrically extending facet of the next adjacent
sequence.

30

9. The metallic screen basket of claim 8, wherein the screen basket is comprised of a plurality of metallic faceted vanes.
10. The metallic screen basket of claim 8, wherein the screen basket is formed from at least one unitary metallic sheet, each sheet having a plurality of trenches formed into its surfaces and a plurality of slits formed therethrough.
11. The metallic screen basket of any of claims 8 to 10 wherein the screen basket comprises stainless steel.
12. The metallic screen basket of any of claims 8 to 10 wherein a corrosion resistant hardened surface is disposed upon the screen basket.
13. The metallic screen basket of claim 8 wherein the screen basket is plated with chromium.
14. The metallic screen basket of claim 13 wherein the screen basket bears a hard plating comprising a major proportion of chromium having hardness of at least about 65 on the Rockwell C scale in a thickness of at least 0.2 mils up to about 1.0 mils.
15. An improved screen for separating a supply stream comprising an aqueous dispersion of papermaking fibers contaminated with adhesives into an accepts stream enriched in fibers and depleted in adhesive relative to said supply stream and a rejects stream enriched in adhesive and depleted in fiber relative to said supply stream, said screen comprising: a housing; a generally cylindrical screen basket disposed within said housing, defining an accepts region exterior to said screen basket; a supply duct issuing into said screen basket within said housing; an accepts duct leading from accepts region in said housing; and a rejects duct adapted to receive aqueous dispersion not passing

through said screen basket; wherein the improvement comprises; said screen basket comprising a plurality of metallic faceted vanes defining an interior supply side surface approximating that of a right circular cylinder having an axis "A", a circumference "C" and a diameter "D", each vane having formed therein: a generally circumferentially extending facet, an upstream generally diametrically extending facet adjacent thereto, and a downstream generally diametrically extending facet adjacent thereto, each said generally circumferential facet being generally parallel to the axis "A" of the cylinder and having a leading edge and a trailing edge, each said leading edge and trailing edge as well as each said upstream generally diametrically extending facet and each said downstream generally diametrically extending facet being generally parallel to the axis "A" of the cylinder, each said leading edge being located upon an imaginary cylindrical surface S1 generally coaxial with said screen basket, and each said trailing edge being located upon another imaginary cylindrical surface S2 generally coaxial with said screen basket, the diametral difference "d" between the distance from the axis "A" to the cylindrical surface S1 and the diametral distance from the axis "A" to the cylindrical surface S2 being between about 0.35 mm to about 0.60 mm, the normal direction to the surface of each said generally circumferential facet on each vane having a component directed toward the adjacent trailing edge of an adjacent generally circumferential facet in an adjacent vane, the angle " α " between each said generally circumferential facet and the diametral direction of said right circular cylinder being between about 80° and 76°, the distance "t" from the leading edge to the trailing edge of each said generally circumferential facet being between about 2.30 mm and 2.5 mm, the upstream generally diametrically extending facet of each vane adjoining the leading edge of a generally circumferential facet and the downstream generally diametrically extending facet of each vane adjoining the trailing edge, the distance between the upstream generally diametrically extending facet of each vane and the downstream generally diametrically extending facet of the

5 next adjacent vane being between about 0.11 mm and 0.145 mm, a relieved channel leading from the supply side to the accepts side of said screen being defined between the upstream generally diametrically extending facet of each vane and the downstream generally diametrically extending facet of the next adjacent vane.

16. The improved screen of claim 15, wherein the screen is comprised of a plurality of metallic faceted vanes.
- 10 17. The improved screen of claim 15, wherein the screen is formed from at least one unitary metallic sheet, each sheet having a plurality of trenches formed into its surfaces and a plurality of slits formed therethrough.
18. The improved screen of any of claims 15 to 17 wherein the screen comprises
15 stainless steel.
19. The improved screen of any of claims 15 to 17 wherein a corrosion resistant hardened surface is disposed upon the screen.
- 20 20. The improved screen of any of claims 15 to 17 wherein the screen is plated with chromium.
21. The improved screen of claim 15 wherein the screen bears a hard plating comprising a major proportion of chromium having hardness of at least about
25 65 on the Rockwell C scale in a thickness of at least 0.2 mils up to about 1.0 mils.

Abstract

A screen structure which is unusually effective at removing stickies from recyclable fiber but is tolerant of substantial swings in throughput which result in variations in the flow velocity through the screen - slot velocity. One example of the screen structure is created by forming a very large number of similarly shaped vanes then locking them into a ring structure to form a cylindrical screen basket but equivalent surface configurations can also be formed into sheet stock.

[Figure 1]

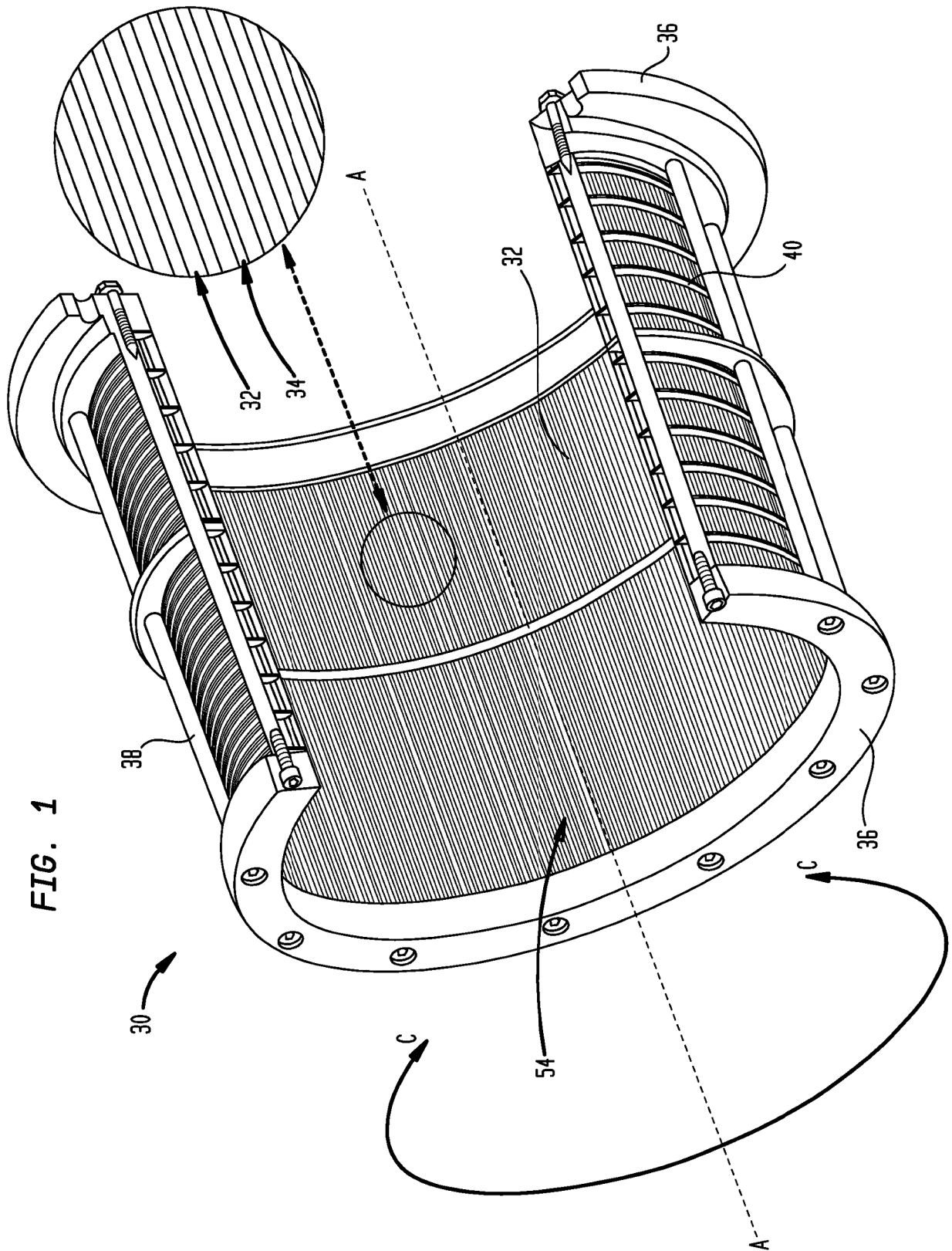


FIG. 2

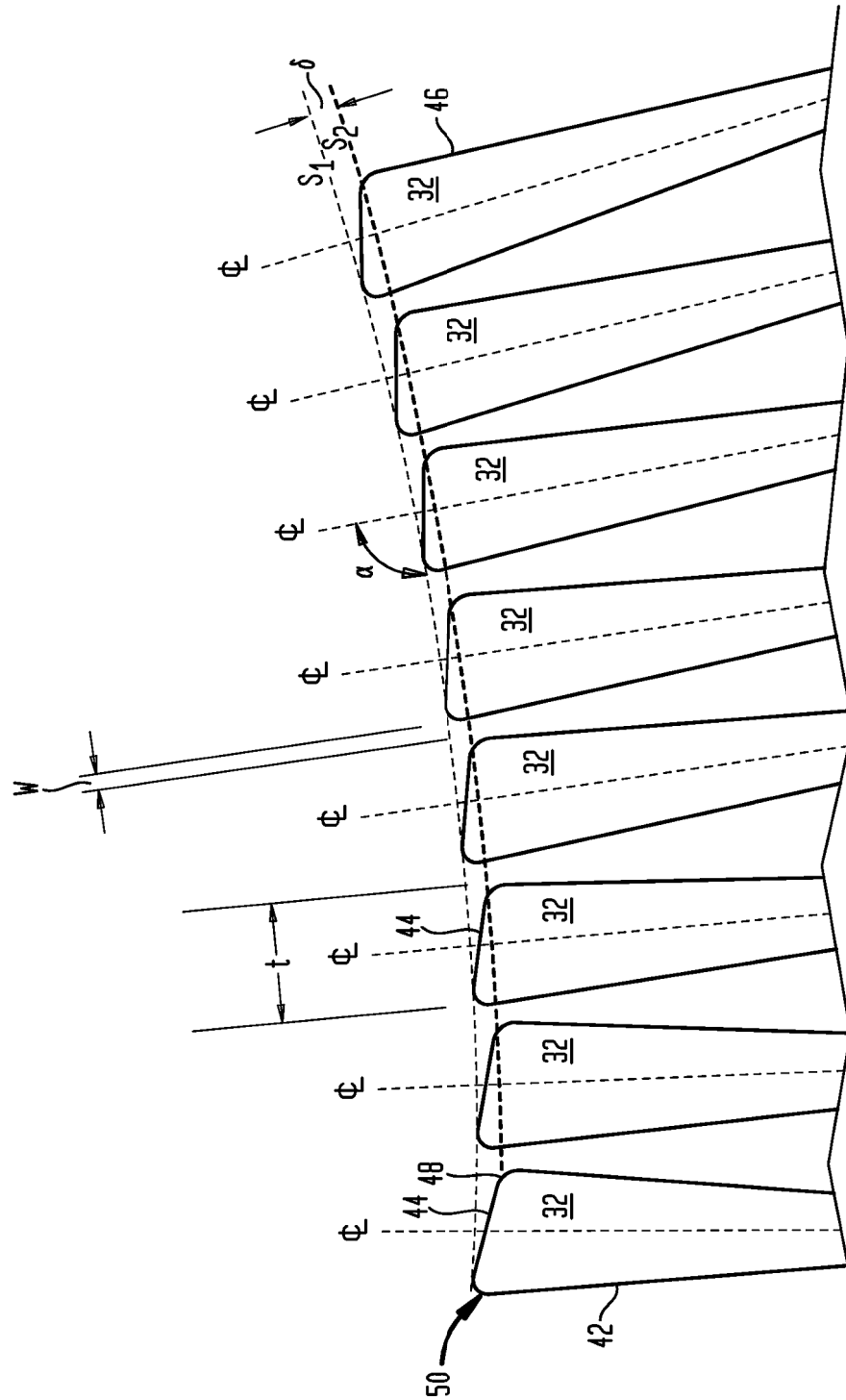


FIG. 3

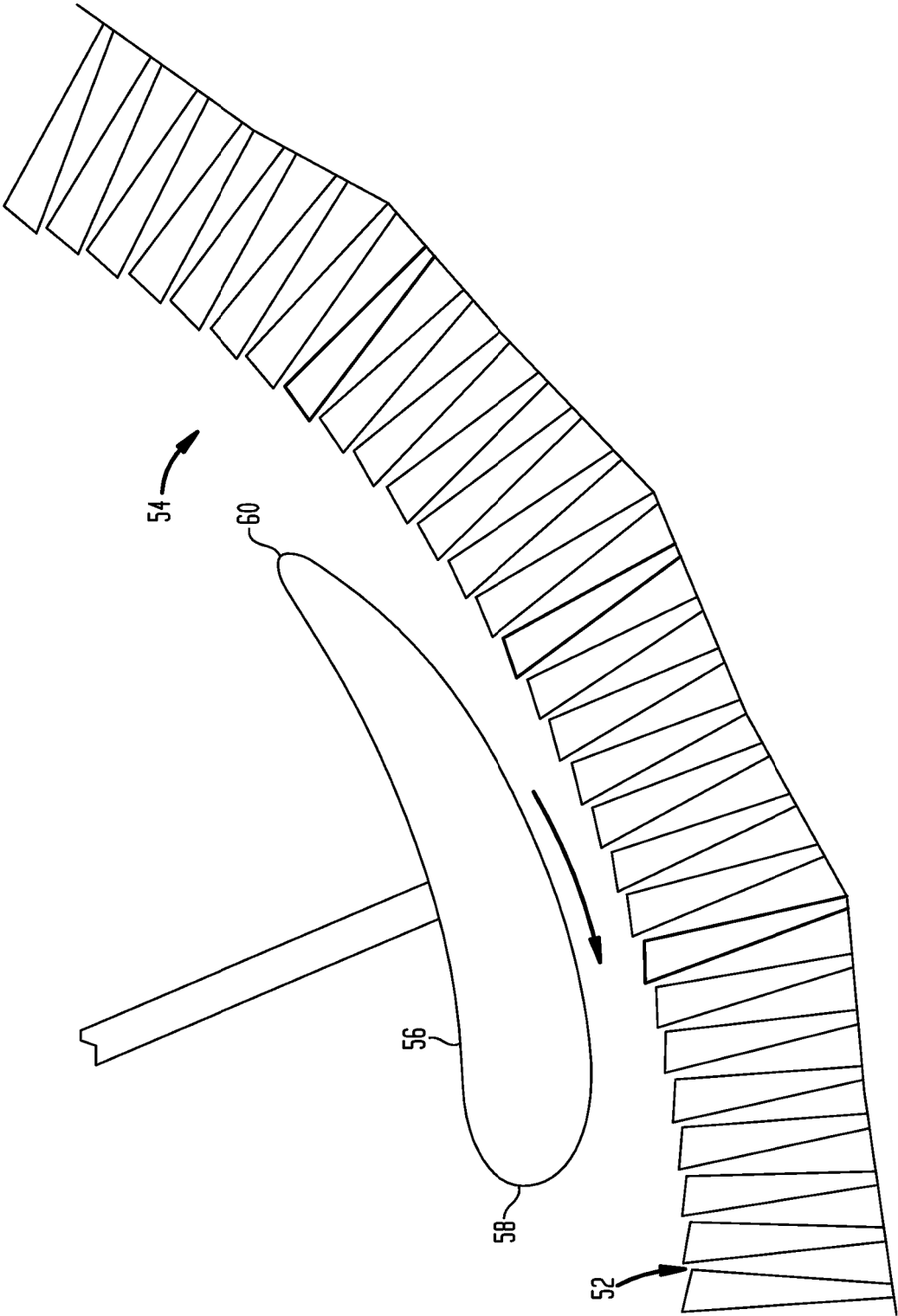


FIG. 4

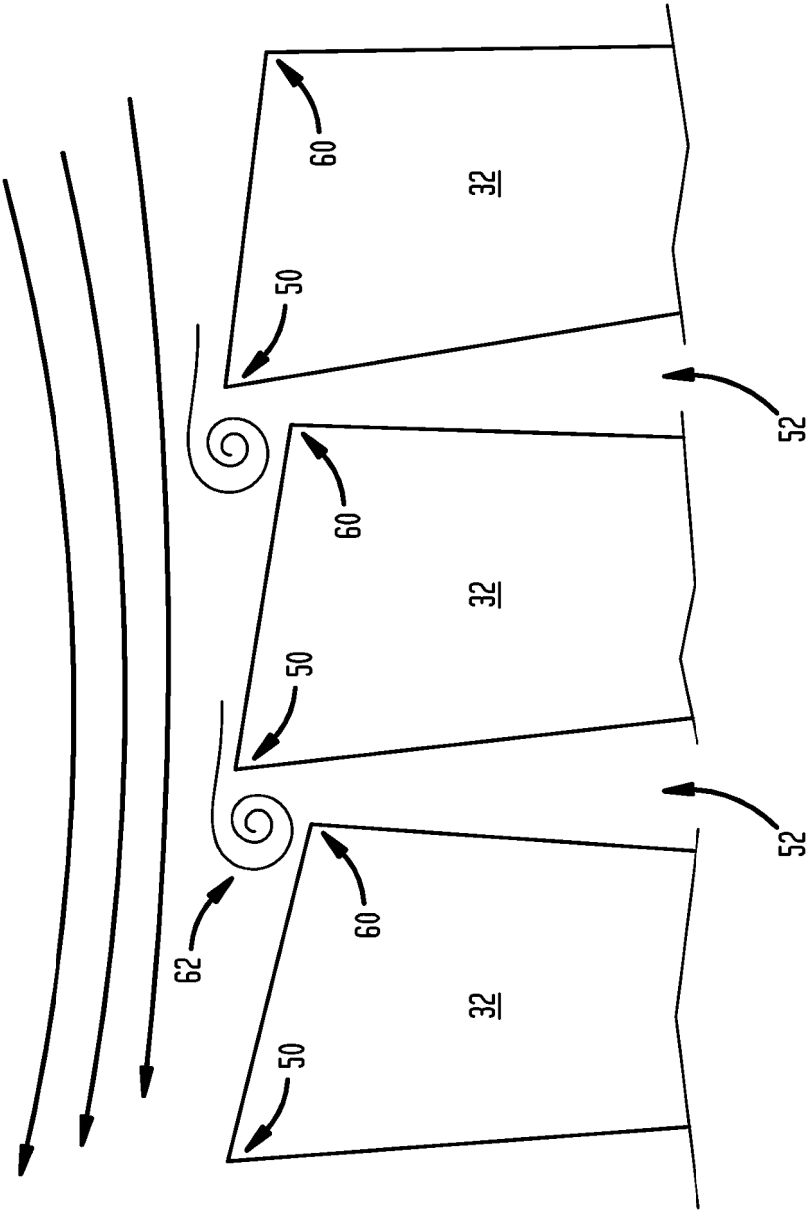
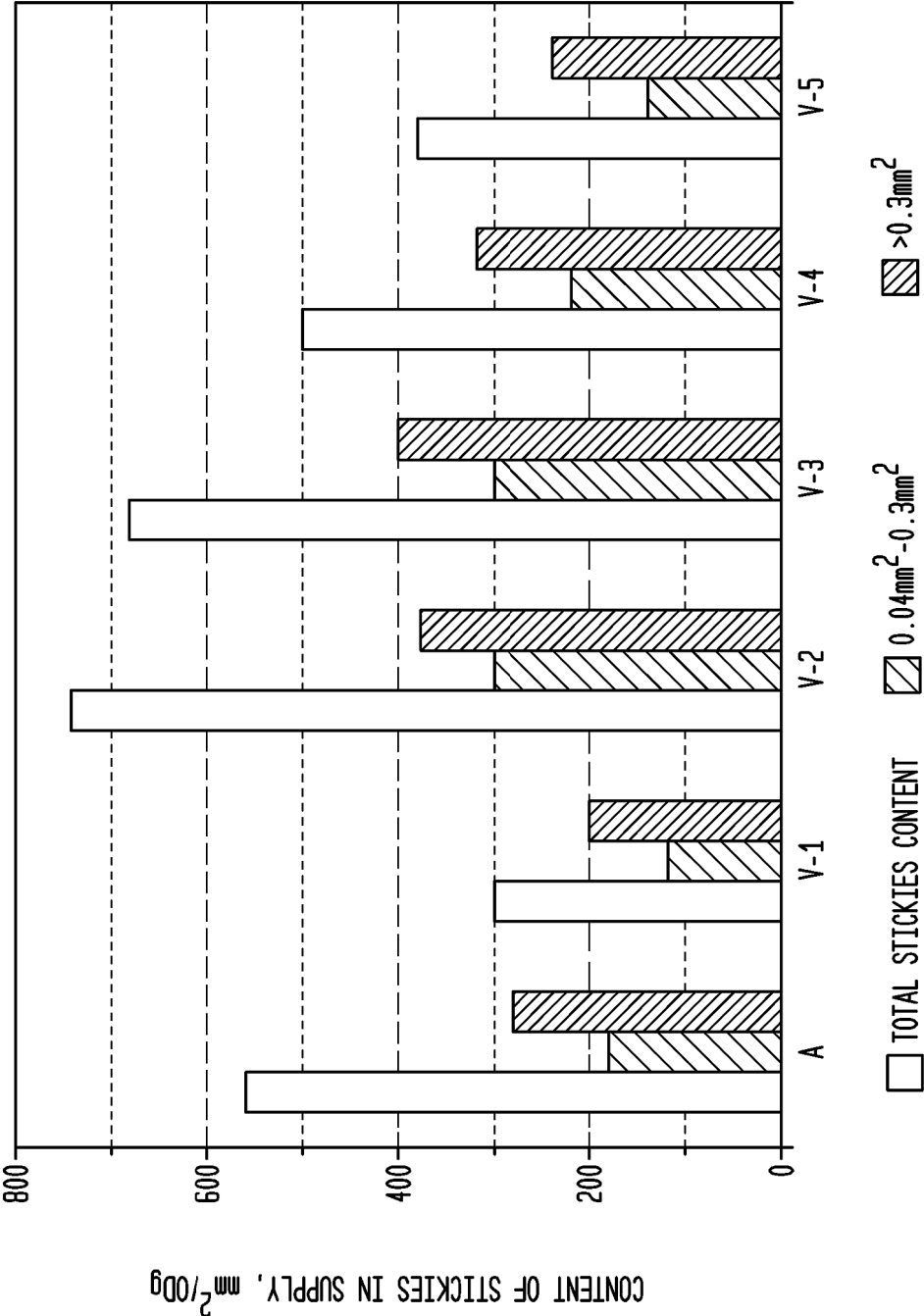


FIG. 5



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FIG. 6

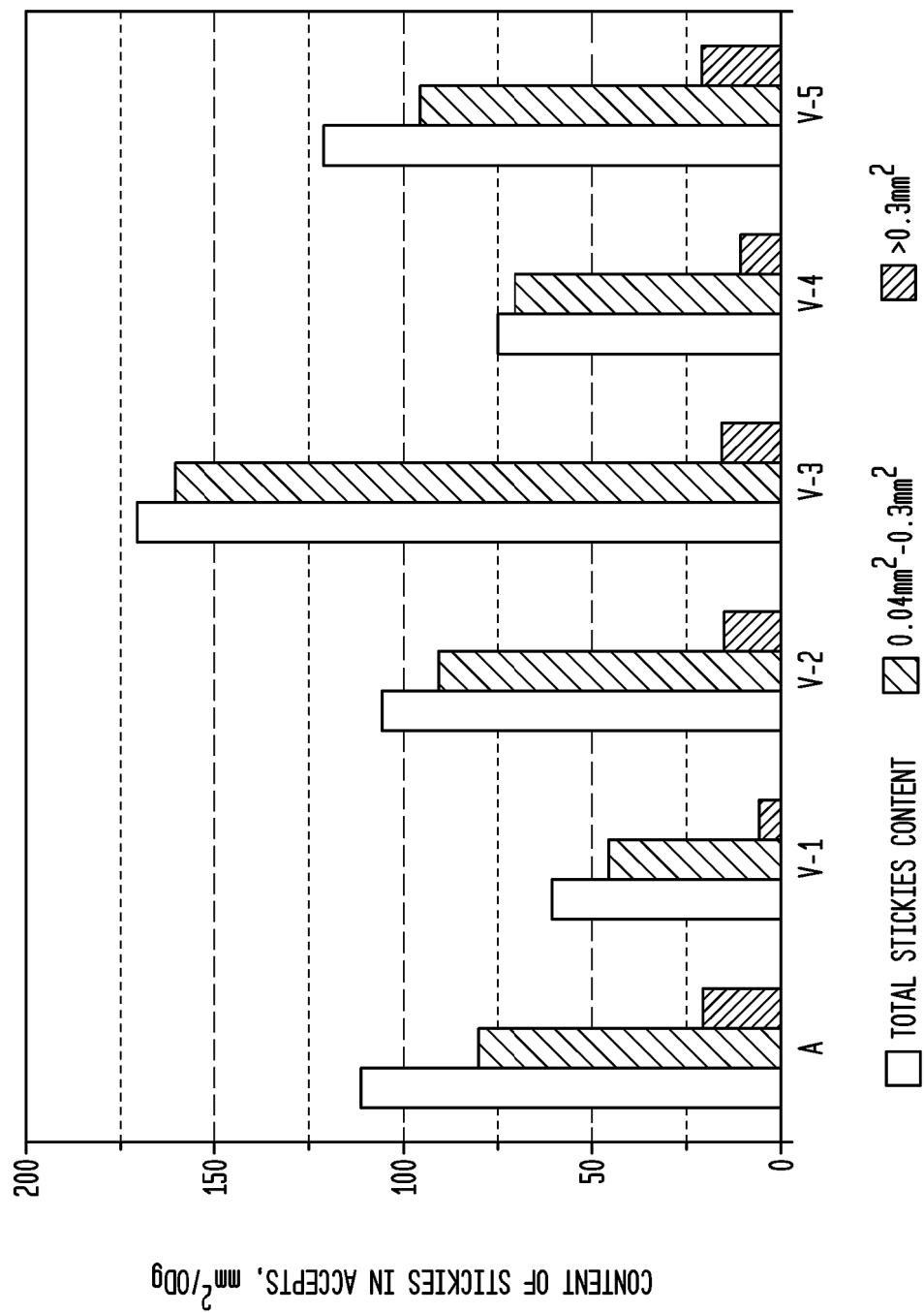
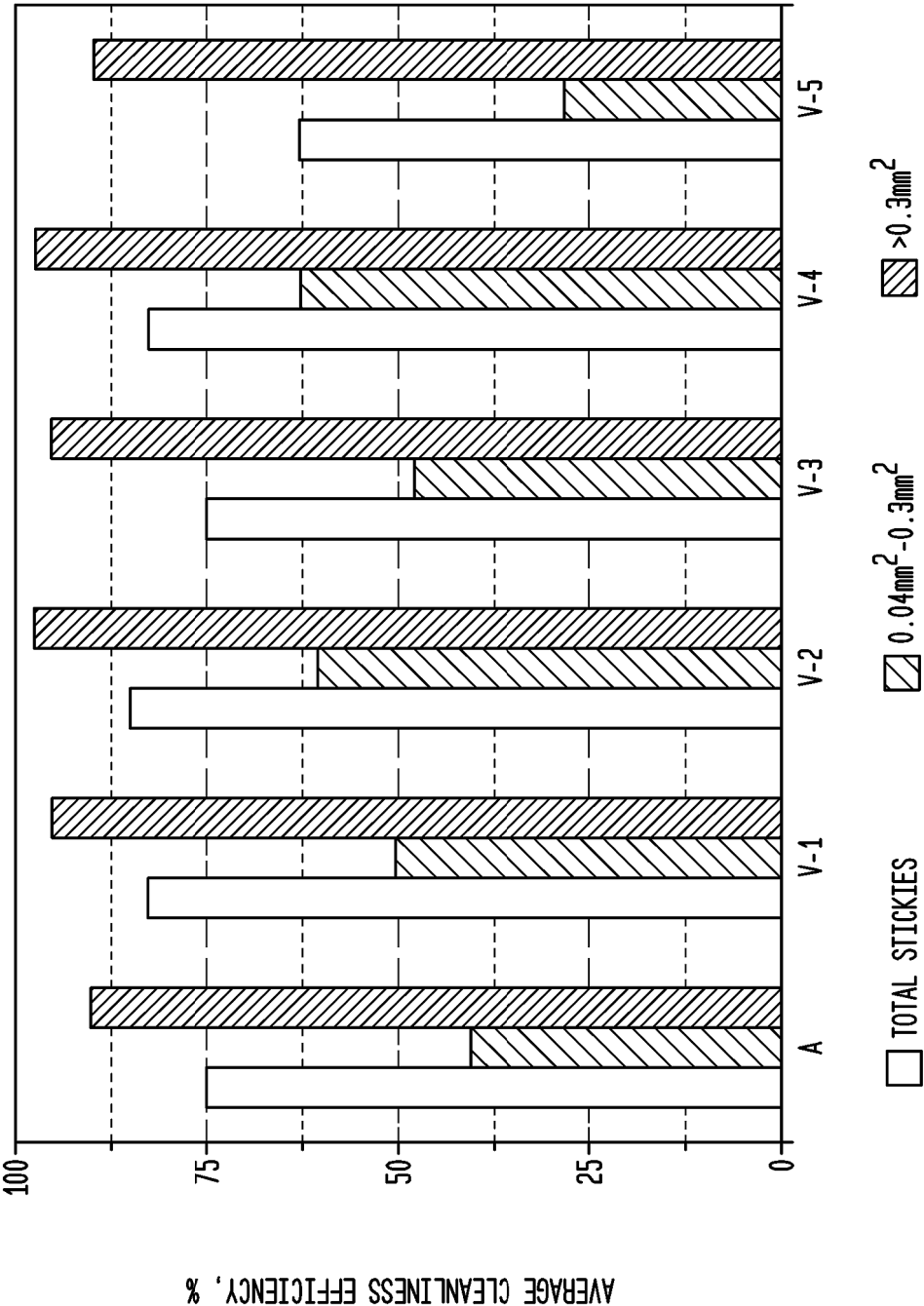
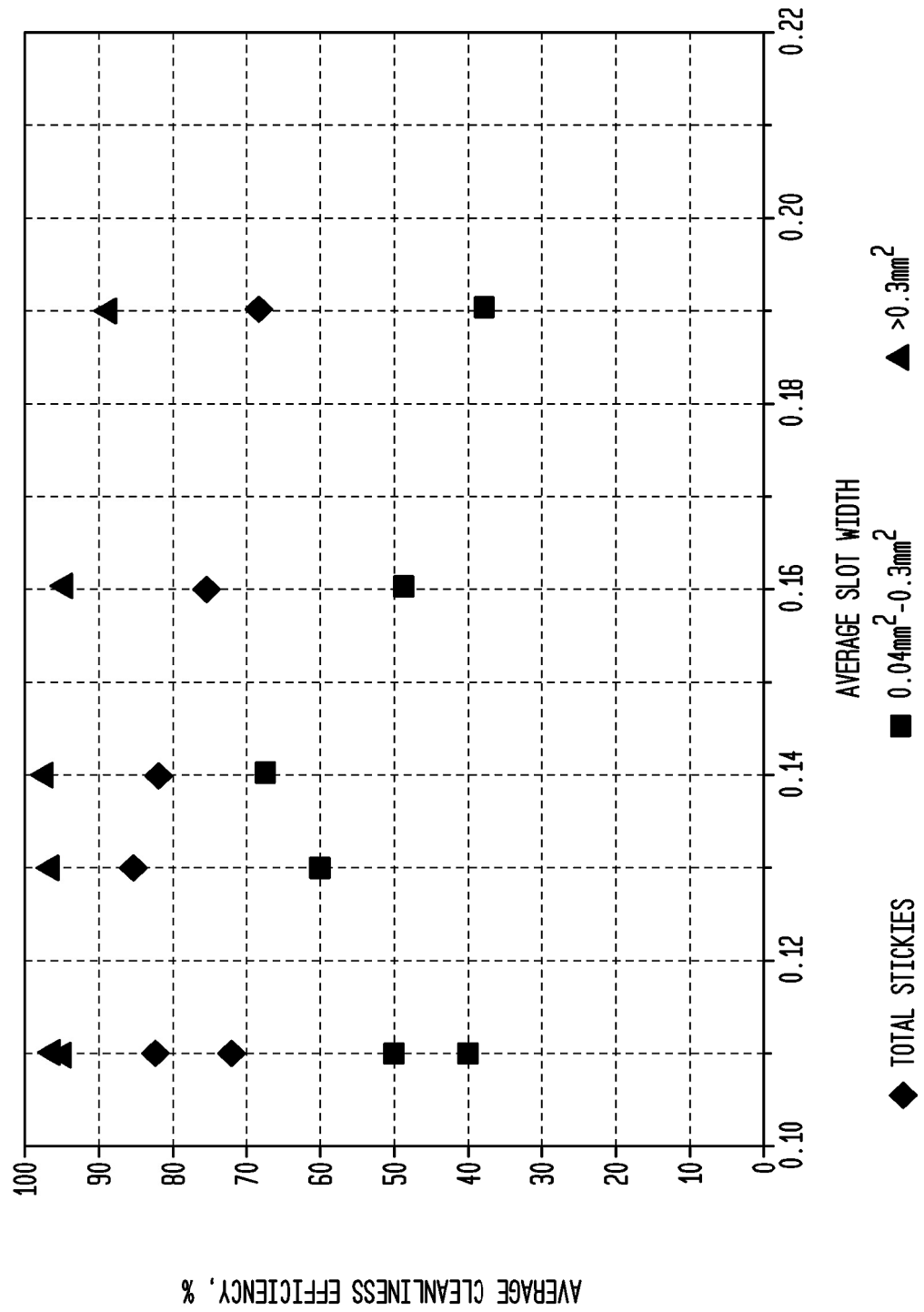


FIG. 7



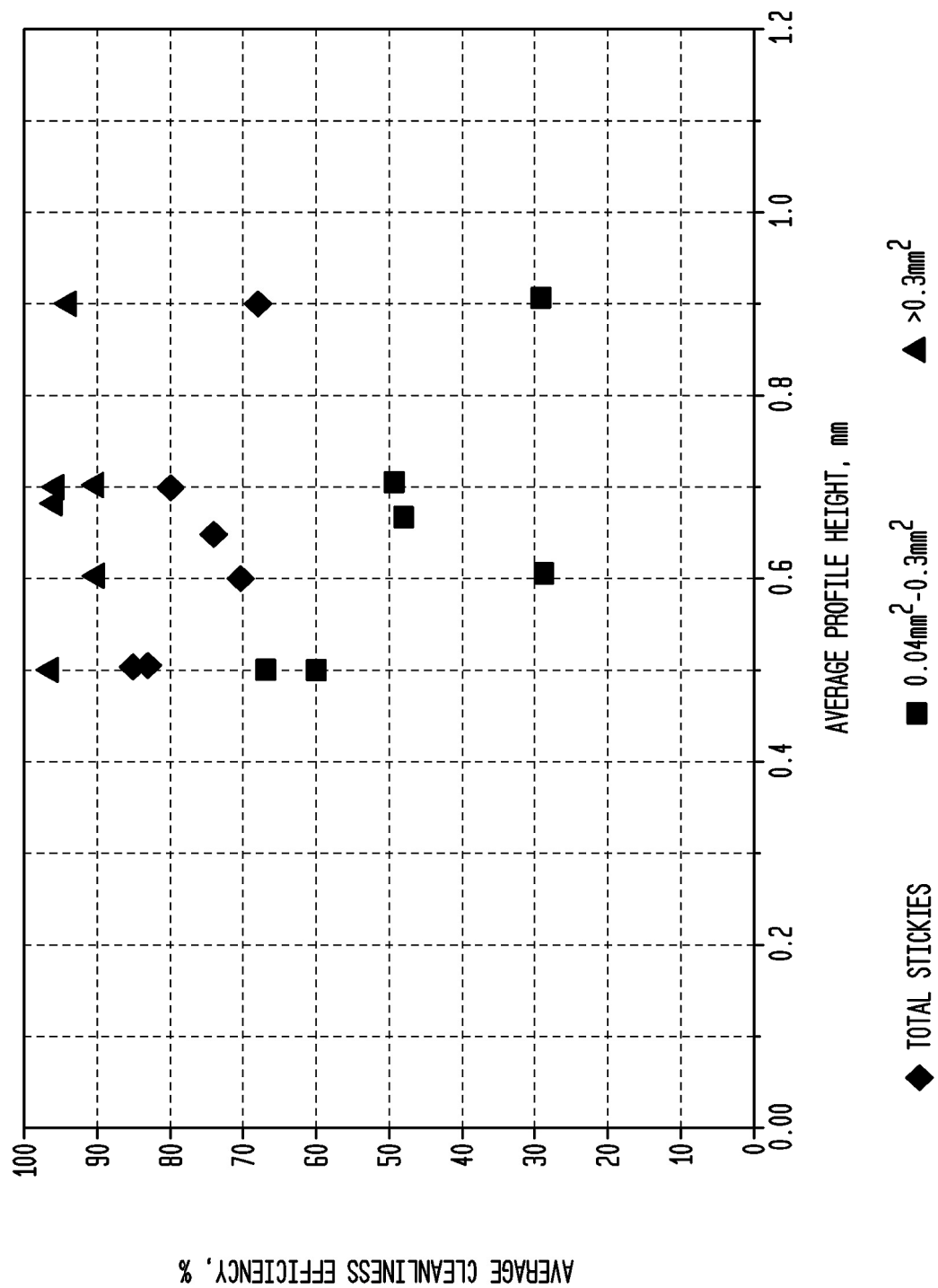
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FIG. 8



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FIG. 9



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FIG. 10

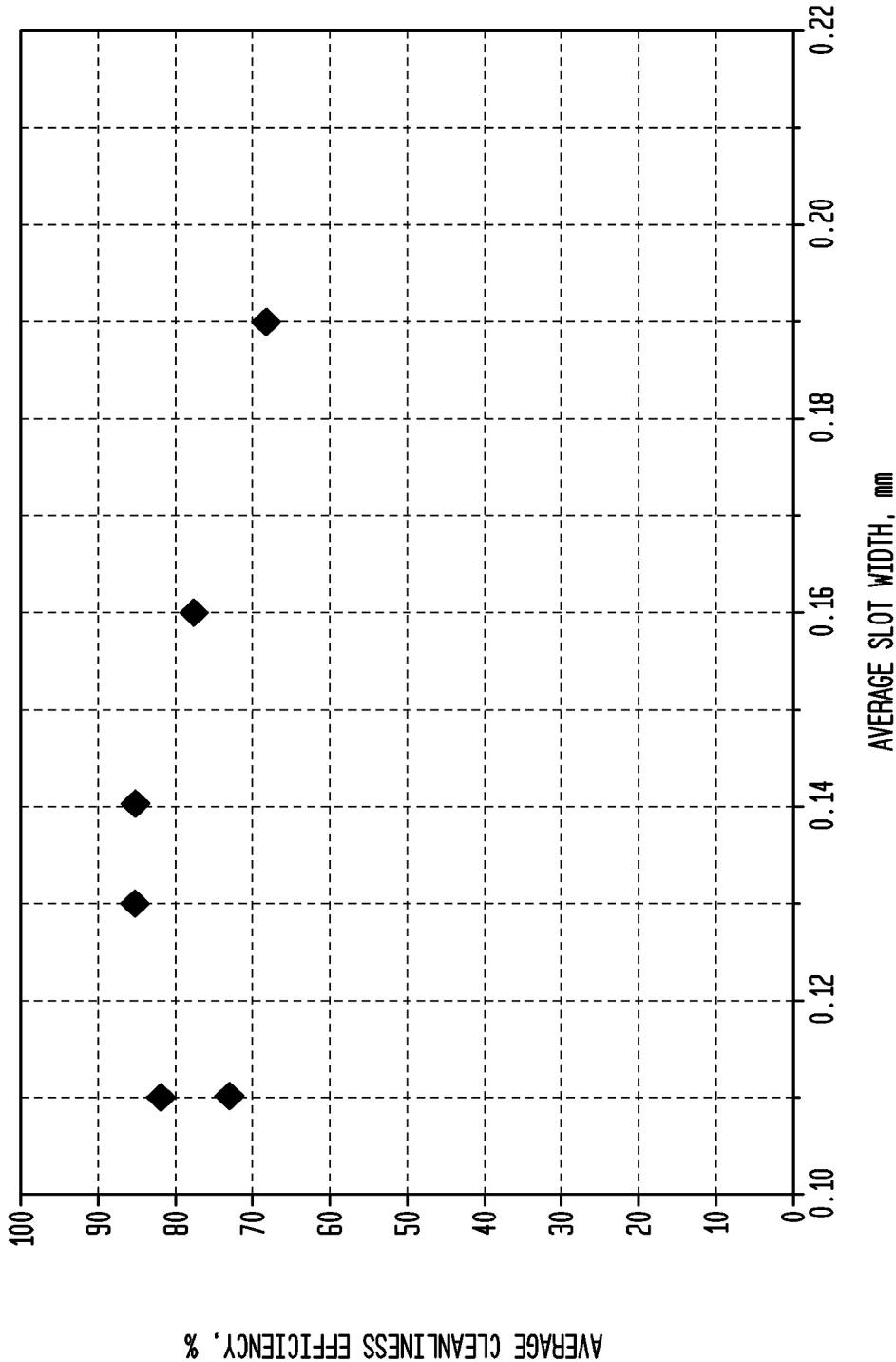
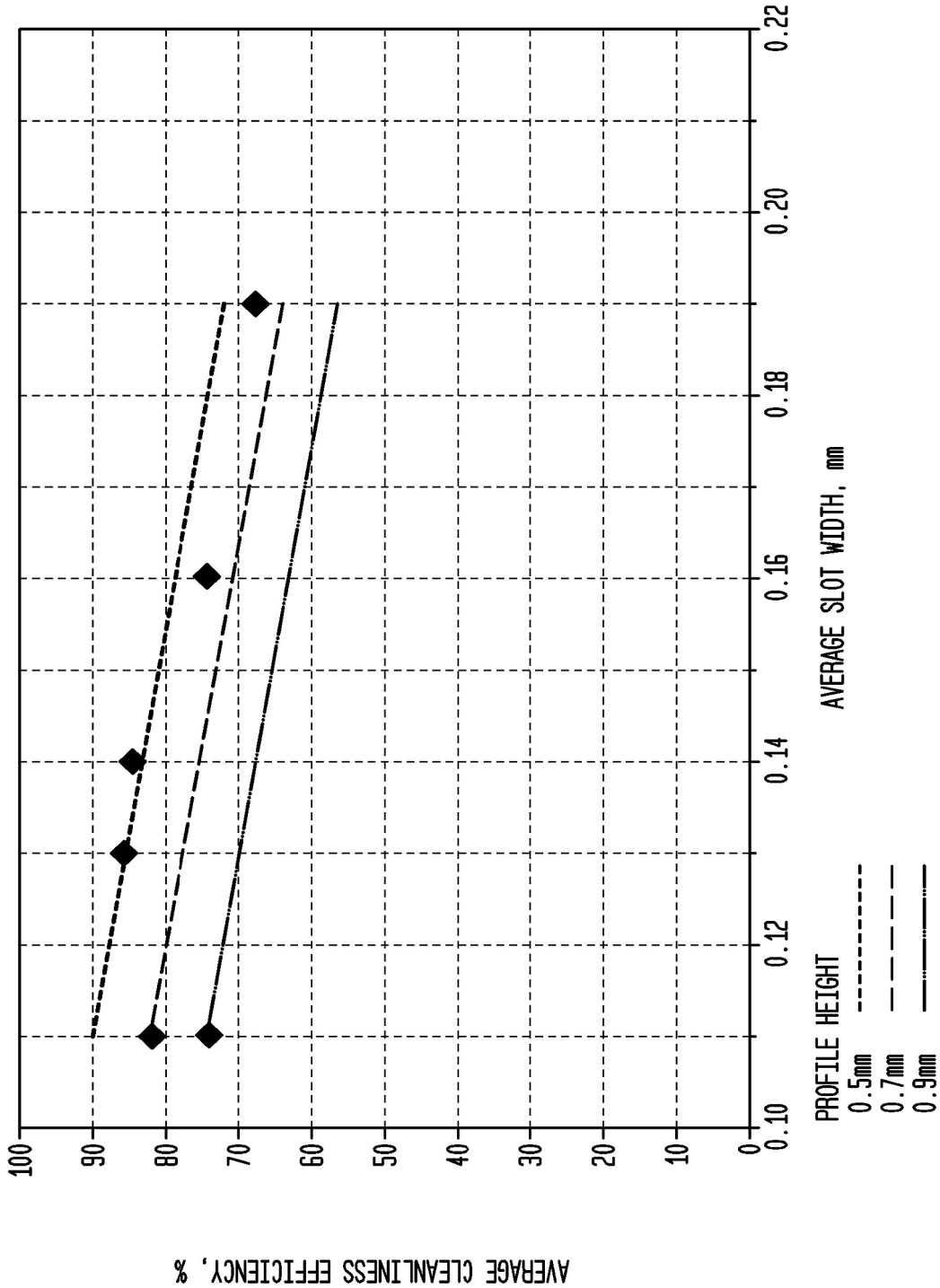
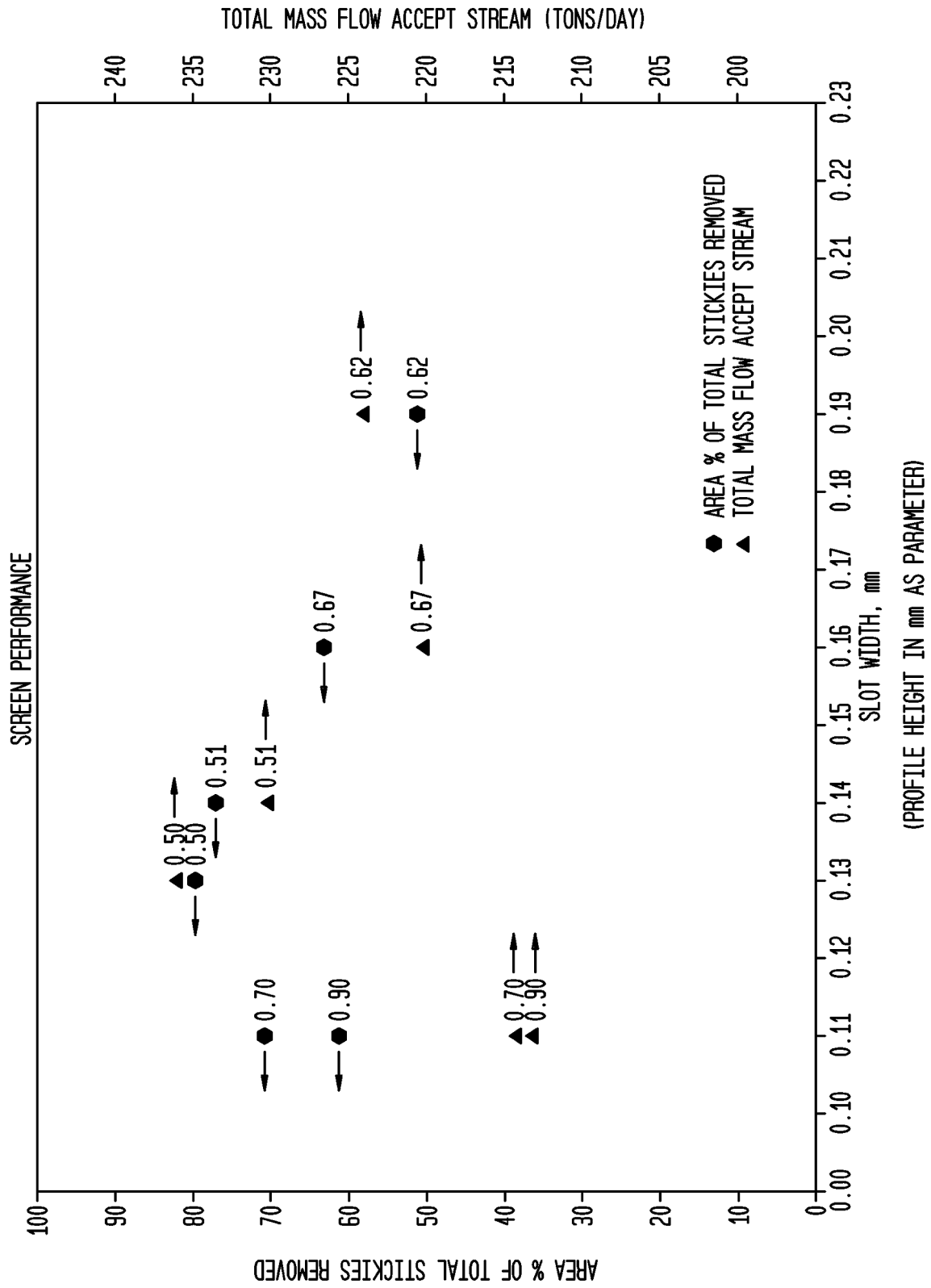


FIG. 11



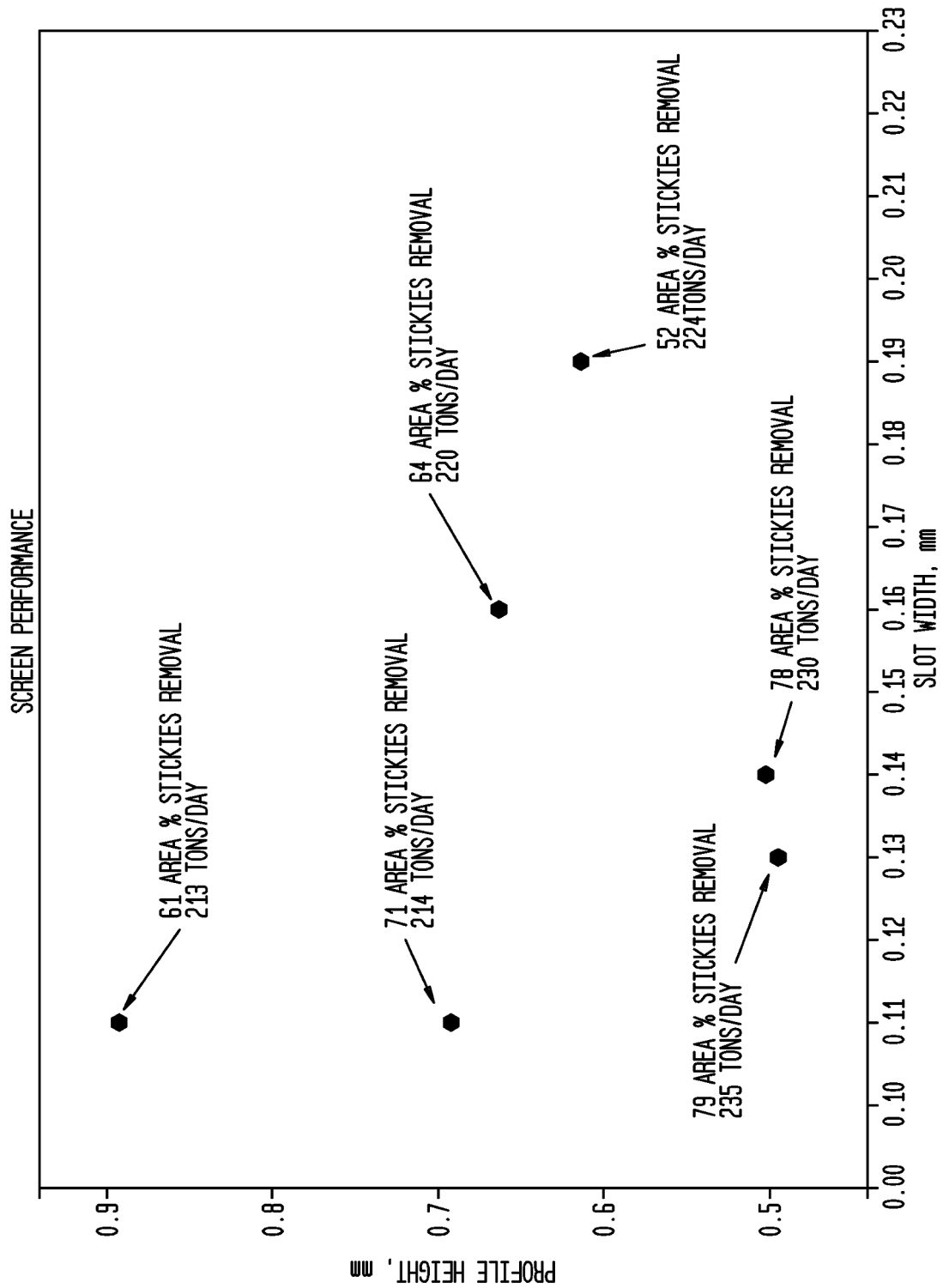
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FIG. 12



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FIG. 13



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FIG. 14

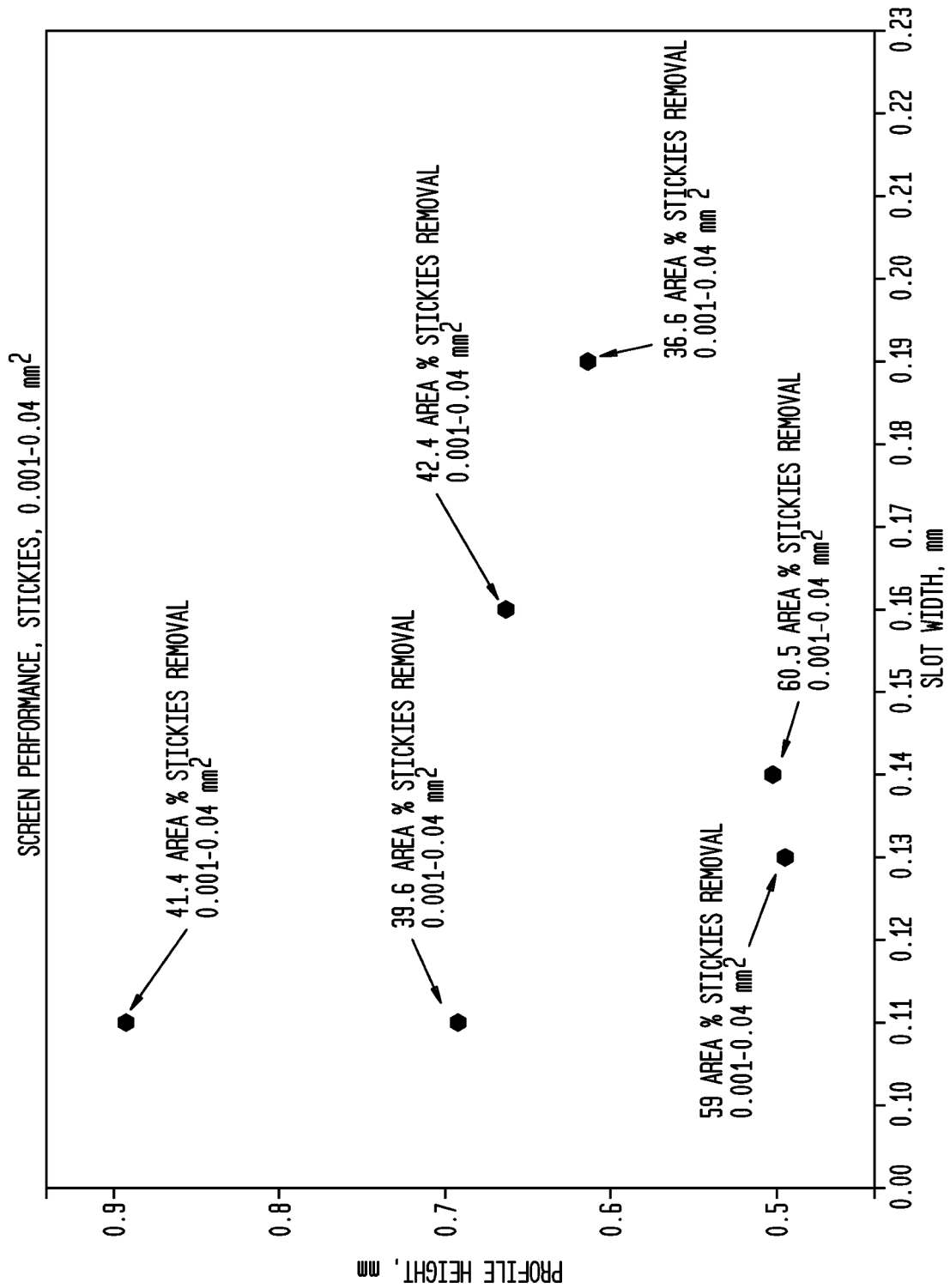
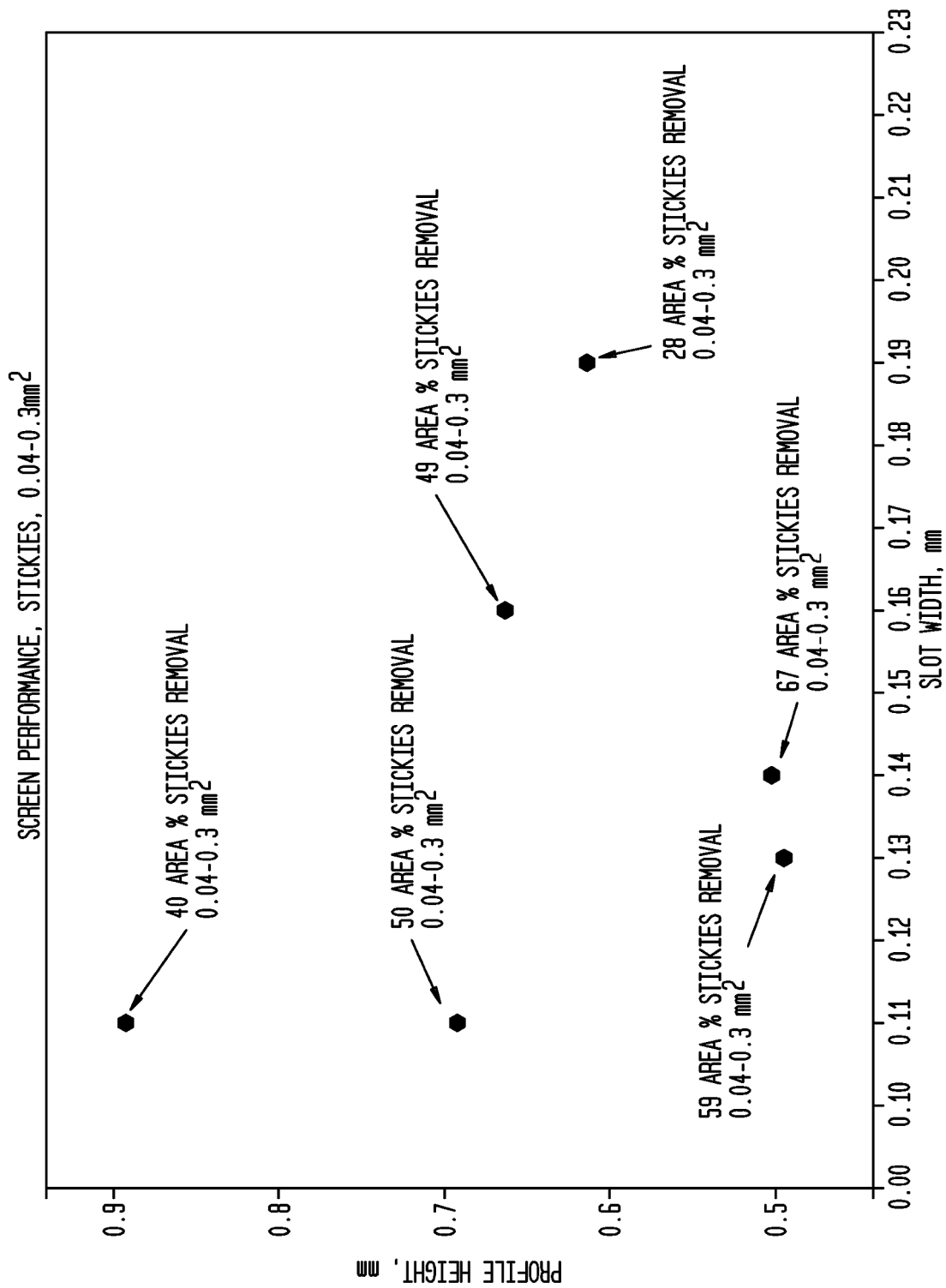
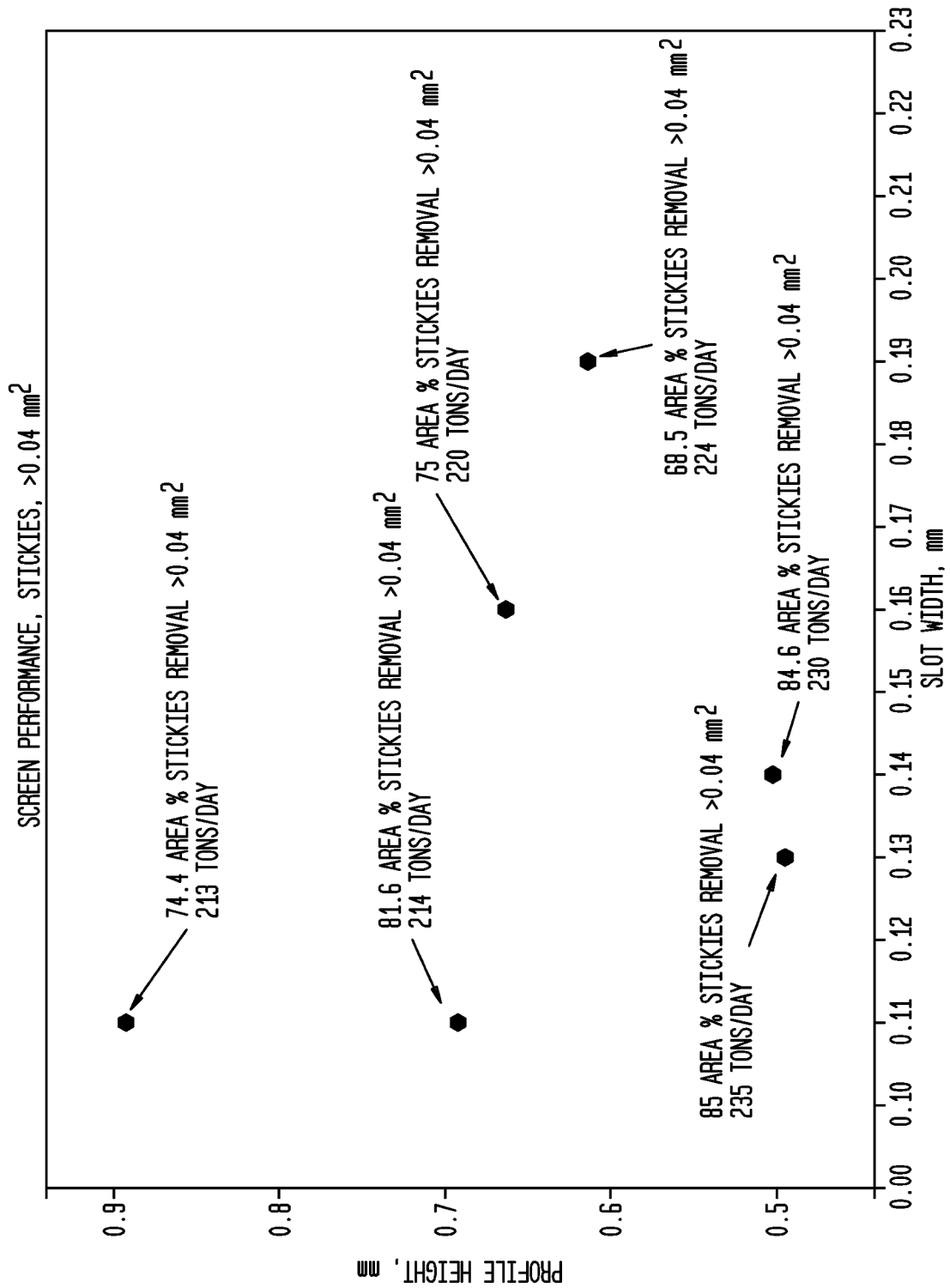


FIG. 15



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FIG. 16

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FIG. 17

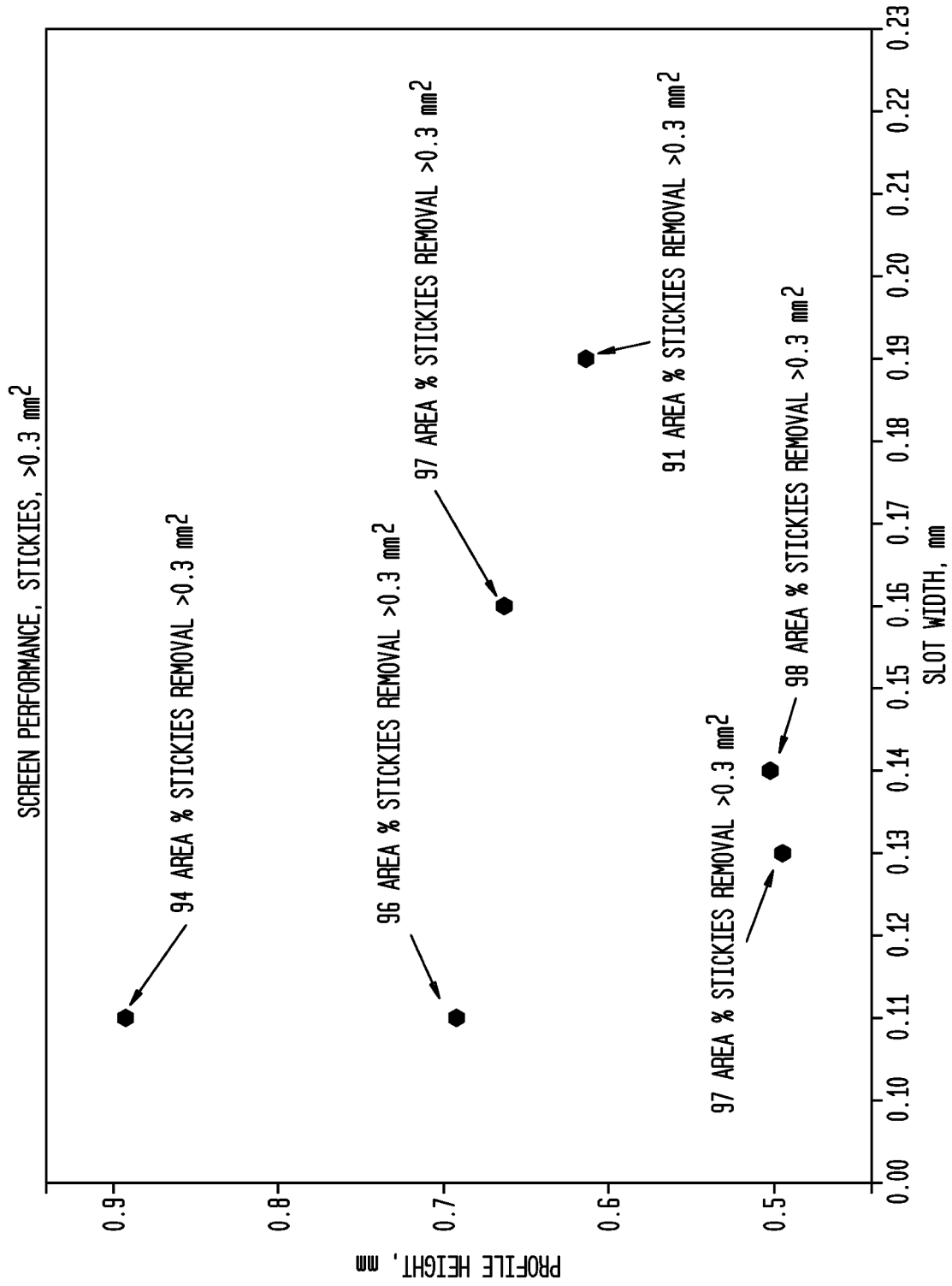


FIG. 18

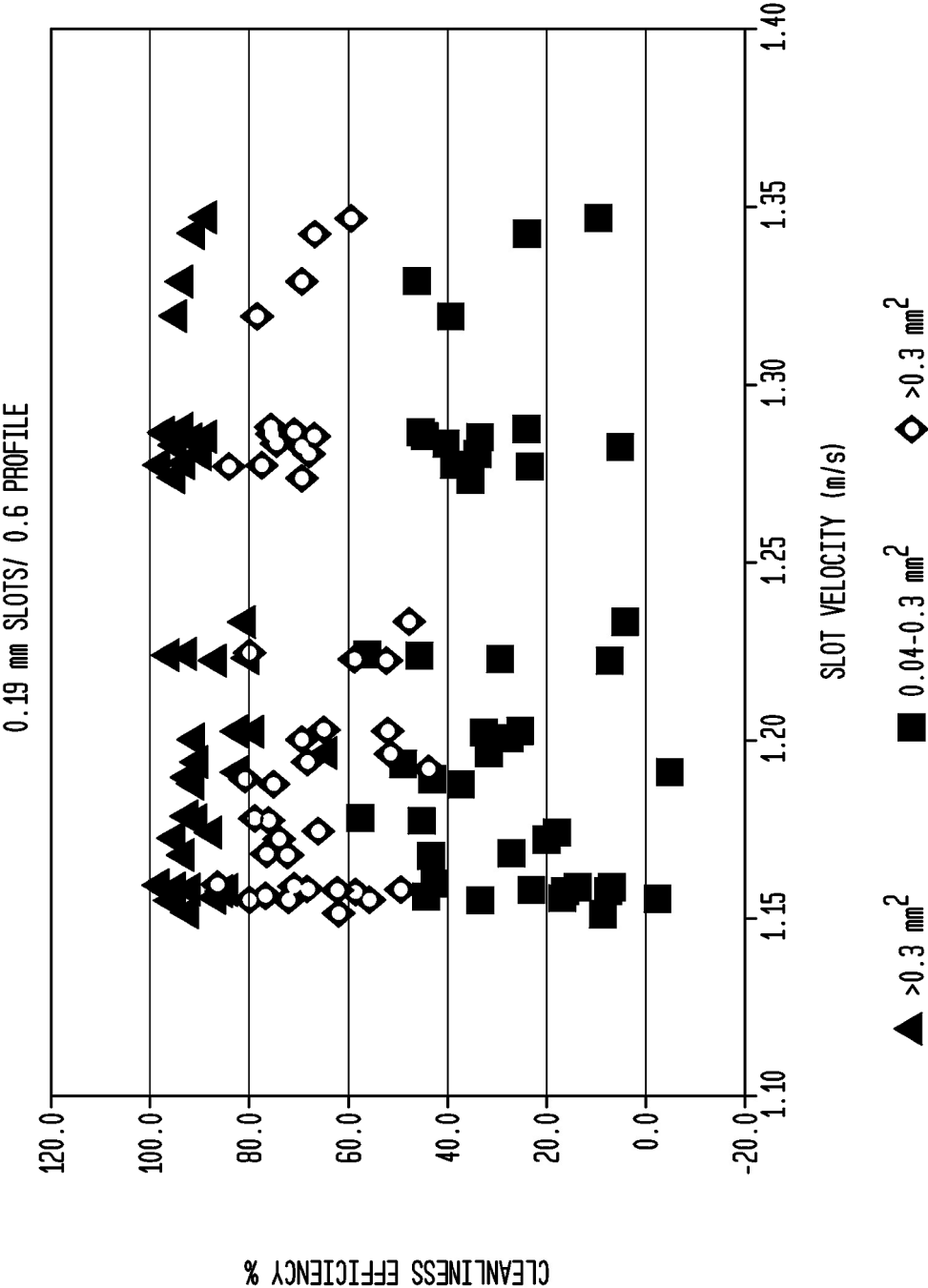


FIG. 19

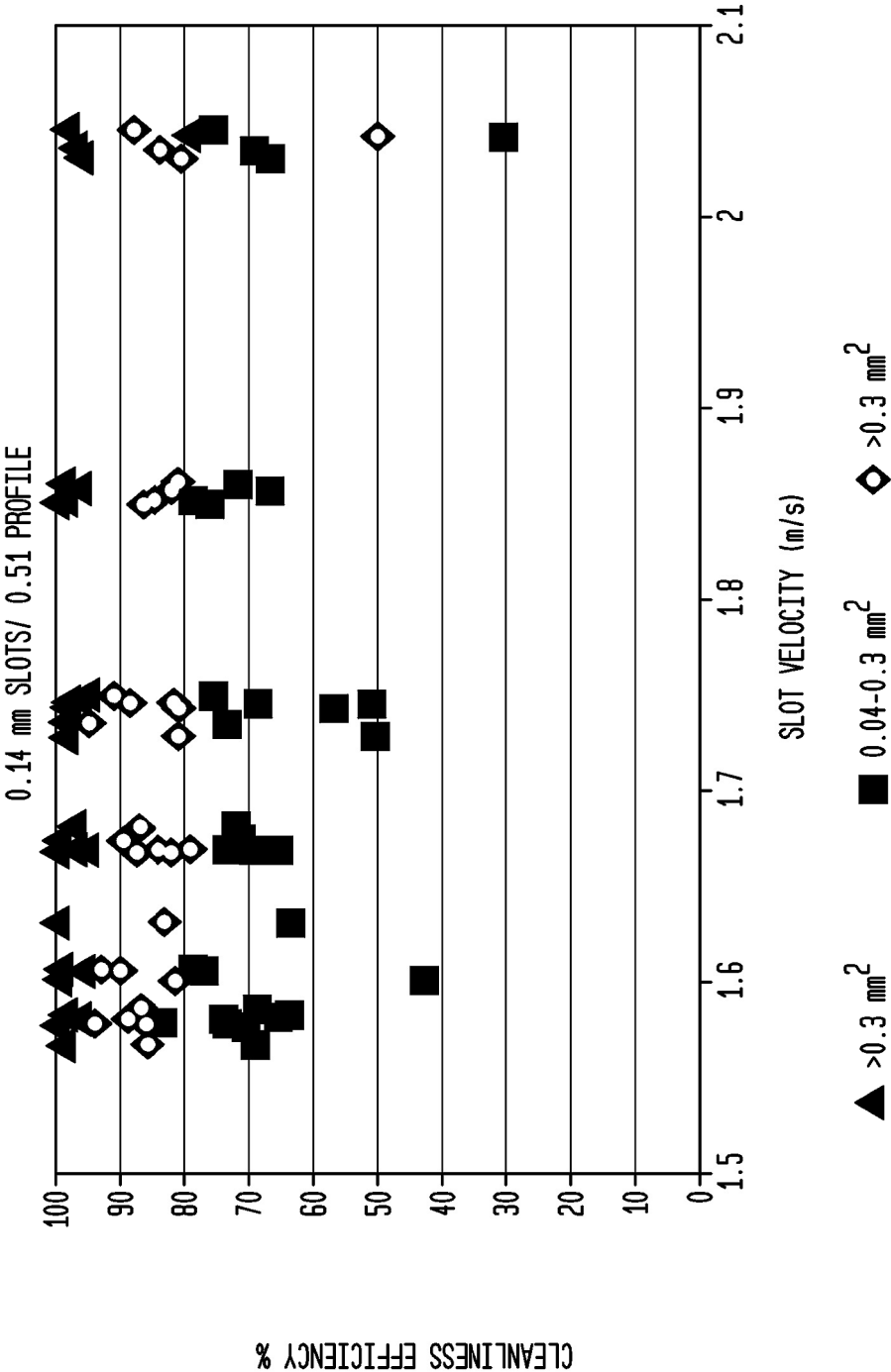


FIG. 20

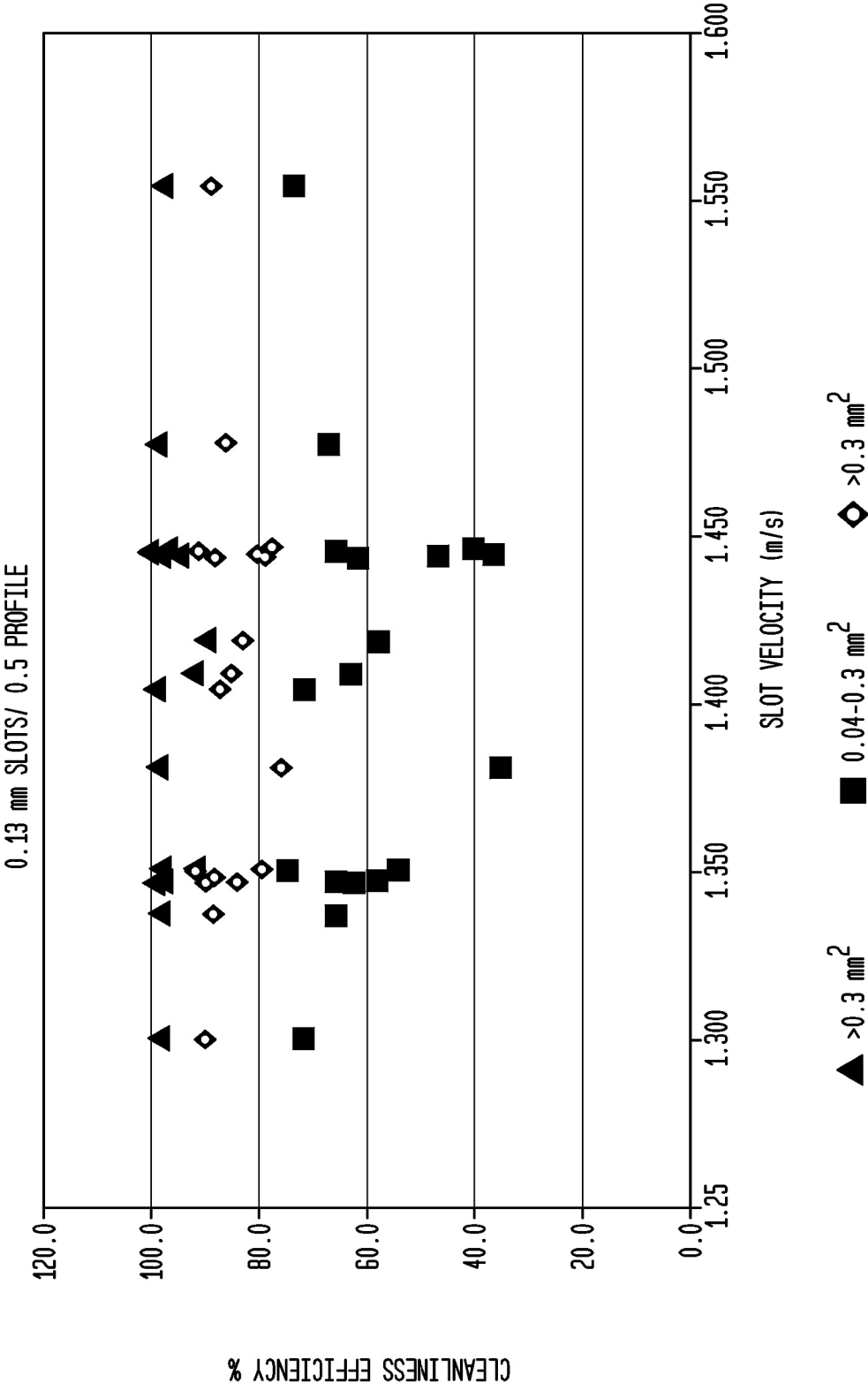


FIG. 21

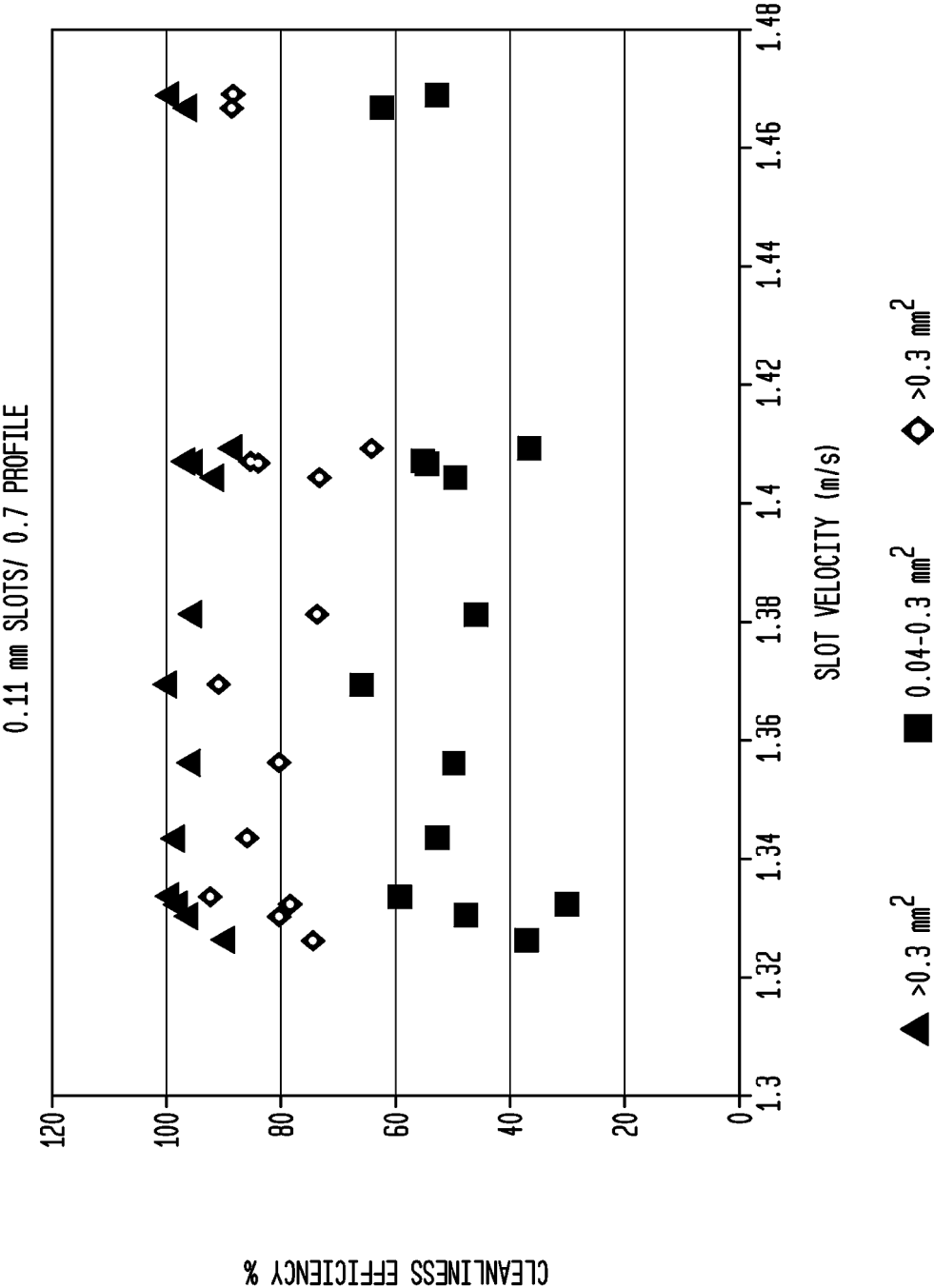


FIG. 22

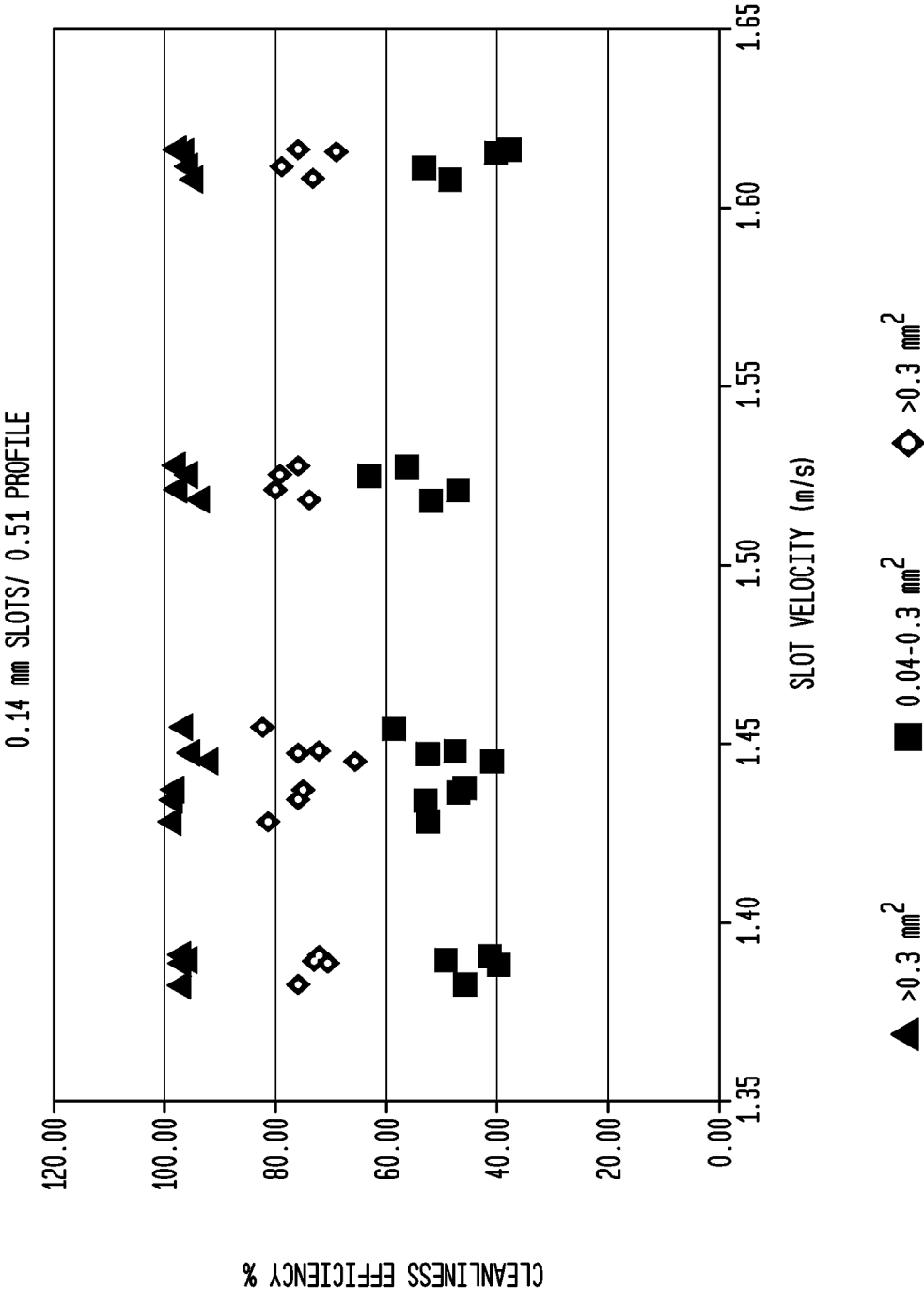
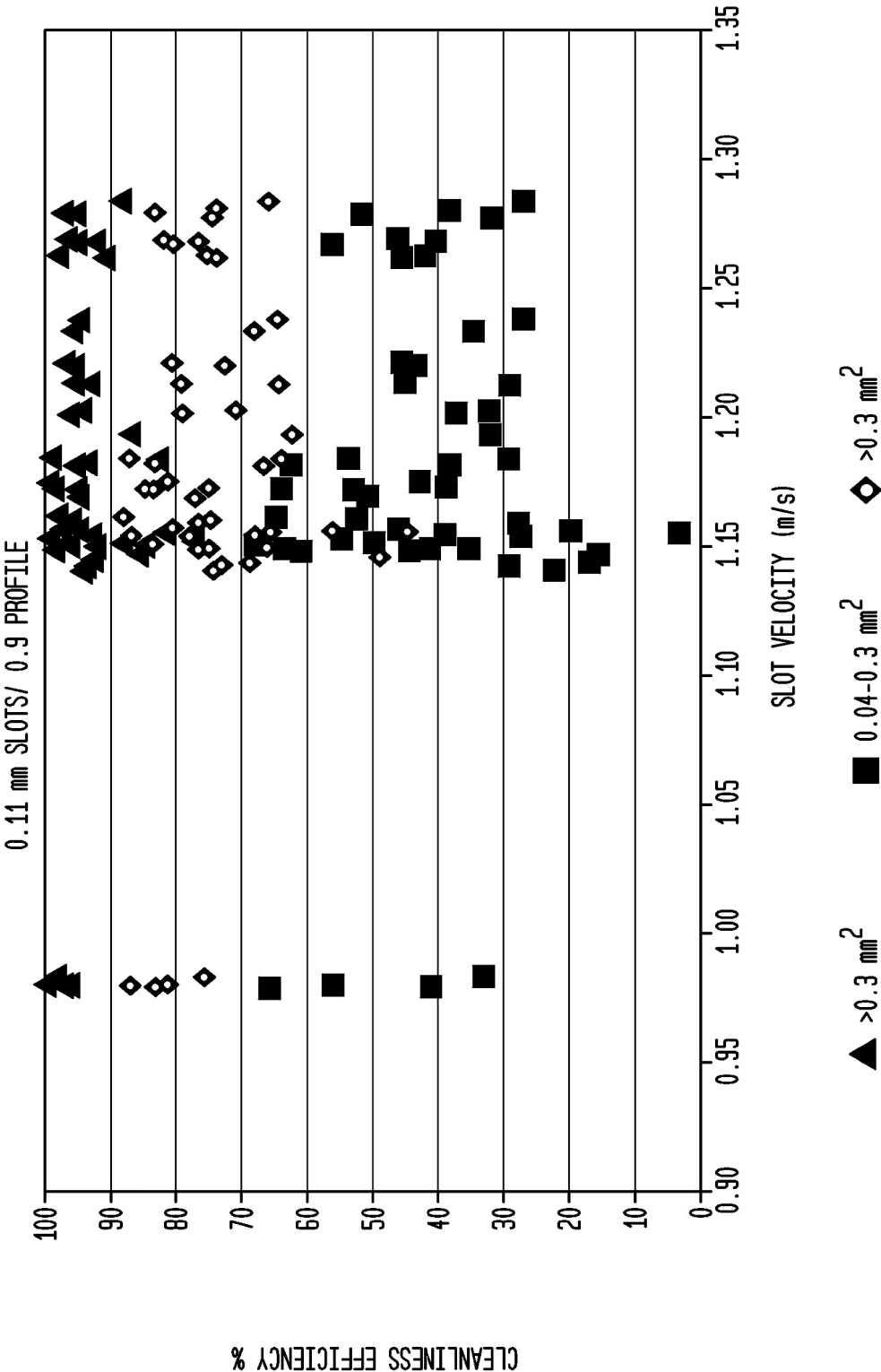


FIG. 23



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FIG. 24
CLEANLINESS EFFICIENCIES VS SLOT WIDTH
AND PROFILE HEIGHT

