March 24, 1970 H. L. McWHORTER 3,502,321

SHEET DELIVERY AND COLLATING MACHINE

Filed June 19, 1967 2 Sheets-Sheet 1

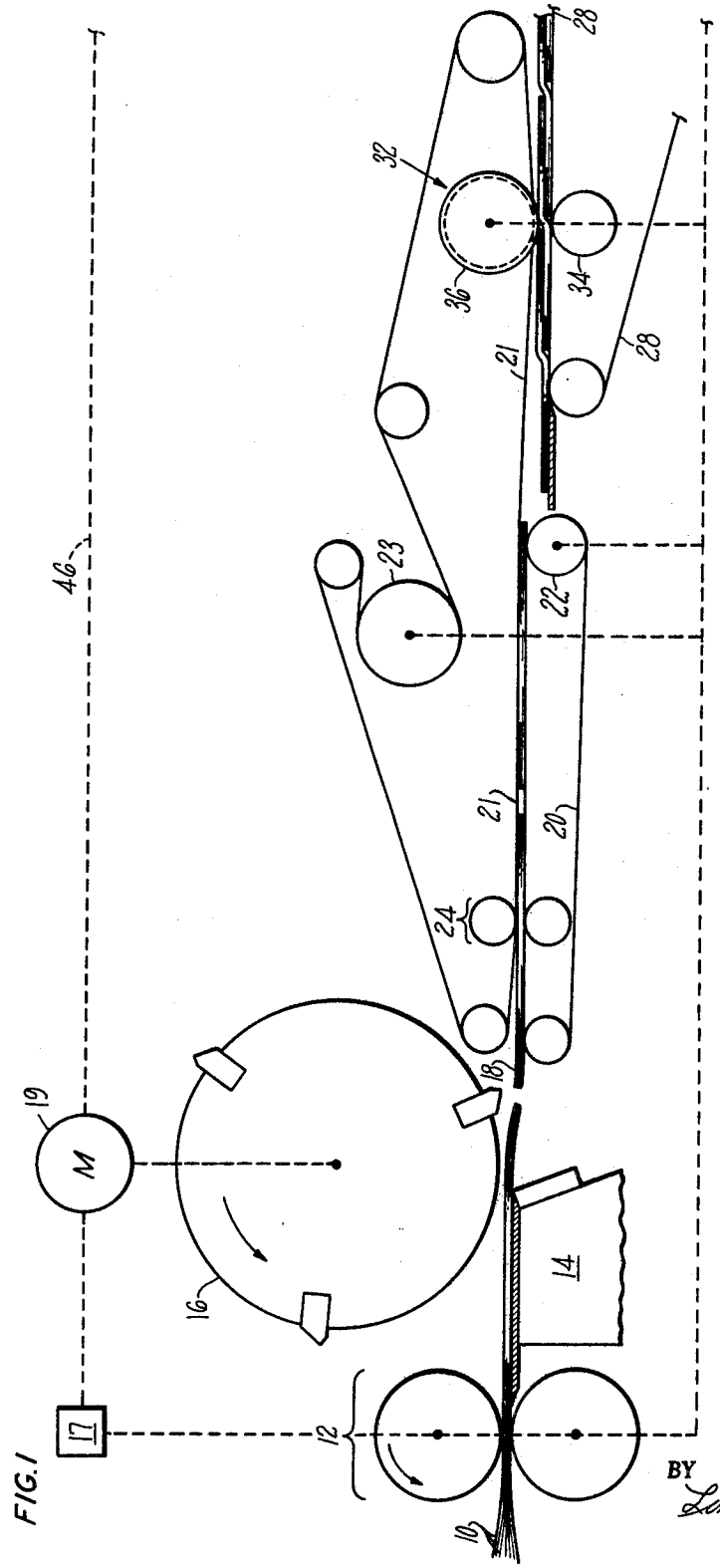

FIG. 1

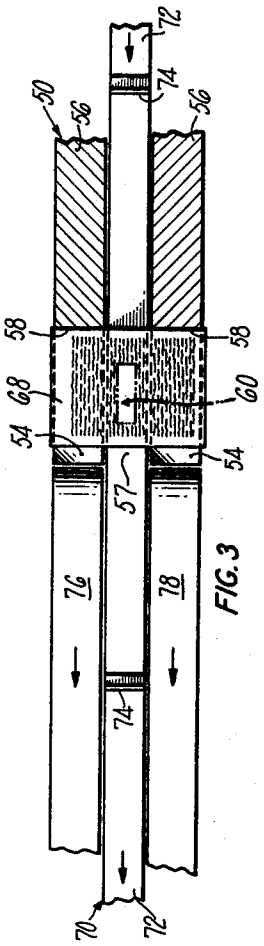

FIG. 3

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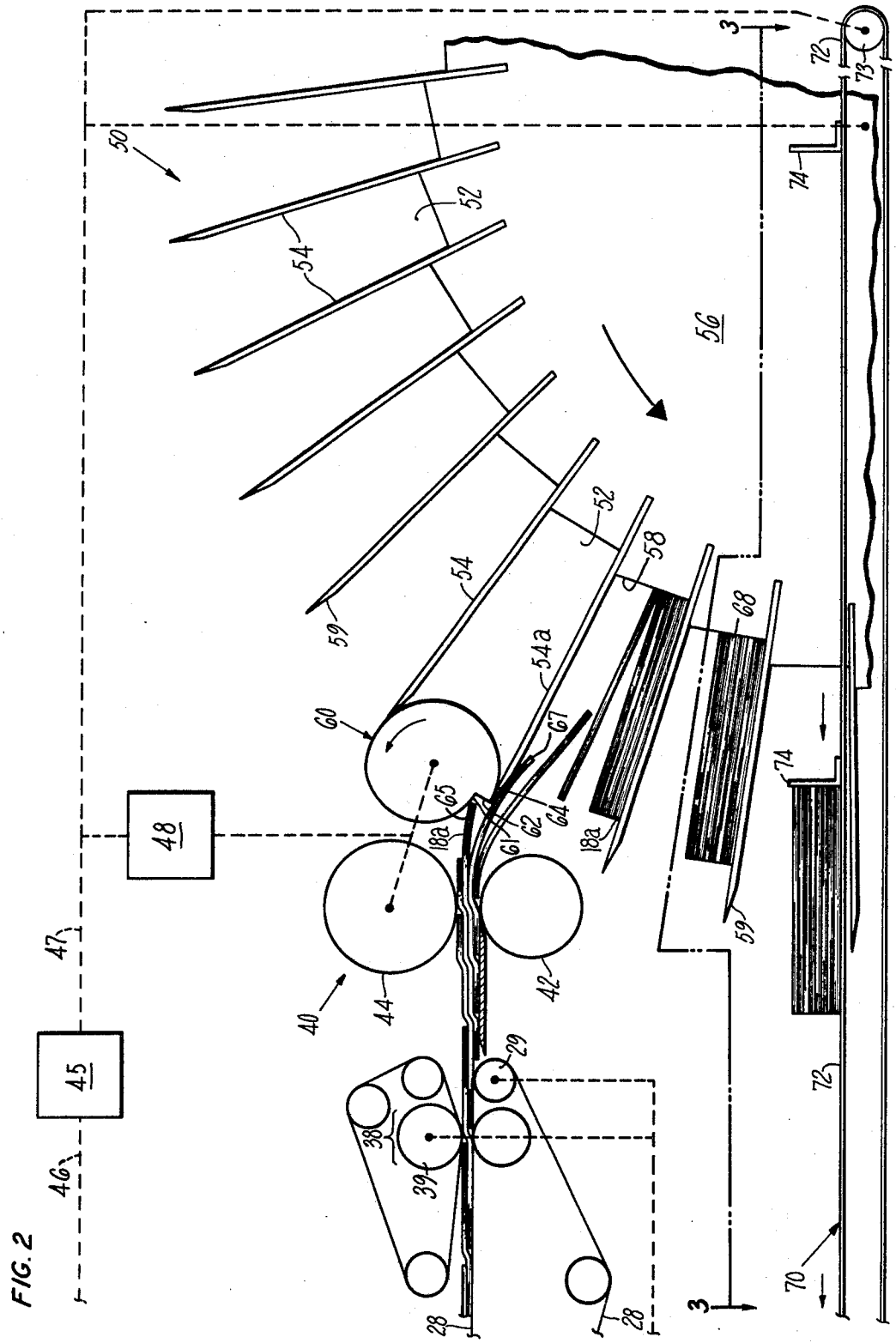

FIG. 2

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SHEET DELIVERY AND COLLATING MACHINE

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U.S. Cl. 270—58 15 Claims

ABSTRACT OF THE DISCLOSURE

The machine of this invention includes a conveyor for delivering a series of sheets in uniformly overlapped condition, a collator continuously rotatable about a fixed horizontal axis at a delivery end of the conveyor and having a plurality of peripheral sheet collecting pockets successively movable into and out of registry with oncoming sheets for collecting complements of a predetermined number of sheets, and a sheet separating and shifting member positioned between and rotatable in timed relation to the conveyor and the collator for deflecting a last sheet of a complement of sheets to ensure its entry into a receding pocket while permitting the next sheet of a following complement to freely enter an adjacent advancing pocket of the collator.

This invention generally relates to the sheet handling art and particularly concerns a delivery and collating machine usable with paper handling equipment.

A primary object of this invention is to provide an improved sheet delivery and collating machine capable of reliable, precision performance at extremely high speeds and which is free of adjustment requirements during a production operation.

Another object of this invention is to provide such a machine of significantly simplified construction incorporating a minimum number of parts particularly suited for use with printing presses and the like for effecting efficient continuous sheet handling.

A further object of this invention is to provide such a machine capable of handling sheets of varying size over a wide range of operating speeds as encountered, e.g., in the automatic manufacture of books, in the production of sheets in specified quantities such as reams, and the manufacture of pads of paper.

A still further object of this invention is to provide an improved sheet delivery and collating machine of rugged compact construction particularly suited for continuous production operation and having minimal maintenance requirements while virtually eliminating the need for complex mechanisms normally associated with equipment of this type for effecting abrupt changes in speeds and directions of the operating parts.

Other objects will be in part obvious and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereafter set forth and the scope of the application which will be indicated in the appended claims.

In the drawings:

FIG. 1 is a diagrammatical side elevational view of part of a sheet delivery and collator machine embodying this invention;

FIG. 2 is a continuation of the view of FIG. 1 showing a collator incorporated in this invention; and

FIG. 3 is a section view, partly broken away, on a reduced scale taken generally along line 3—3 of FIG. 2.

Referring now in detail to the drawings wherein a typical machine utilizing a preferred embodiment of this invention is illustrated, individual webs or ribbons **10** of sheet material, such as paper, are shown being fed in stacked formation through driven feed rolls **12** and along a generally horizontal path to a stationary bed knife **14** which cooperates with a rotary multi-knife cutter **16** to cut the ribbons **10** into stacks **18** of desired length. Feed rolls **12** and rotary cutter **16** are driven in synchronism under the power of an electrical motor **19** with a gear box **17** shown as being provided in the driving connection between the motor **19** and the feed rolls **12** for setting relative peripheral speeds between the feed rolls **12** and the rotary cutter **16** to provide a preselected length of cut sheets.

While the apparatus of this invention may be used with a variety of equipment such as sheeters and similar apparatus for producing specified quantities of cut blank sheets, e.g., it will be assumed for purposes of describing this invention that the ribbons **10** are being discharged from a printing press after having been printed in a repeat pattern, and are suitably presented in strips of equal width in an ordered arrangement to the feed rolls **12** for automatic manufacture of books wherein the lengths of cut stacks **18** correspond to selected page length as determined by the repeat printing pattern.

As each stack **18** of sheets is cut, it is separated from the ribbons **10** (passing through feed rolls **12**) by opposed sets of high speed belts **20** and **21** driven by rollers **22** and **23** shown in the drawings as being suitably connected to the motor **19** so that the belts **20**, **21** travel at a surface speed approximately ten percent greater than the peripheral speed of the feed rolls **12** to produce a gap between the trailing end of each cut stack **18** and the leading edges of the following ribbons **10**. Rollers **24** establish a nip on the leading end of the stacks **18** and are settable horizontally to equal the preselected length of the cut stacks **18**.

From the high speed belt section, the cut stacks or packets **18** of paper sheets are fed onto low speed belts **28**. The latter are positioned parallel to but somewhat lower than high speed belts **20** and are shown supported on rollers such as at **29** suitably connected to drive the low speed belts **28** at **51** percent of the peripheral speed of feed rolls **12** so that the packets **18** smoothly and uniformly overlap before entering a nip assembly **32** provided in the low speed belt section. The nip assembly **32** is settable horizontally within the low speed belt section to ensure that the trailing end of each packet is past roller **22** at the downstream end of the high speed belt section upon the leading end of each packet **18** entering the nip assembly **32**.

Braking of the overlaped stacked sheets is effected by the nip assembly **32** which includes a back-up roller **34** for properly positioning the low speed belts **28** relative to a cooperating upper roller **36** which is grooved to provide clearance between the upper high speed belts **21** and the packets **18** which then pass through a horizontally settable belt nip assembly **38** at a downstream end of the low speed belt section. Upper rollers **36** and **39** of the nip assemblies **32** and **38** are each shown suitably connected to be driven at a peripheral speed of **51** percent of that of the feed rolls **12** so as to be in synchronism with the low speed belts **28**.

The speed of the overlapped packets **18** of paper sheets is further reduced by a metering nip assembly **40** downstream from the low speed belts **28**. The metering nip assembly **40** comprises a rubber idler roll **42** which forms a nip with a driven metering roll **44** for applying a tangential driving force to the overlapped packets **18** to further control their advance.

For ensuring delivery of books, e.g., of a specified length determined in accordance with a given number

of cuts required to be made by the rotary cutter **16** for each book, a gear box **45** is shown connecting a motor output shaft **46**, which will be understood to make one revolution per cut, to a drive shaft **47** for driving the latter at a rate of one revolution per book. By providing properly selected change gears **48**, the metering roll **44** is connected to the drive shaft **47** to rotate at a predetermined peripheral speed relative to that of the rotary cutter **16** whereby the overlapped packets **18** pass through the metering nip assembly **40** and are effectively reduced in length to a known length per book.

For collecting complements of overlapped packets of stacked sheets emanating from the metering nip assembly **40**, wherein each complement will be assumed to form a completed book for purposes of describing this invention, a collator **50** is shown downstream of the metering nip assembly **40** and having open peripheral sheet collecting pockets **52** successively movable in unison into and out of register with the continuous stream of oncoming sheets. In the specific illustrated embodiment, the pockets **52** are defined by equiangularly spaced forks **54** shown fixed to extend radially outwardly from a pair of spaced collating wheels **56** (FIG. 3) with the forks **54** of each wheel **56** being aligned for common actuation but laterally spaced to form a gap **57** between the forks **54**. The collator **50** is shown connected to the drive shaft **47** for rotation in a counterclockwise direction about a fixed horizontal axis at a predetermined constant speed such that a "fresh" pocket **52** will be advanced to confront and receive the oncoming sheets following the delivery of each completed book from the metering assembly **40**. So that the packets will be neatly stacked in alignment, flat abutment surfaces **58** are formed on the periphery of collating wheels **56** between adjacent forks **54** with the abutment surfaces **58** extending at right angles to a leading fork of each adjacent pair.

To ensure facile high speed collation in a continuous production operation, sheet delivery to the collator **50** is effected at an approximately constant level as each pocket **52** is successively rotated in descending relation to the sheet flow path with a tangential velocity component of the forks **54** being substantially normal to the line of approach of the sheets. Throughout registry of each pocket **52** with the oncoming overlapped packets **18** fed from the metering assembly **40**, each fork **54** will be seen to be in an upwardly tilted attitude with respect to the metering assembly **40**, and a tapered end surface **59** is provided on each fork **54** to assist in separating the oncoming packets into different books.

Dependable separation of the overlapped packets **18** into separate complements for collection is imperative for reliable operation, and for this reason a sheet separating and shifting member, or cam separator, **60** is provided between the metering nip assembly **40** and the collator **50** for effecting precision separation of the sheet complements for entry into individual pockets **52** at a poduction rate in the order of three times that normally associated with conventional machines.

More specifically, the cam separator **60** is positioned in the sheet flow path within the gap **57** (FIG. 3) in operative intersection with the forks **54** of the spaced collating wheels **56** and is supported for rotation about a horizontally disposed axis positioned parallel to but somewhat below that of the metering roll **44**. A contoured cam surface portion **61** is formed on the cam separator **60** in continuation with a radial cam surface portion **62** and a leading cam nose portion **64** projecting outwardly at a maximum radial distance from its axis. The separator **60** is shown connected to the gear box **48** to be driven at a 1:1 speed ratio with the metering roll **44**, and the active cam surface (excluding radial portion **62**) is designed with a perimetric length equal to the perimeter of the metering roll **44**.

Extremely accurate separation of the packets **18** into different complements or books is ensured by the leading cam nose portion **64** which acts to depress the leading end of the last packet **18** of each of the sheet complements to guide them into their respective pocket **52** under a descending fork upon which the next following complement of sheets is to be deposited. By reason of the design and positioning of the separator **60** and its aforementioned common driving arrangement with the metering roll **44**, a preselected number of complete revolutions of the separator and metering roll will correspond to a completed book and during its delivery the collator **50** will simultaneously rotate to advance one pocket, and the radial portion **62** of the separator **60** will always be in synchronization with leading edges of the first packet **18** of a new book while the leading nose portion **64** will always engage the preceding sheets which form the last sheets of a previous book.

Assuming that the packet **18***a* represents the first sheets of a new book being fed to the collator **50**, the separator **60** moves through a starting angular position wherein its leading nose portion **64** is generally tangent to the lower tapered surface **59** of fork **54***a* and the radial portion **62** is then synchronized with the leading edge **65** of the packet **18***a* with the cam surface portion **61** positioned above the top surface of the fork **54***a* as shown in the drawing. Thus, in the starting angular position of the separator **60**, it will be seen that the leading edge **65** of packet **18***a* is free to move above fork **54***a* to be the bottom packet of a new book while the leading edge **67** of the preceding packet is deflected below fork **54***a* for entry into its receding pocket by engagement of the leading cam nose portion **64**.

In a typical application of the machine of this invention, 10 to 78 cuts by the rotary cutter **16** have been found to provide an adequate over-all range of cuts required to make up a single book, and by simply selecting proper gear ratios of the change gears **48**, the metering roll **44** and the separator **60**, each having a circumference of, say, 15 inches, can be operated to turn, e.g., 2, 4 or 8 complete revolutions per book during an angular displacement of the collator **50** advancing one pocket, thus ensuring that only 30, 60 or 120 inches of overlapped packets corresponding to a single book will pass through the metering nip assembly **40** and into an individual sheet collecting pocket **52** of the collator **50**. Assuming that stacked sheets cut by the rotary cutter **16** are selectively varied from 6 to 10 inches in length, a book consisting of ten 6 inch lengths of stacked sheets will be reduced in length from 60 to 30 inches at the lowest extreme of the range of cuts, and at the highest extreme a book consisting of seventy-eight 10 inch lengths will be reduced in length from 780 to 120 inches. The overlapping section of the conveyor between the high and low speed belt sections reduces the original sheet lengths by one half, and the metering nip assembly **40** reduces this half-length to the next lower length of 30, 60 or 120 inches to provide a completed complement of packets corresponding to a single book.

To ensure trouble-free operation without malfunction even at extremely high operating speeds, the radial portion **62** of the separator **60** is of a sufficient length to prevent leading edges of a packet being split between or impaled upon a fork, but the length of radial portion **62** must be less than the chordal distance of fork travel per each revolution of the separator **60** to ensure against a leading edge such as **67** of a last packet of a book improperly entering between cam surface **61** and the upper surface of fork **54***a*. The machine elements may be driven so that the separator **60** makes any integral number of revolutions per book (or index of pocket), provided that the number of revolutions per book does not exceed the ratio obtained by dividing the chordal distance between fork tips by the length of radial portion **62**. Such provision ensures that the revolutions of separator **60** in excess

of one will have no meaningful effect upon contacting those packets intermediate the first and last packets of a book.

Thus, the overlapped packets corresponding to each book are continuously and smoothly fed from one pocket into the next, without any break in sheet feeding, by operation of the separator **60** which positively engages the last packet **18** of each book to change its orientation relative to the metering nip assembly **40** while maintaining the attitude of the last packet and the attitude of a first packet of the next following book in entering relation to their respective pockets.

Moreover, high speed operation is readily attained without danger of jamming while yet completely eliminating any need for complex mechanisms normally associated with apparatus of this type dependent upon abrupt changes in the directions and speeds of operating parts for separating sheets into counted complements. By this invention, all machine elements have simple rotary motion and are gear driven to achieve precise registration ensuring dependable operation at significantly increased production rates. It will also be seen that the upper surface of the piled packets within each pocket **52** is maintained at an approximately constant level by reason of the continuous rotary movement of the collator **50**, thereby automatically accommodating increased thicknesses of the delivered stacks.

Completed books or complements such as at **68** are then transferred to a delivery station by an endless belt **70** which coacts with the collator **50** to successively remove the completed books **68**. The belt **70** has an upper horizontal run **72** positioned in the gap **57** between the collating wheels **56** and is supported by rollers (only one shown at **73**) suitably connected to the drive shaft **47** for driving the belt **70** in properly timed relation to the continuously moving collator **50**. As each fork **54** descends toward the belt **70**, the former leading edges of the stacked packets of each completed book **68** will engage the abutment surfaces **58** between adjacent forks so as to be disposed perpendicular to the upper run **72** of the belt **70** upon moving into parallel relation therewith to be engaged sequentially by a plurality of spaced L-shaped plates **74** carried by the belt **70** and removed in neatly stacked arrangements to the next delivery station, e.g., to be provided with covers and bound into books. Opposite side edges of the completed books are desirably maintained against sagging by a pair of belts **76, 78** synchronized with and positioned on opposite sides of belt **70**.

The above described machine is of compact, rugged construction and can readily handle sheets of varying size over a wide range of operating speeds wherein paper ribbons or webs are being delivered at linear speeds from about 10 to over 1,000 feet per minute. Even in the upper speed range, the machine of this invention is capable of smoothly and automatically handling sheet delivery and collating in a continuous production operation with minimal wear, vibration and malfunctions.

As will be apparent to persons skilled in the art, various modifications and adaptations of the structure above described will become readily apparent without departure from the spirit and scope of the invention, the scope of which is defined in the appended claims.

I claim:

1. In a sheet handling machine, a conveyor operable for transporting a continuous stream of overlapped sheets along a path, a continuously movable collator disposed downstream of the conveyor and including a series of pockets each having an entrance opening toward the conveyor, the pockets being successively movable in unison past the conveyor for respectively collecting sheet complements of a predetermined number, means controlling advance of the sheets in a predetermined attitude relative to the collator, and a sheet separating and shifting member mounted for movement between the conveyor and the collator for positively engaging a last sheet of each complement for changing its orientation relative to the conveyor while maintaining the attitude of said last sheet and the attitude of a first sheet of the following complement in entering relation to their respective pockets of the continuously movable collator.

2. The machine of claim **1** wherein said means includes a metering nip assembly positioned in the path of the overlapped sheets upstream of the sheet separating and shifting member and having a metering roll engageable with the approaching sheets, the metering roll being driven in timed relation to the movement of the sheet collecting pockets to continuously deliver thereto complements of a predetermined number of sheets with each of the complements being individually deposited in one of the pockets.

3. In a sheet handling machine, a conveyor operable for transporting a continuous stream of sheets along a path, the conveyor including a high speed belt section, a low speed belt section downstream of the high speed belt section, and an overlapping section between the high speed and low speed belt sections for effecting delivery of the sheets in overlapping condition, a continuously movable collator disposed downstream of the conveyor and including a series of pockets each having an entrance opening toward the conveyor, the pockets being successively movable in unison past the conveyor for respectively collecting sheet complements of a predetermined number, a sheet separating and shifting member mounted for movement between the conveyor and the collator for positively engaging a last sheet of each complement for changing its orientation relative to the conveyor while maintaining the attitude of said last sheet and the attitude of a first sheet of the following complement in entering relation to their respective pockets of the continuously movable collator, and a metering nip assembly between the low speed belt section and the sheet separating and shifting member and coacting therewith for ensuring delivery of a preselected number of sheets in each of the sheet complements to their respective pockets of the collator.

4. The machine of claim **1** wherein the sheet collecting pockets of the collator successively descend in one angular direction about a fixed horizontal axis past a delivery end of the conveyor in timed relation therewith, and wherein the sheet separating and shifting member is continuously rotatable about a fixed horizontal axis in synchronism with the conveyor for positively deflecting a last sheet of each of the sheet complements to ensure its entry into its respective sheet collecting pocket while permitting undeflected movement of a first sheet of the next sheet complement into a following adjacent pocket of the collator.

5. The machine of claim **2** wherein the sheet separating and shifting member comprises a rotary cam rotatable about a fixed axis in spaced parallel relation to the metering roll and having a contoured cam surface portion formed in continuation with a radial cam surface portion and a leading cam nose portion, the cam being driven in synchronism with the metering roll such that the cam nose portion acts to deflect a leading edge of a last sheet of each of the sheet complements into its respective sheet collecting pocket while the leading edge of a first sheet of the following complement is free to enter the next following pocket of the collator.

6. The machine of claim **3** wherein the low speed and high speed belt sections are operable at preselected relative surface speeds to effect uniform half length overlapping of the sheets in the low speed belt section.

7. The machine of claim **5** wherein the collator comprises a carrier having a plurality of forks defining the sheet collecting pockets, the forks being mounted in equally spaced relation on the carrier for angular movement past the rotary cam about a fixed axis parallel to that of the last mentioned element, and wherein the

adial cam surface portion is of a preselected length ess than the angular displacement of fork travel per ach revolution of the rotary cam.

8. The machine of claim **5** wherein the sheet collecting pockets of the continuously movable collator are lefined by a plurality of angularly spaced forks, and vherein the cam is supported for rotation in noninterering operative intersection with the forks of the collator, the cam being continuously rotated in timed relation to the collator from a starting angular position, vherein the leading cam nose portion is adjacent and generally tangent to one of the forks, such that each of he following forks is successively moved past the leading cam nose portion as the cam is moved through its starting angular position.

9. The machine of claim **5** wherein the cam has an active cam surface with a perimetric length equal to the perimeter of the metering roll, and wherein a common drive is provided for driving the metering roll and the cam at a predetermined angular velocity such that a preselected number of complete revolutions of the metering roll and cam ensures delivery of separate sheet complements of a known count to the collator.

10. In a sheet handling machine, a collator continuously movable in one direction about a fixed horizontal axis disposed in confronting transverse relation to a line of approach of a continuous stream of oncoming overlapped sheets, the collator having a plurality of open peripheral sheet collecting pockets successively and continuously movable into and out of register with oncoming sheets for collecting predetermined counted and separated complements of sheets and moving the same along a common path, and sheet separating means upstream of the collator for separating a last sheet of each complement and a first sheet of a following complement for collating said two sheets in separate sheet collecting pockets.

11. The machine of claim **10** wherein a plurality of forks are attached to the collator to extend outwardly in equiangularly spaced relation and defining the sheet collecting pockets, and wherein a flat abutment extends between each pair of adjacent forks in perpendicular relation to a leading fork thereof and against which abutment the sheets are stopped relative to the forks to assist in aligning the sheets in neatly stacked condition.

12. The machine of claim **10** wherein delivery of the sheet complements into their respective sheet collecting pockets is effected at an approximately constant level relative to the axis of the collator.

13. The machine of claim **10** further including a metering nip assembly positioned upstream of the collator and having a metering roll engageable with the approaching sheets, the metering roll being driven in timed relation to the movement of the sheet collecting pockets past the line of approach of oncoming sheets to continuously deliver complements of a predetermined number of sheets into the sheet collecting pockets with each of the complements being individually received in one of the same.

14. The machine of claim **11** wherein each of the forks is disposed in an upwardly tilted attitude with respect to the oncoming sheets throughout registry therewith of their respective sheet collecting pockets, the forks being continuously movable with a tangential velocity component substantially normal to the line of approach of the sheets in descending relation thereto.

15. The machine of claim **14** further including an endless conveyor having an upper run positioned in noninterfering operative intersection with the forks of the collator and continuously traveling outwardly therefrom in timed relation thereto for removing each of the sheet complements from the individual forks as they successively descend through a position parallel to the upper run of the endless conveyor.

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