INDEX

ENCAPSULATION EQUIPMENT, LLC

INDEX K SERIES ENCAPSULATOR

Detailed Machine Description

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1. INTRODUCTION

The Index K series capsule filler is a high speed machine designed to orientate, separate, fill, close, and eject gelatin capsules.

The purpose of this overview is to introduce the reader to the Index K Series equipment, controls, and processes. The overview addresses the following subjects:

- Identification of major machine components.
- Brief explanation of the overall operational process.
- Detailed explanation of each major section of the machine.
- Detailed explanation of machine controls.

Figure 1 shows the front of the INDEX K Series as seen from the operator's point of view.

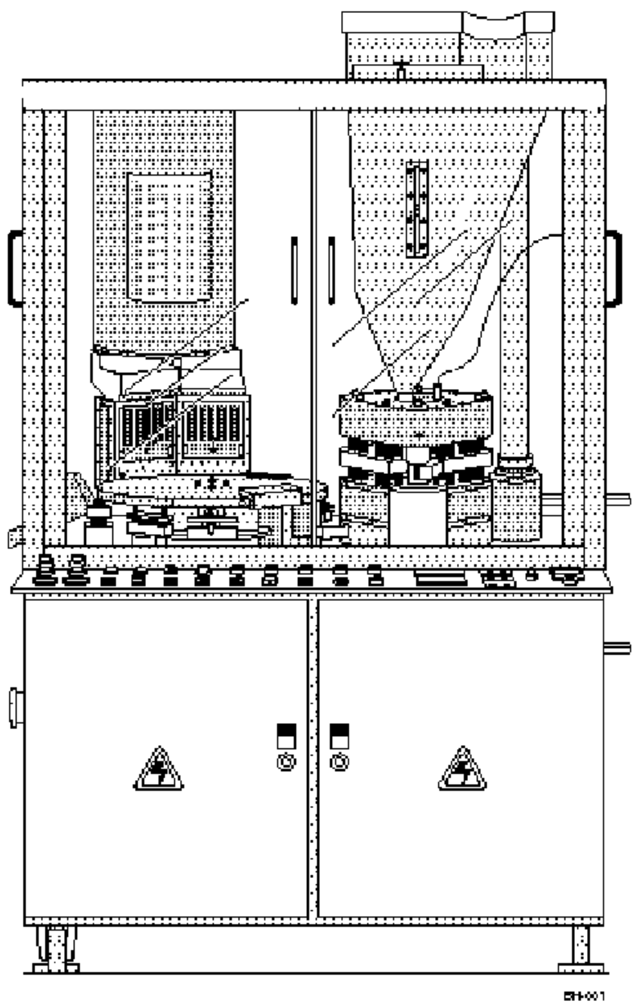


Figure 1. Front of INDEX K Series

GENERAL OVERVIEW OF MACHINE

This general overview of the machine includes the following:

- Machine cabinet and guarding
- Machine drives
- Brief explanation of capsule-filling processes and major components

1.1 MACHINE CABINET AND GUARDING

The Index K Series machine is constructed on a metal frame that supports both the operational machine components and the protective guards used to separate the machine components from outside interference. Clear Lexan doors surround the top portion of the machine while metal doors and panels are used on the lower section. Figure 2 shows the major parts of the Index cabinet.

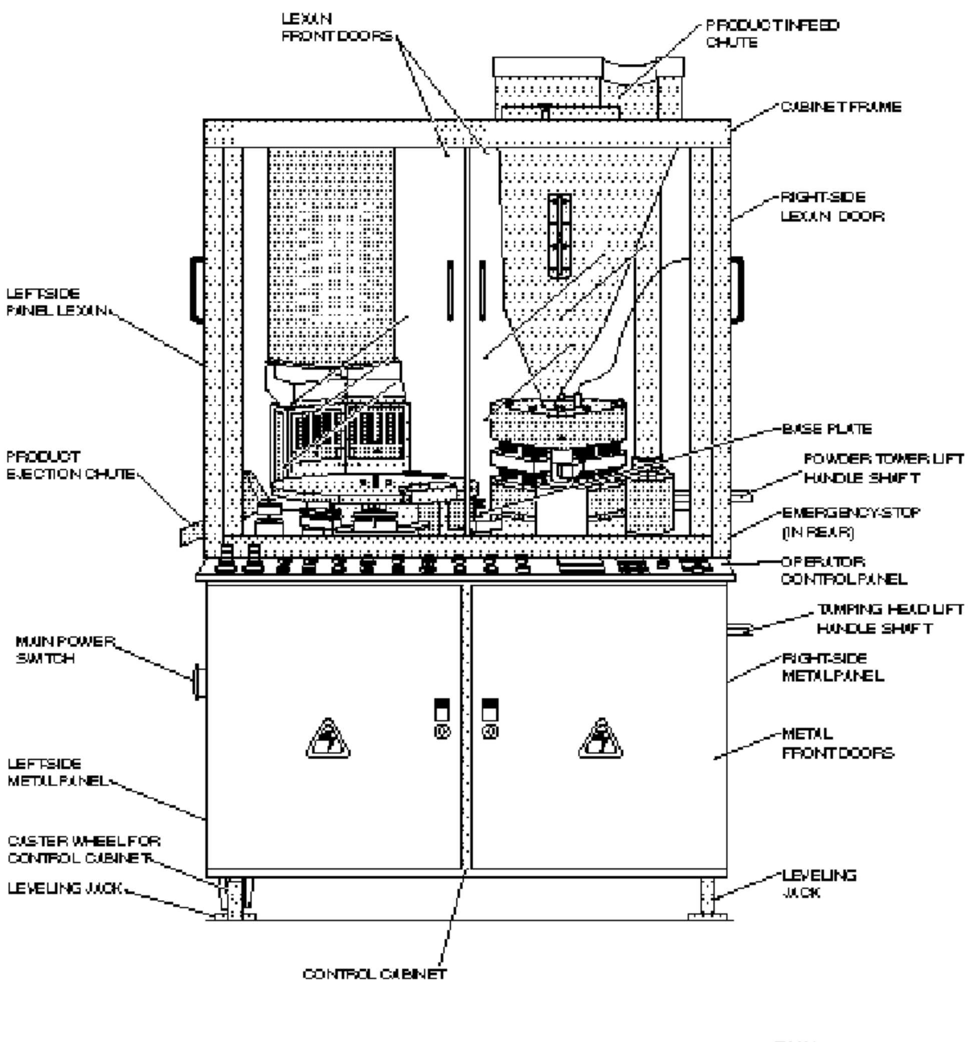


Figure 2. Major Parts of INDEX Cabinet

1.1.1 Machine Frame, Bottom Plate, and Base Plate

The overall cabinet of the INDEX measures 66 inches tall, 47 inches wide, and 47 inches deep. The top portion of the machine is 38.5 inches tall while the bottom section is 27.5 inches tall. The top part of the machine is called the upper enclosure and the bottom part is called the lower enclosure.

The base of the machine is a heavy steel frame needed to support the total weight of the machine. A 1/2-inch steel plate is installed across the bottom area of the machine's base. The drive motor, related gearbox components, and vacuum pump are all mounted onto this bottom plate. About 30 inches above the bottom plate is a 55 mm thick plate of stainless steel separating the bottom and top sections of the machine. This base plate is mounted on top of the machine's base frame, and has holes through it for mounting the various machine components and drives. The base plate weighs over 1,000 pounds. The mass of this base plate is critical to the machine because it provides a very stable foundation onto which all the main operational components are attached.

Because of the bottom base plates, and the heavy components mounted onto them, a forklift is needed when the machine must be moved. Screw jacks are used under the corners of the machine to both level and support the machine frame.

1.1.2 Upper-Enclosure Guards

The top half of the cabinet houses the machine's operational area. Lightweight rails are used for the cabinet frame above the operational area. The clear lexan doors are mounted in lightweight metal door frames hinged to the vertical corner rails that form the cabinet's frame. These clear upper doors allow the process equipment to be seen while it is operating. The upper enclosure helps contain any dust created by the processes occurring inside the operational area.

Controls Cabinet - The controls cabinet is hinged on the right side so that it can be unlatched from the left-front corner of machine and pulled away toward the right. A caster wheel under the left end of the controls cabinet supports the cabinet as it is being pulled out of the way to the right. After the control cabinet is rolled away from the machine, parts of the machine's drive system can be seen from the front of the machine. Figure 4 shows the Index K120 with the controls cabinet pulled away from the main cabinet.

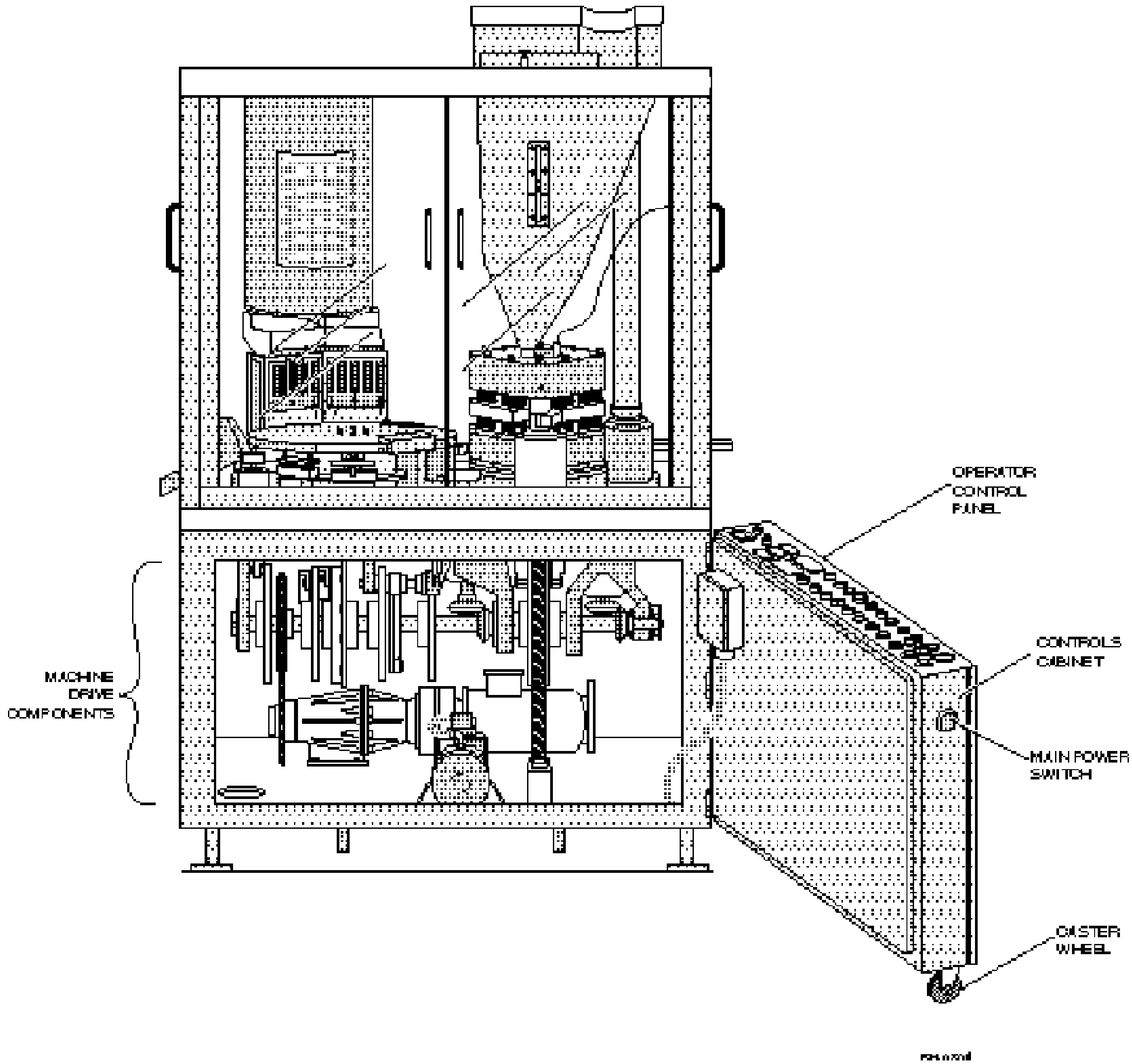


Figure 4. Front of INDEX with Control Cabinet Pulled Away

1.1.3 Lower-Enclosure Guards

The left, right, and rear sides of the machine's lower half are covered by metal panels attached to the machine's frame. When the controls cabinet is securely installed against the front of the machine's frame, the cabinet covers the lower-front part of the machine. These metal panels and the control cabinet enclose the machine's mechanical drives. The doors of the controls cabinet, and the lower-enclosure panels, must stay closed at all times when the machine is being started or run.

1.1.4 Guard Sensors

All of the protective doors and panels on the machine are equipped with sensors that detect when one of the doors is opened, or when a panel is removed. The door sensors are mounted on the frame of the upper-enclosure and located near the top edge of each door. The sensors for the lower-enclosure panels are mounted vertically onto the corner posts of the lower-enclosure.

All of the guard sensors are electrically connected to the machine's control circuits. If a panel or door is open while the machine is being started, the machine will not start. If a panel or door is opened while the machine is being run, the machine will immediately stop.

1.1.5 Emergency Stop Controls

The proper way to stop the machine is through the use of the operator controls located on the front control panel, but in emergency situations the machine may be shut down by activating either the machine's MAIN POWER switch or the machine's emergency stop control. The MAIN POWER switch is located near the left-front corner of the lower enclosure, and the emergency stop control is located near the right-rear corner of the lower enclosure. During normal machine operations, the emergency stop control must be pulled out. When either the emergency stop control is pressed or the MAIN POWER switch is turned off, the machine will stop almost instantly.

1.1.6 Safety Guard Bypasses

Although not recommended as a normal practice, the guard sensors on the enclosure doors and panels may be bypassed so that the doors or panels can be opened for those personnel needing to observe or adjust the machine as it is being jogged or manually rotated. The **BRAKE BYPASS / NORMAL** control on the front panel must be placed to the **BYPASS** position to disable the sensors. The machine's control cabinet may also be pulled away from the machine's frame so that the drive components can be more easily observed.

WARNING: To prevent possible electrical shock, keep the front doors on the machine's control cabinet closed while power is applied to the machine. Also to prevent personal injury caused by the rotating parts of the machine's drive components, do not run the machine with the side panels removed or the control panel pulled away from the frame. Do not bypass safety guard sensors unless cleared to do so for maintenance purposes.

MACHINE DRIVES

The Index K120 is driven by a single electrical motor, a gear reducer (gearbox), a drive chain, and a main camshaft. Beveled gears, cams, and cam followers associated with the main cam are the devices that actually deliver both power and direction to the operational components of the machine. Figure 5 shows the location of the drive motor, gearbox, drive chain, and main cam, as seen when the controls cabinet has been pulled away from the main cabinet.

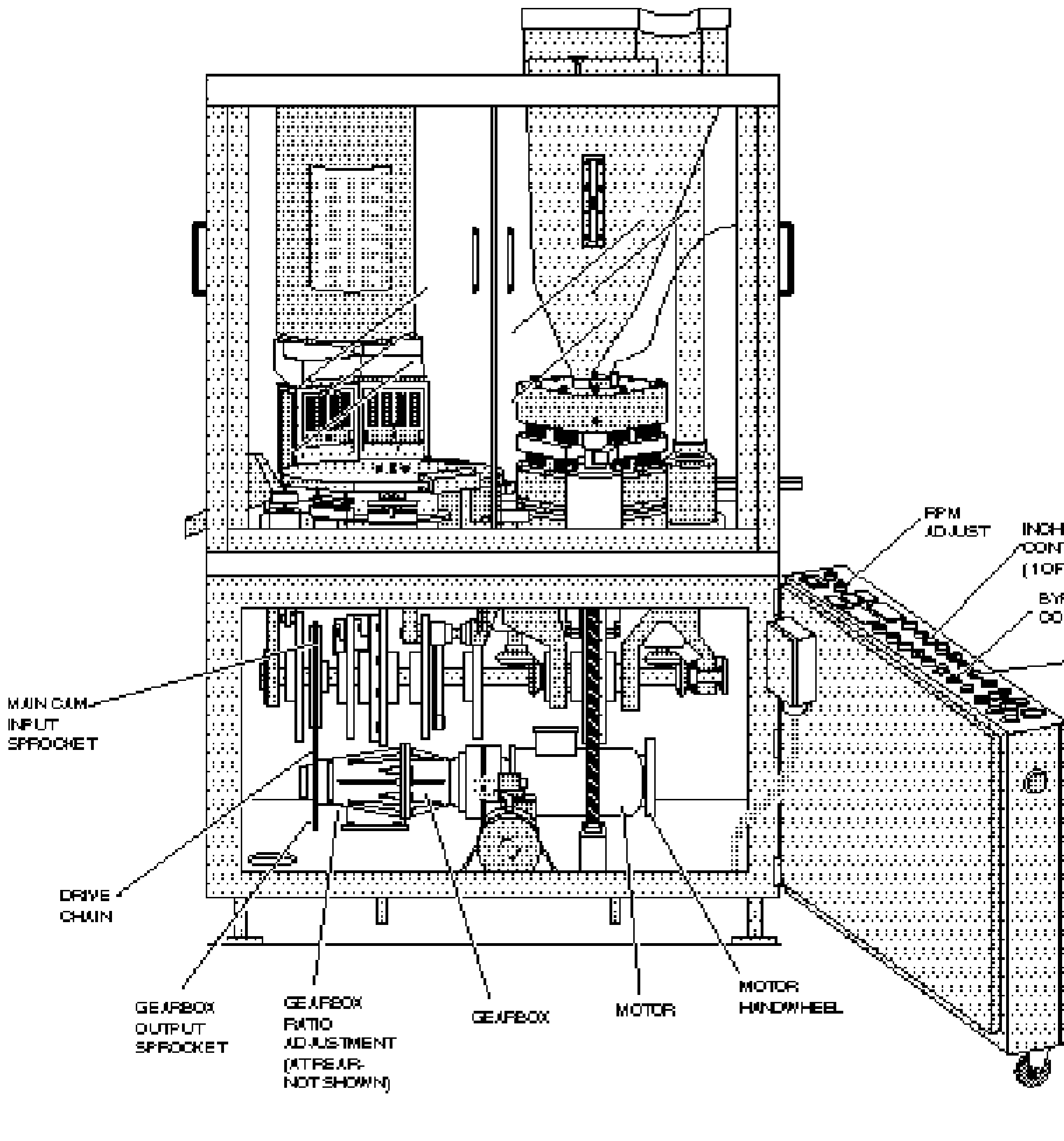


Figure 5. Location of Drive Motor, Gearbox, Drive Chain and Main Cam

The recommended rotational speed for the machine is 120 revolutions per minute (rpm) at the drive motor. The rotational speed can be more or less than the recommended speed. Through the gears of the gearbox and the sprockets of the gearbox and the main cam, the main cam can be set to rotate at the same speed of the drive motor. If the speed is decreased too much, production rates can be affected, along with the possibility of loading the motor at the slower speeds. If the rotational speed is increased too much, excessive wear may occur on the rotating components of the machine, especially the cam followers.

1.1.7 Drive Motor and Control Brake

Drive Motor - The drive motor used on the Index K120 is located just inside the rear panel of the lower enclosure. The 10-horsepower, variable-speed, AC motor is mounted to the bottom plate of the machine. The output end of the motor is coupled directly to the input end of a gear reducer (gearbox). The speed of the motor, and thus the rotational speed of the machine, is controlled by a "**MAIN MOTOR-RPM ADJUST**" control located on the machine's operator control panel.

Bypass Control - The drive motor is equipped with an electronically controlled brake system that locks down the drive motor when the machine is stopped or not operating. The brake is controlled by the **BRAKE BYPASS / NORMAL** control located on the front control console. The control must be placed into the **BYPASS** position to release the motor brake.

Tamping-Head Assembly - The devices used to lift and lower the tamping-head assembly for grade changes or maintenance has a lower-limit switch mounted on the bottom plate and near the right-center of the machine. The machine controls will not operate unless the tamping-head assembly is manually lowered to trip this lower-limit switch.

Jogging and Manual Control - After the brake has been released, the motor can be jogged slowly forward with the two jogging controls also located near the center of the control console, or the motor and driveline can be rotated manually by a hand-wheel located on the right end of the motor (as seen from the front of the machine). This hand-wheel is also often called the motor's "flywheel".

1.1.8 Gear Reducer (Gearbox)

Gearbox Output - Toward the left-center corner of the lower enclosure is the gear reducer or gearbox used to transfer power from the drive motor to the main camshaft. A chain-drive sprocket is attached to the output shaft of the gearbox. The chain connects the gearbox to the input sprocket attached to the left end of the machine's main camshaft.

Gearbox Variable Control - The gearbox is equipped with a control device that allows the input-to-output ratio of the gearbox to be changed to match given production needs.   The variable control allows the output speed of the gearbox to be increased or decreased for a given motor speed. The variable control handle is located an inch or so away from the output sprocket of the gearbox.

1.1.9 Main Cam (Camshaft)

Just below the base plate, and mounted left to right near the front of the machine, is the main camshaft (cam) used to both drive and synchronize (time) all of the operational devices used in the machine. The center shaft of the main cam rides inside roller bearings mounted inside of yokes attached to the bottom side of the base plate. The cam is located above and in front of the machine's drive motor and gearbox. Figure 6 shows where the drives to the process devices are connected to the main cam.

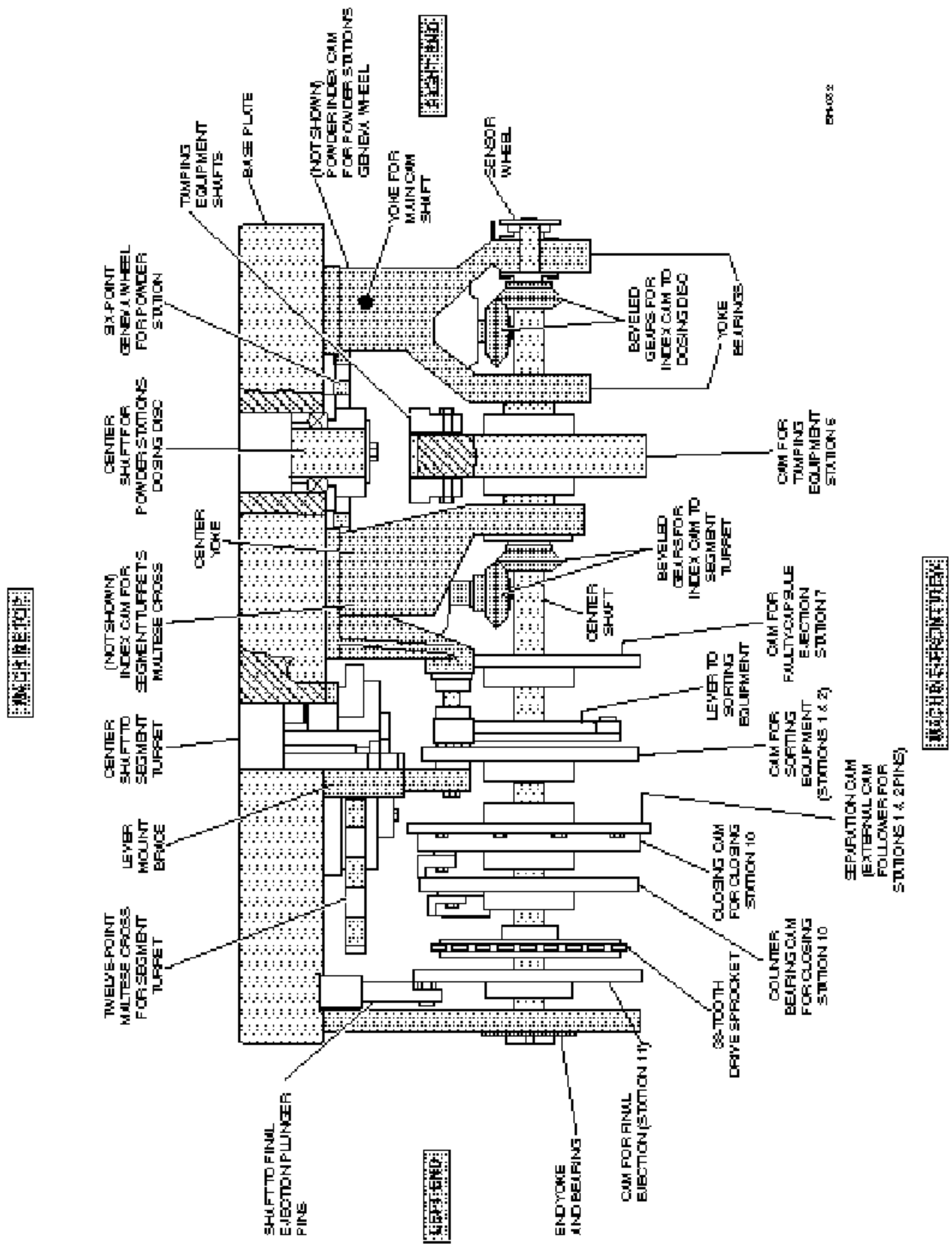


Figure 6. Main Cam Drives to Process Devices

Main Cam Input - Near the left end of the main cam, as seen from the front of the machine, is a 38-tooth chain sprocket. A loop of drive chain connects the output sprocket of the gearbox to the input drive sprocket attached to the cam. When the motor turns the gearbox, the gearbox sprocket and drive chain make the cam's sprocket turn the main camshaft.

Main Cam Outputs - When the main camshaft rotates, it in turn makes all of the cams and beveled gears attached to it rotate. When these attached devices rotate, the devices connected between the camshaft attachments and the process devices cause the process devices to operate. The main cam must make twelve (12) complete revolutions for one complete rotation of the segment turret that is driven by the main cam.

The following are process devices driven or controlled by the main cam:

- Drive components to the segment turret
- Drive components to the capsule sorting and separating equipment (Stations 1 and 2)
- Drive components to the dosing station disc (Station 5)
- Drive components to the tamping head and pins (Station 5)
- Drive components to the faulty capsule equipment (Station 7)
- Drive components to the capsule closing equipment (Station 10)
- Drive components to the final capsule ejection equipment (Station 11)

NOTE: The main cam and its related drive devices will be described in Section 3.0.0)

Figure 7 shows, as an example, a left-side view of the cam components (cam, lever, and shaft) used for the fault ejection equipment at process station 7.

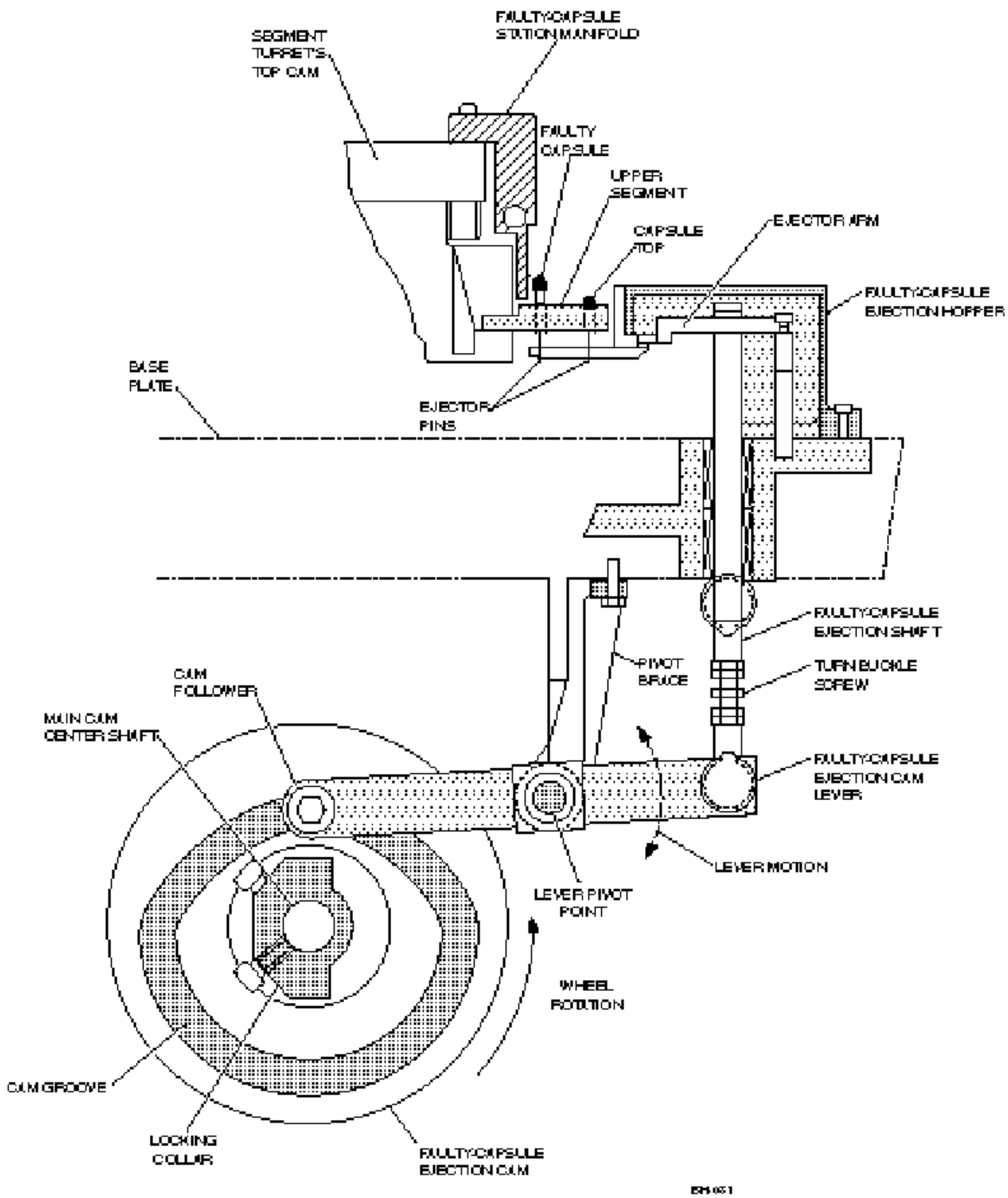


Figure 7. Left-Side View of Fault Ejection Cam Components

1.2 BRIEF EXPLANATION OF CAPSULE-FILLING PROCESSES AND MAJOR COMPONENTS

The purpose or function of the Index is to place precise amounts of granulated product (powder) into capsules at a very fast rate. The major component areas filling these capsules are all housed inside the upper-enclosure area of the machine. Figure 8 shows the major process areas of the Index capsule filler.

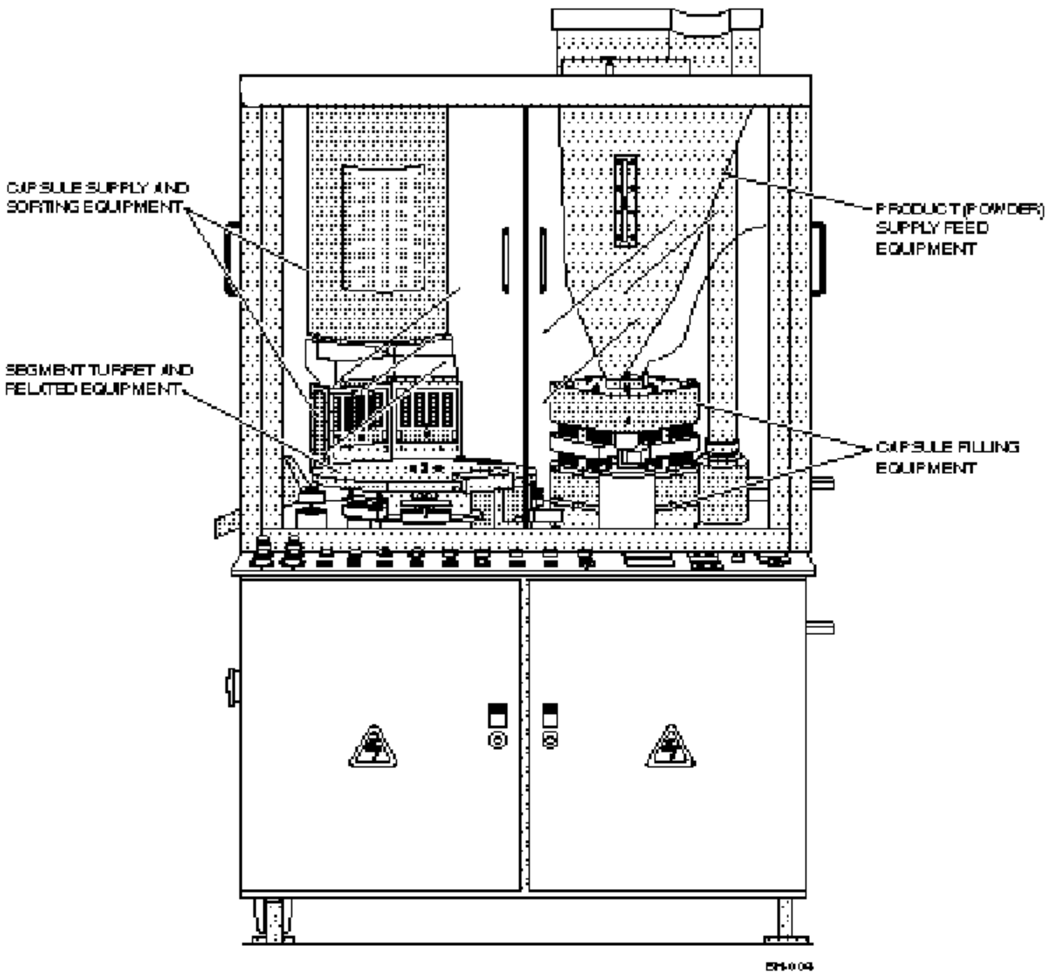


Figure 8. Major Process Areas

- The major process assemblies of the Index K120 include the following:
- Segment turret and associated segments
- Capsule supply, sorting, and separating equipment
- Product (powder) supply and feed equipment
- Capsule filling (or dosing) equipment
- Capsule ejecting, closing, and cleaning equipment

1.2.1 Segment Turret and Associated Segments

Segment Turret and Process Stations - The capsule-filling processes take place at 12 process stations positioned around a turntable-like device called the segment turret. The segment turret rotates in the clockwise direction, one position or station at a time. This stepping action, one position or station at a time, is often called indexing.

Main Cam Association - The segment turret is driven by devices connected to the main cam located below the base plate. As stated earlier, the main cam must rotate twelve (12) times to make the segment turret rotate one complete revolution. All other machinery movements within the operational area are timed or synchronized to the rotational movements of the segment turret. ***(These and other timing issues will be covered in more detail later in this text.)***

Process Stations - All of the machine's processing devices are mounted around the segment turret. The processing devices supply the capsules and product; open, fill, and close the capsules; and eject both the bad (faulty) and good capsules from the machine.

Figure 9 shows the location of the segment turret and some of the key process stations associated with it.

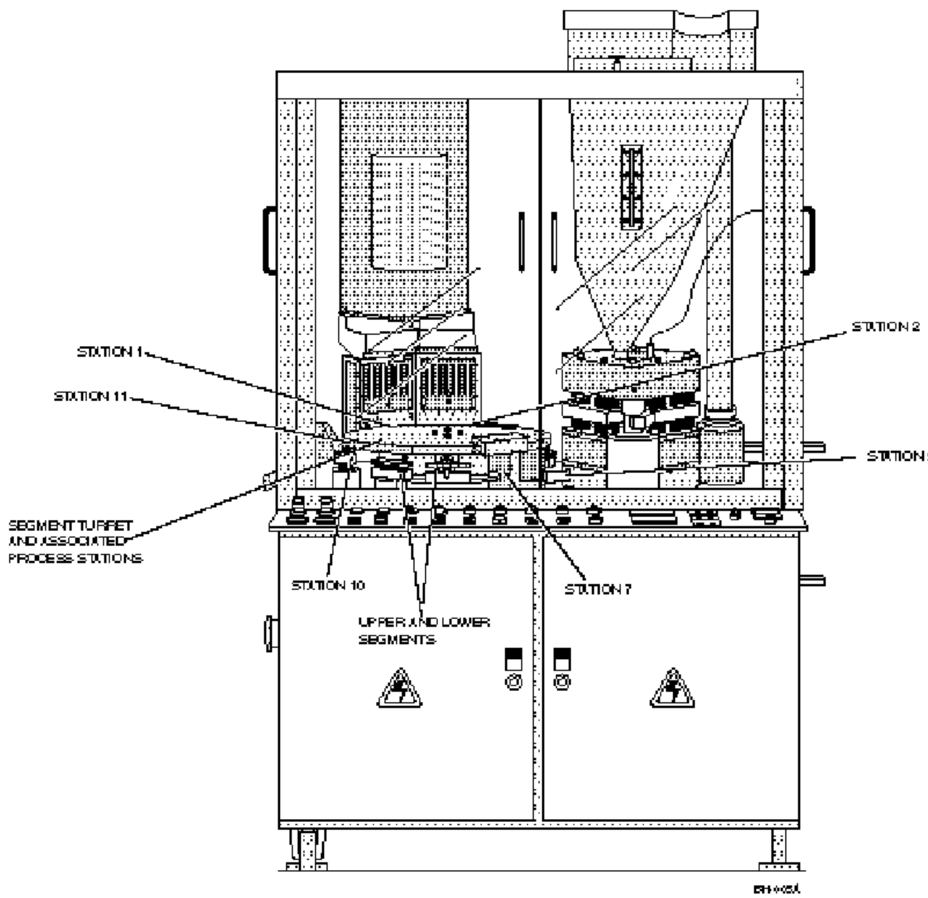


Figure 9. Locations of Segment Turret and Selected Process Stations

Segments - The block-like devices surrounding the segment turret are the segments. Each segment block has a specific set of evenly spaced and sized bores drilled in it. The bore sizes determine the size of capsule that is being processed. The segments used on the Index K120 have 16 capsule holes in them. Each time a different size of capsules is to be run, the machine must be equipped with 12 new sets of segments.

The segments are arranged in matched sets with the upper segment located directly over the lower segment. For the capsules to be smoothly loaded into segments, the two segments must be perfectly aligned over each other. Figure 10 shows a close-up view of a set of segments.

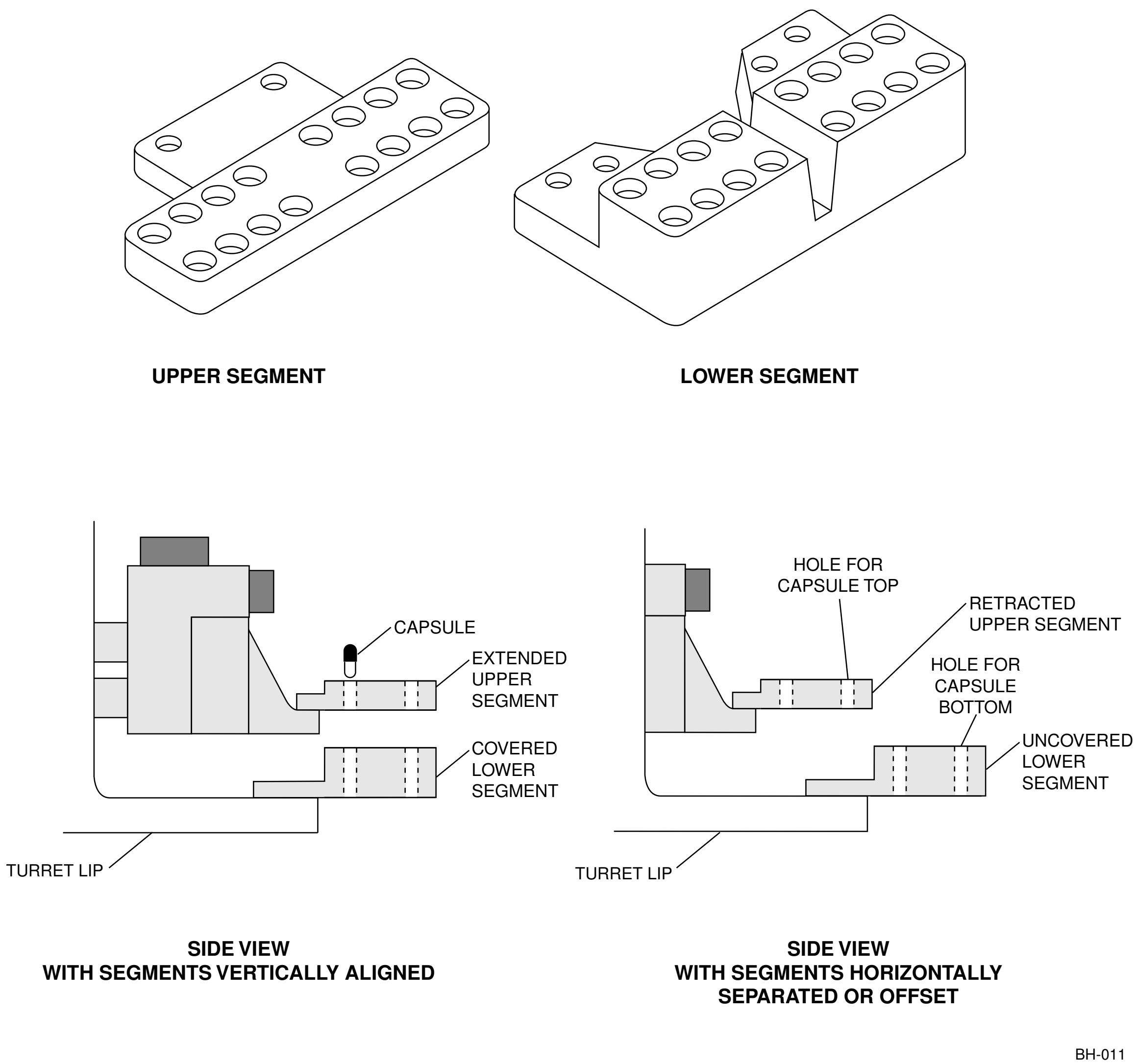
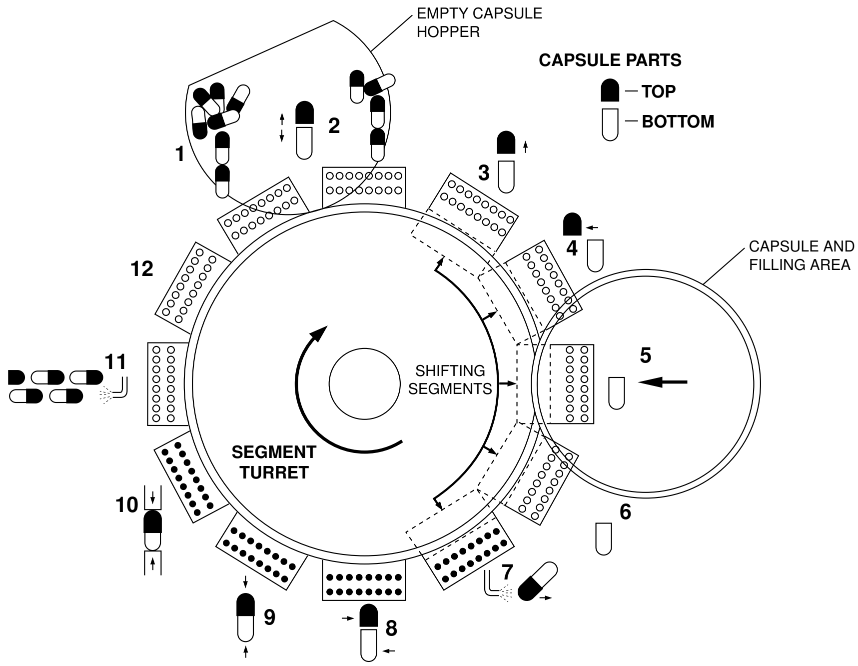


Figure 10. Close-Up Views of Segments

During one full process cycle (rotation), the segment turret carries matching sets of segments clockwise through each of the various process stages or stations, momentarily stopping at each station to allow the process work to occur. The segment turret has 12 sets of these matching segments.

Capsule-Filling Process - The key to understanding the capsule-filling process is to select one set of segments and then follow those segments from process station 1 through process station 12. Figure 11 shows an overhead drawing of the segment turret and the various process stations through which the capsules pass.



STATIONS	
1 & 2	CAPSULE FEED, LOADING, AND SEPARATION
3	SEGMENT SEPARATION (VERTICAL SHIFT)
4	CAP REMOVAL (HORIZONTAL SHIFT)
5	POWDER DOSING STATION
6	OPEN (NOT USED)
7	UNSEPARATED (FAULTY) CAPSULE EJECTION
8	REALIGNMENT OF CAPSULES (HORIZONTAL SHIFT)
9	SEGMENT COMBINATION (VERTICAL SHIFT)
10	CLOSING STATION
11	EJECTION STATION (FINISHED PRODUCT)
12	HIGH-INTENSITY SEGMENT CLEANING STATION

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Figure 11. Process Stations for Capsules Processed by INDEX

1.2.2 Capsule Supply, Sorting, and Separating Equipment

Capsule Supply Equipment - Near the left-rear corner of the machine is the capsule hopper. An operator must reach up over the left side of the machine's cabinet to pour empty capsules into the top of the capsule hopper. Your machine may or may not be equipped with a sensor that detects the level of empty capsules inside the capsule hopper.

As the empty capsules escape from the bottom of the capsule hopper, they go down through the capsule supply and sorting equipment at processing stations 1 and 2. The capsule sorting equipment is also called the capsule magazines. Figure 12 shows the location of the capsule supply and sorting equipment.

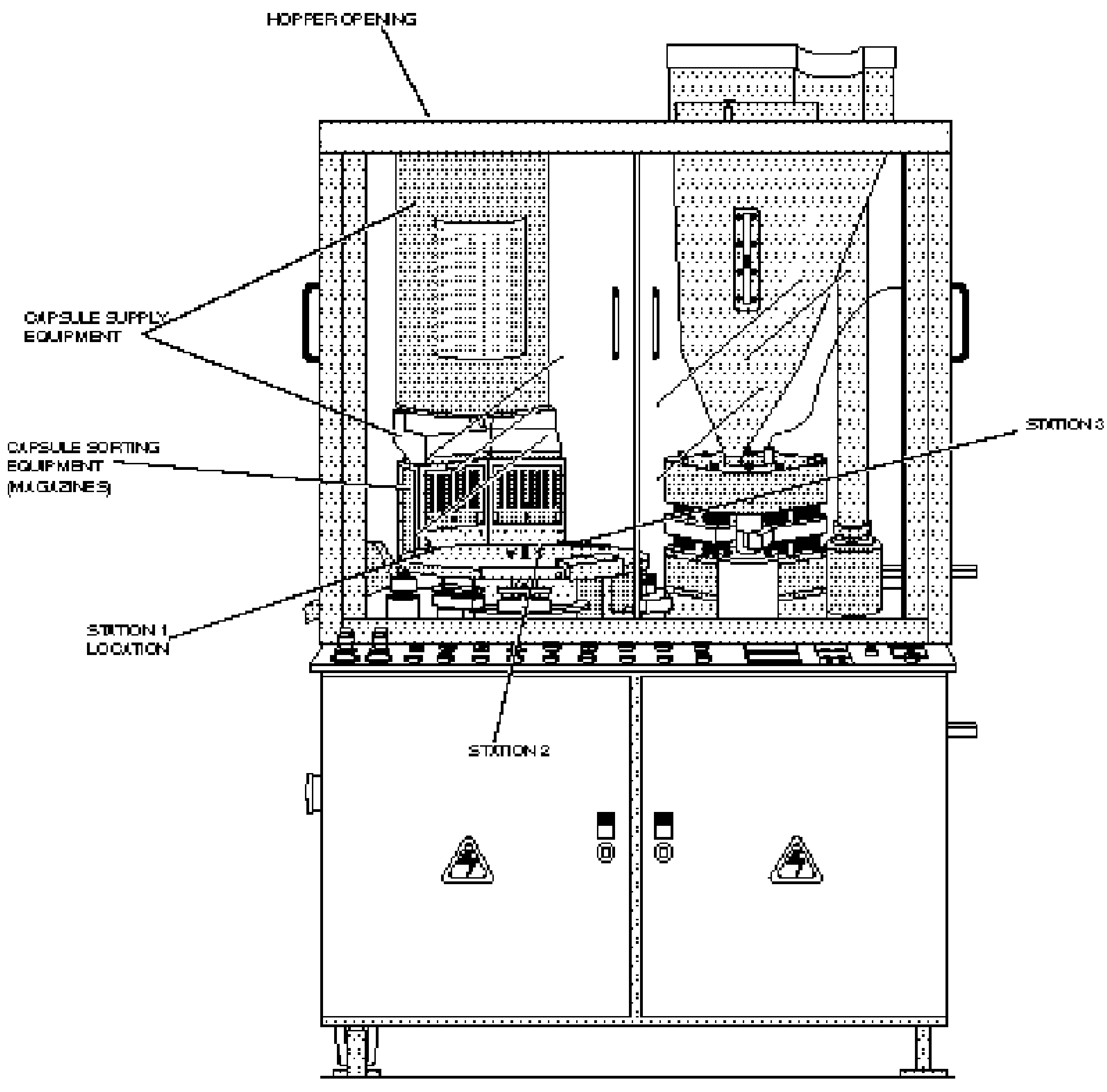

Figure 12. Location of Capsule Supply and Sorting Equipment

Capsule Sorting, Aligning, and Separating Equipment - The equipment above and behind stations 1 and 2 sorts and aligns the capsules so that the smaller bottom end of each capsule is pointing down. Once aligned by the capsule magazines, the capsules are next placed down into the holes of the capsule-holding segments positioned in stations 1 and 2 below the capsule feeding equipment. After the segments have been loaded with empty capsules, vacuum is used to pull the bottom halves of the empty capsules down away from the top halves. The top and bottom halves of the capsules are still vertically aligned, but separated at this point inside their respective upper and lower segment blocks.

At station 3, the cam actions of the segment turret start to move the upper segment vertically from its previous position above the lower segment. As the segment turret moves the segments on into station 4, the cam actions of the segment turret move the upper segment in the horizontal direction and closer to the center of the segment turret's donut. Retracting the upper segment is necessary to expose the top of each capsule's bottom half (positioned in the lower segment) so that it can be filled. Remember that each hole in the bottom segment should contain the bottom half of an empty capsule. As the segment turret moves the segments out of station 4, the upper segment is completely retracted from over the lower segment. Figure 13 shows an overhead view for the locations of processing stations 1, 2, and 3 surrounding the segment turret.

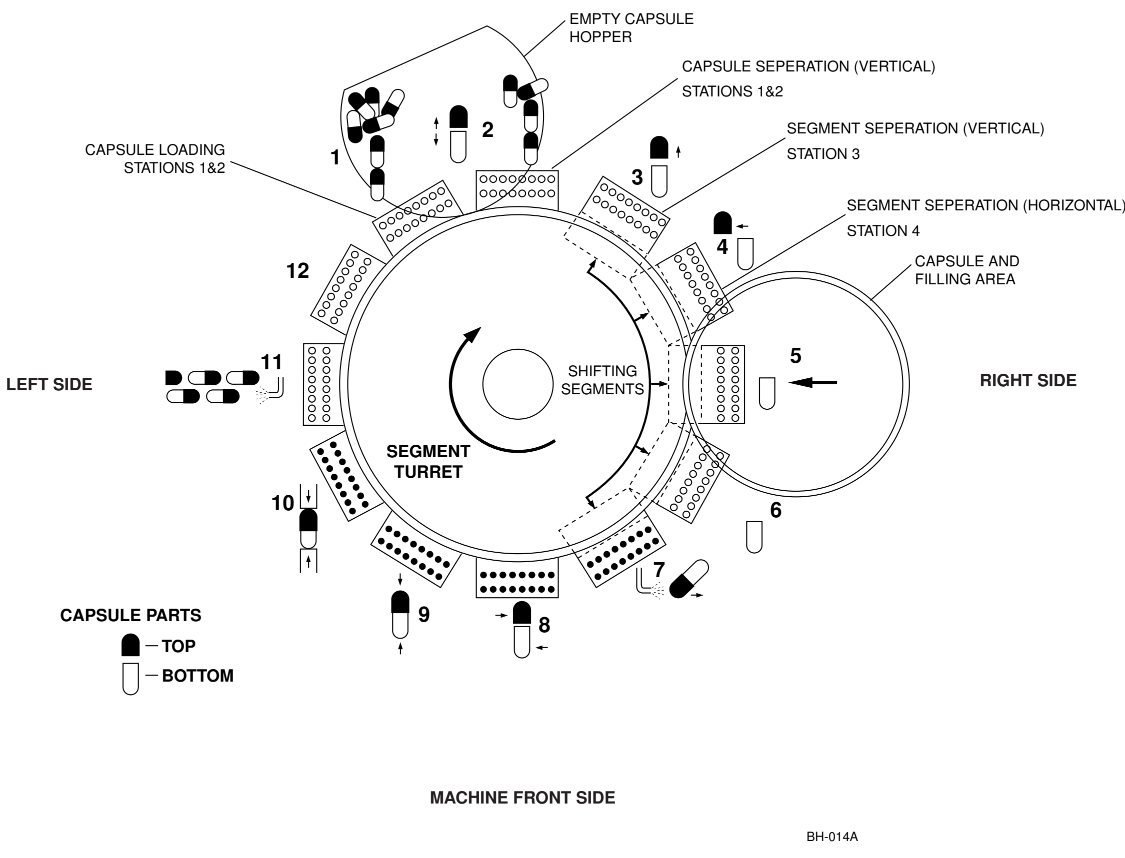

Figure 13. Locations of Process Stations 1, 2, and 3

Main Cam Association - The equipment items used for capsule sorting, aligning, loading (into the segments below) and vertical separation are all driven by devices connected to the machine's main cam. The vertical and horizontal separation of the capsule tops and bottoms is caused by cam actions within the segment turret itself. The segment turret of course is also driven from the main cam. ***(These and other drive issues will be discussed later in Section 3.0.0.)***

1.2.3 Product (Powder) Supply and Feed Equipment

At the right-rear corner of the machine is the hopper and feed equipment used to supply the product (powder) to the capsule-filling equipment located near the bottom-right corner of the operational area. The machine operator must reach over the top of the machine's right-side wall to manually add the powder into the powder input opening at the top of the powder hopper. Figure 14 shows the location of the product (powder) supply and feed equipment.

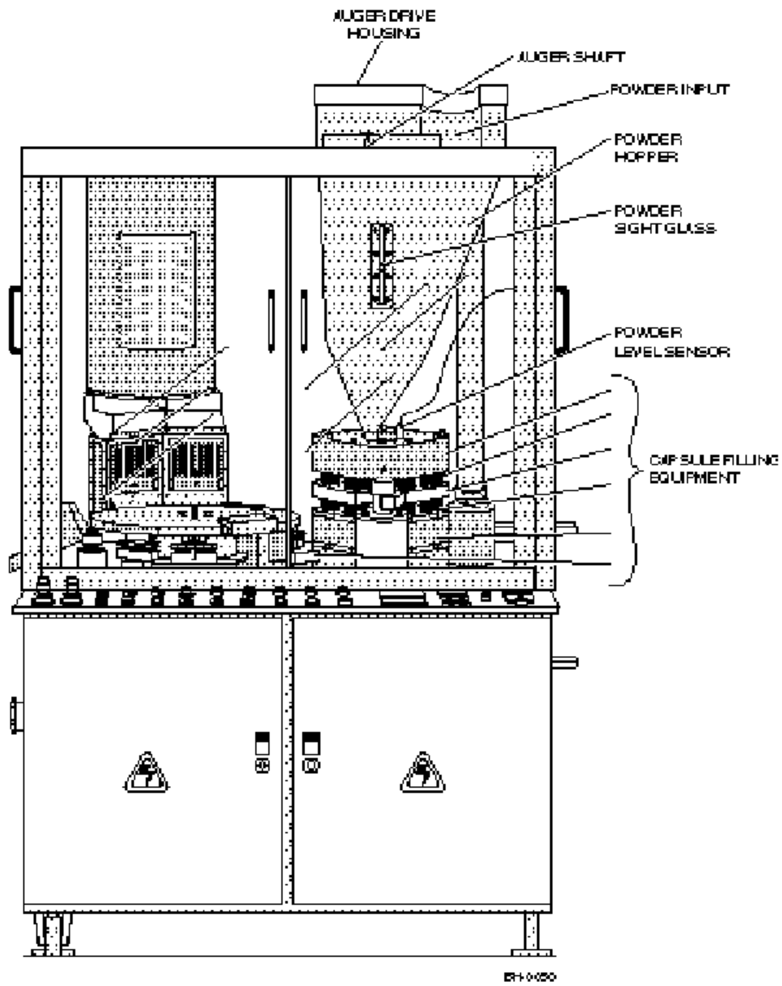

Figure 14. Location of Product (Powder) Supply and Feed Equipment

After powder is in the hopper, an auger drive motor (located inside the drive housing mounted on top of the machine) turns a sweeper arm and an auger inside the hopper to force the powder down into the capsule-feeding equipment below the hopper. A level sensor detects the level of powder in the powder bowl of the filling equipment. The powder-feed equipment has no association with the machine's main cam.

1.2.4 Capsule Filling Equipment

Segment Positioning - As the segment turret continues to rotate clockwise past the station 4 area, the lower segment (with the open capsule bottoms in it) gets moved under the processing station 5. Station 5 is the powder dosing station that places the powder into the open capsule bottoms. Figure 15 shows the location of the capsule-filling equipment components above station 5.

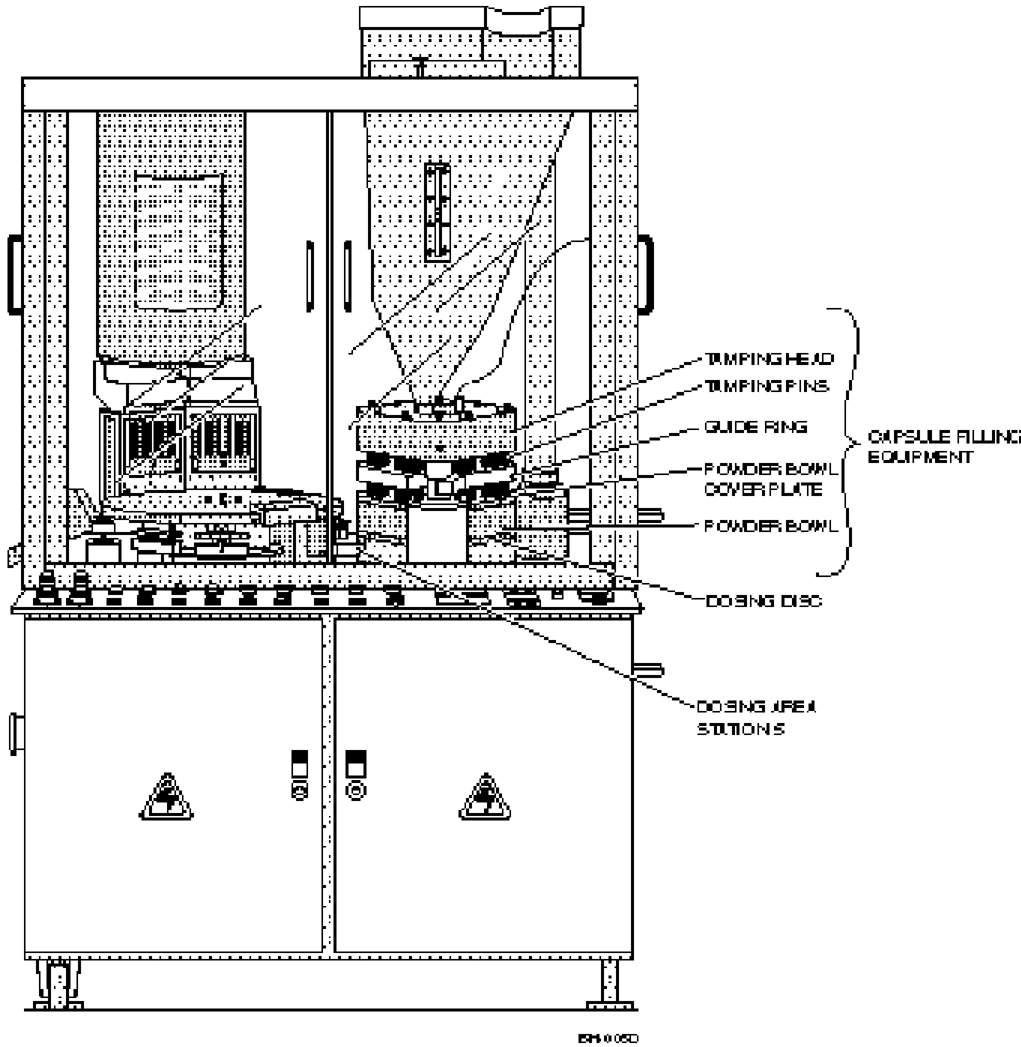

Figure 15. Location of Capsule-Filling Equipment

Tamping and Dosing Station - The tamping and dosing equipment above the station 5 area prepares and places a specific amount or dose of product into the empty capsules carried by the lower segment positioned in the station. The dose is actually a small pellet-shaped slug of product (powder) shaped by the tamping pins and dosing disc. The disc is located at the bottom of the powder bowl shown in Figure 15, and the tamping pins are just above the powder bowl. Figure 15A shows the tamping and dosing actions occurring inside the powder bowl.

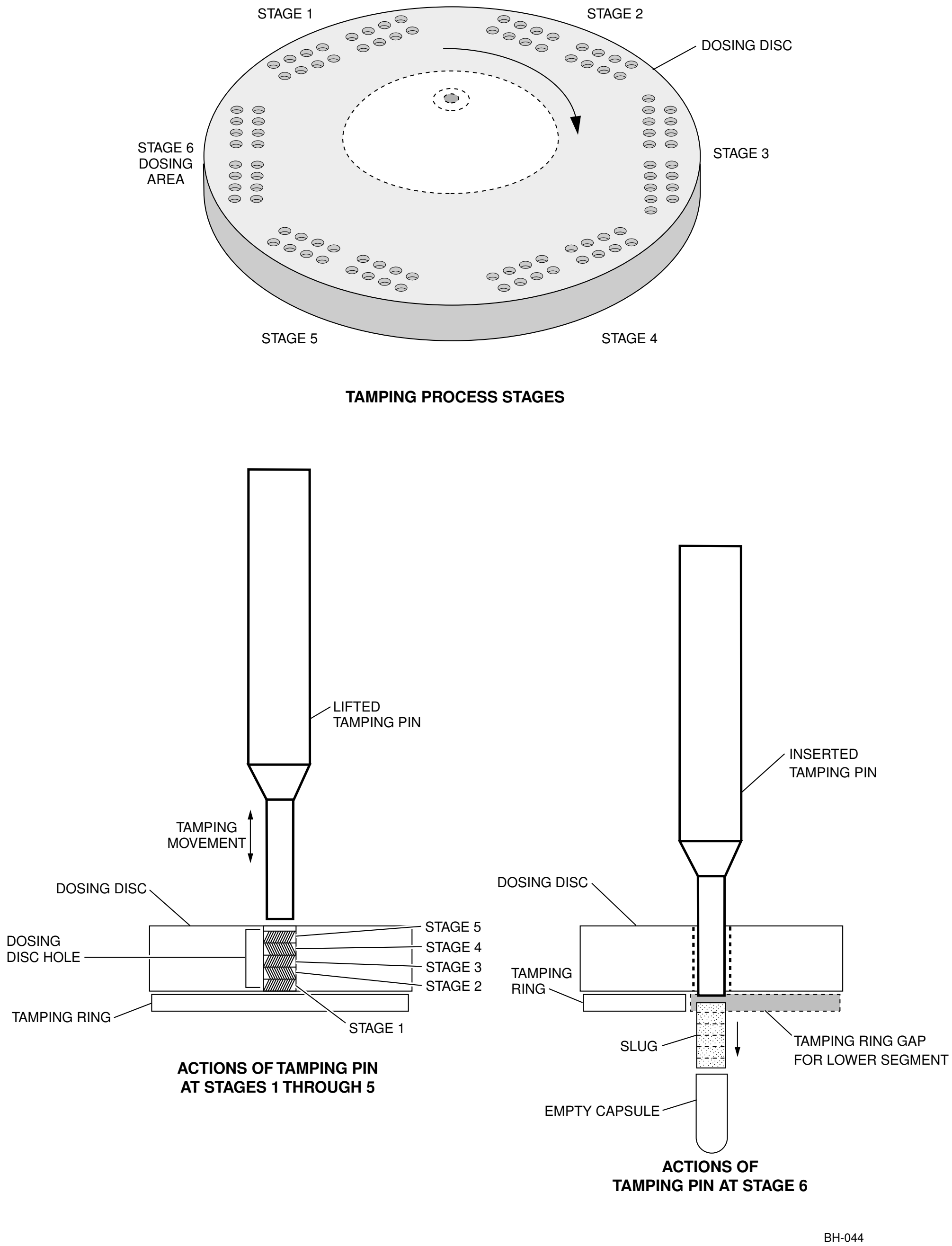

Figure 15A. Tamping and Dosing Actions Inside of the Powder Bowl

Dose Forming - The powder dropping into the powder bowl from the powder hopper hits the cone in the middle of the dosing disc and gets spread across the top surface of the dosing disc (inside the powder bowl). The disc has six sets of holes in it (16 holes per set). When powder is spread over the disc, the powder falls into and over the holes. A device, called a tamping ring, below the dosing-disc holes keeps the powder from escaping until they get moved into the dosing area. As the disc rotates, the powder over the hole tops is pushed down into the holes by tamping pins that are repeatedly lifted and lowered vertically into the holes. The tamping pins pack the powder five times into a set of holes before the disc moves the holes into the dosing area. The result of this tamping action is the creation of a slug of powder.

Dosing of Capsules - After the dosing disc moves a set of holes into the area above the empty capsules already positioned in the dosing station, the holes of the dosing disc will be aligned directly over the segment holes and empty capsules in the station. The tamping ring below the dosing disc has a gap in it at this point and the bottoms of the dosing disc holes are uncovered. On the next downward stroke of the tamping head and pins, the pins push the powder slugs out the bottom of the dosing disc holes and into the capsule bottoms below. As soon as the powder is loaded into the capsule bottoms, the tamping pins are withdrawn vertically to get them out of the dosing disc and away from the capsules and segments.

Segment Repositioning - When the tamping pins are clear, the segment turret rotates again clockwise moving the segment with the filled capsule bottoms out of station 5 to station 6. Station 6 has no process function.

Main Cam Association - The rotational movements of the dosing cam, and the vertical movements of the tamping head and pins, are all driven by devices attached to the main cam. The dosing disc must be timed to have the holes loaded with slugs arrive in the dosing area of station 5 just after the segment turret positions the segment with the empty capsules there. The tamping pins must extend down into the dosing disc holes just after the dosing disc stops in the station.

As soon as the tamping pins have reached their fullest insertion into the dosing disc and have been fully withdrawn, the main cam will shift the segment turret one more position clockwise. The shifting segment turret gets the segment with the filled capsules out of the station, and the next segment (with empty capsules) into the station for the next round of capsule filling.

Just after the segment turret moves the filled capsules out of the station 5 area, the dosing disc begins rotating to move the empty holes out of the station so that they can be refilled. As the dosing disc rotates one position clockwise, another set of filled dosing disc holes will be moving into the station so that the filling cycle can start over. The dosing disc makes two full rotations to the segment turret's one full rotation.

1.2.5 Capsule Ejecting, Closing, and Cleaning Equipment

There are two process stations around the segment turret where capsules are ejected from the segments. Between the first ejection station and the second ejection station are stations that realign and close the capsule tops to their respective bottoms. After the final capsules are ejected, the segments pass through a cleaning station. Figure 16 shows the location of the two ejection stations, the closing station, and the cleaning station around the segment turret.

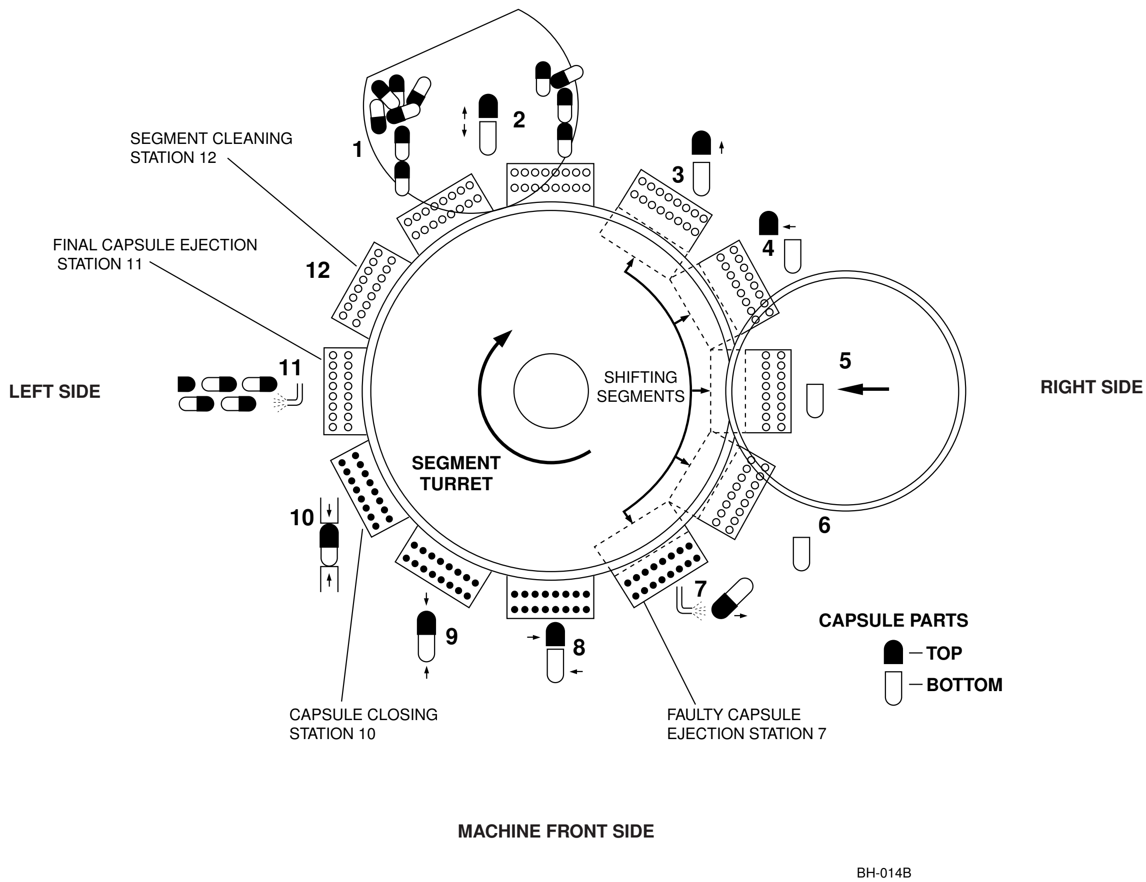

Figure 16. Locations of Ejection, Closing, and Cleaning Stations

Faulty Capsule Ejection - After the capsule bottoms are filled at station 5, the segment turret rotates further clockwise past the area of station 6 and moves the segments into station 7. Station 7 is the faulty capsule ejection station. The function of this station is to get rid of any capsule whose bottom half did not separate from the top half earlier at process stations 1 and 2. This process ensures that no empty capsules get ejected with the finished products. If a capsule bottom is still attached to its top at this point, the bottom half can be seen hanging down below the upper segment.

After the segment turret stops the segments at station 7, devices connected to the main cam cause plunger pins within the station 7 area to momentarily extend up into the holes of the upper segment. If the upper segment contains only capsule tops, the plunger pins do not touch the capsule tops. If a capsule bottom is still attached to its top, the rising plunger pins will push against the bottom half of the empty (faulty) capsule and force the whole capsule out the top of the upper segment. Compressed air blowing across the top of the upper segment blows the faulty capsules into a collection container located over the station and toward the front of the machine. After the faulty capsules have been ejected, the segment turret rotates further clockwise to carry the segments into station 8.

Capsule Realignment - As the segment turret starts to move the segments out of station 7, devices inside the segment turret start to push the upper segment back out (horizontally) away from the segment turret's center to align the upper segment over the lower segment. By the time the turret has rotated the segments into station 8, the upper segment should be again aligned over the lower segment. This action also realigns the capsule tops over their respective bottom halves carried by the lower segment. At station 9, the segments are brought closer to each other (vertically) so that the capsule bottoms can be reconnected with the capsule tops.

Capsule Closing - As the segment turret rotates further, it carries the segments into the capsule closing area of station 10. Inside of station 10, devices connected to the main cam cause closing components within the station to momentarily place enough pressure onto the top and bottom ends of the capsules to force the two sections back together. The bottom of the capsule is pushed up into the top half of the capsule. Locking groves in the capsule halves hold the two halves together after the pressure from the closing components is removed. As soon as the closing components have retracted, the segment turret rotates further clockwise to move the segments and capsules into the station 11 where the finished (filled) capsules are ejected from the machine.

Final Capsule Ejection - Station 11 has ejection plunger pins (driven from the main cam) that push the finished capsules up and out of the segments. Compressed air blows from the inside area of the segment turret area toward the ejection chute on the left side of the machine. The flow of air toward the ejection chute carries the filled capsules away from the segments and out of the machine.

Segment Cleaning - After the finished capsules have been ejected from the segments, the segment turret rotates one more time to move the empty segments into station 12 for an intense cleaning. Station 12 has jets of compressed air to loosen any powder remaining on the empty segments. The air jets are positioned in such a manner that they create a swirling affect inside the holes of the segments. The swirling air cleans the holes and the segment itself better than direct shots of air. A dust-collecting line is attached to the side of the metal housing covering the cleaning station. The housing funnels the collected dust and debris into a vacuum hose connected to a dust collector positioned away from the machine.

Process Repeat - After the segments have been cleaned, the main cam devices make the segment turret move clockwise one more time to place the vertically-aligned upper and lower segments into station 1 again to start another process cycle.

MAIN CAMSHAFT, AND RELATED DRIVES

The main camshaft (main cam) of the Index Capsule Filler is the heart of all process movements within the machine. The center shaft of the main cam is supported at each end by yokes attached to the bottom of the base plate. Bearings inside the yokes allow the shaft to rotate freely. All of the bearing housings, except the outside bearing on the left side of the machine, are equipped with grease fittings so that the bearings can be lubricated on a regular basis.

This section is divided into the following areas:

- Main cam attachments
- Segment turret drive devices
- Dosing disc drive devices
- Sorting equipment, cam, and associated devices
- Capsule-separating equipment, cam, and associated devices
- Tamping equipment, cam, and associated devices
- Faulty-capsule ejection equipment, cam, and associated devices
- Capsule-closing equipment, cams, and associated devices
- Final capsule-ejection equipment, cam, and associated devices

1.3 MAIN CAM ATTACHMENTS

Devices directly attached to the main cam itself include the following:

- Input sprocket (1)
- Beveled gears (2 sets)
- Two-piece cams (7)

All of the process stations within the machine are driven from the beveled gears and cams connected to the center shaft of the machine's main cam. Figure 17 shows the locations of the input sprocket, the beveled gears, and the various cams on the main cam.

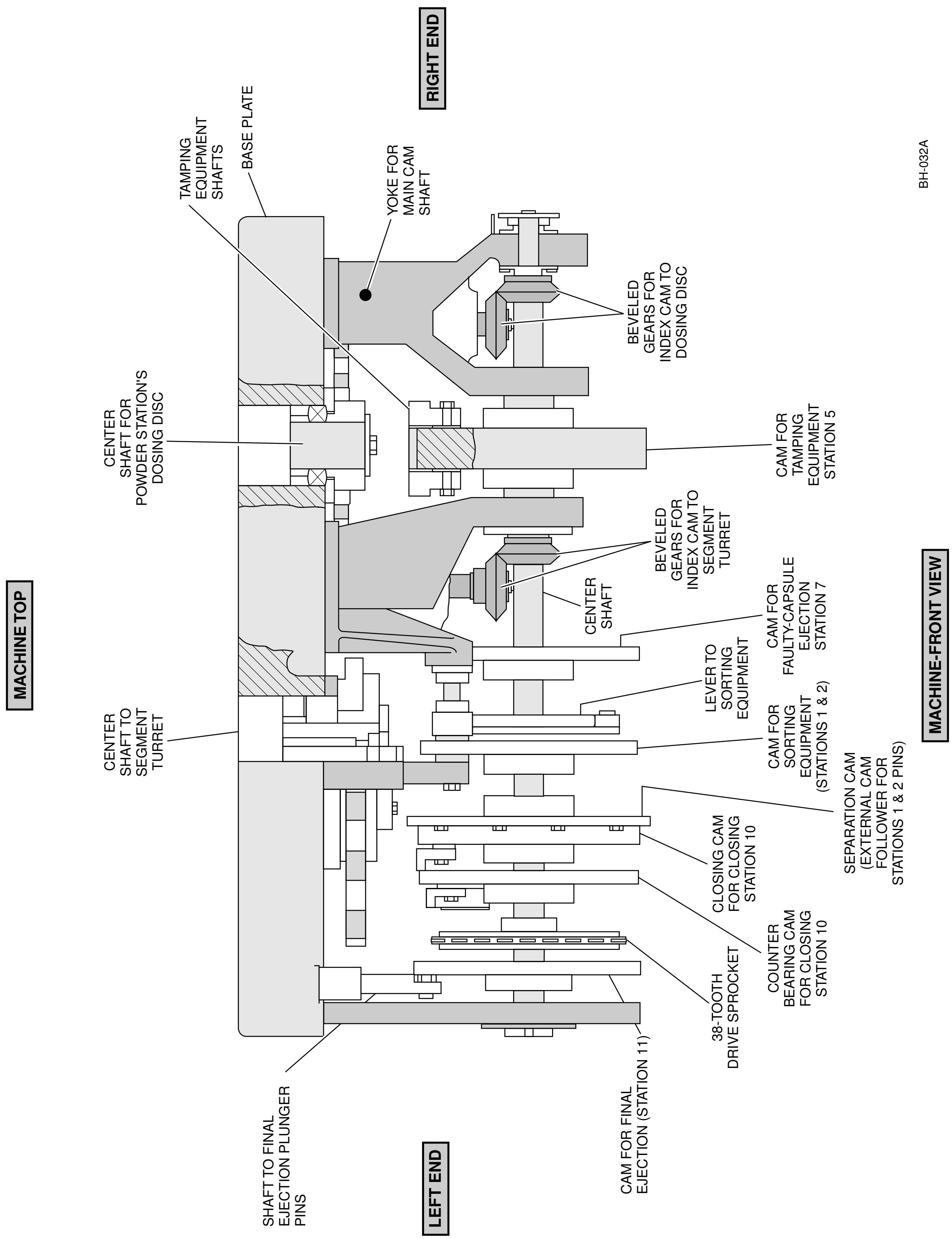

Figure 17. Locations of Main Cam Input Sprocket, Beveled Gears, And Cams

1.3.1 <u>Input Sprocket</u>

The input drive sprocket located near the left end of the main cam (as seen from the front of the machine) is the device used to turn the main cam's center shaft. The sprocket is a one-piece component locked onto the main cam's center shaft by both a key and a setscrew. The linked drive chain from the machine's gearbox to this sprocket makes the main cam rotate. The teeth on the motor's drive sprocket and this input sprocket must be kept in good condition. They must not be worn excessively, chipped, or broken. The links of the chain must also be kept in good condition and must be lubricated. The drive chain to the input sprocket must be without slack, but at the same time not too tight.

1.3.2 <u>Beveled Gears</u>

The INDEX Capsule Filler has two sets of beveled gears connected to its main cam center shaft. One set of gears drives the segment turret, and the second set of gears drives the machine's dosing disc.

Beveled Gear Positions - Beveled gears are specialized components used to transfer rotational drive power between shafts positioned at different angles. On this machine, the angular difference between the center shaft of the main cam and the shaft of the two driven units is 90 degrees. The main cam's center shaft is mounted horizontally beneath the front of the base plate. The shafts driving the segment turret and the dosing disc are also mounted below the base plate, but are positioned vertically above the main cam. Beveled gears are attached to the bottom of each shaft. The two gear sets can be seen toward the right end of the main cam shown earlier in Figure 17.

Beveled Gear Teeth - The horizontal and vertical gears on each of the two gear sets have the same number of teeth. The gears are cut at 45-degree angles so that the gears are positioned perpendicular (90 degrees) to each other. The teeth of the gear on the horizontal shaft must easily mesh with the teeth of the gear on the vertical shaft. Figure 18 shows a close-up view of the 45-degree teeth used on the beveled gears associated with the machine's dosing disc.

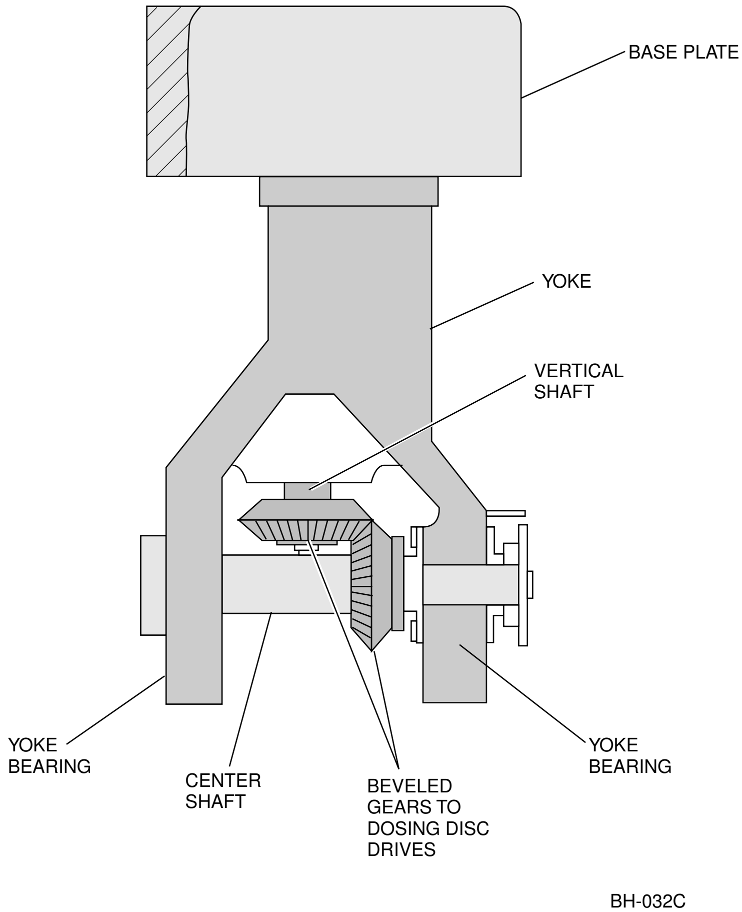

Figure 18. Close-Up of Beveled Gears

Power Transfer by Beveled Gears - When the center shaft of the main cam is turned, it rotates the beveled gears attached to it. The rotating center-shaft gears pull and push against the teeth of the gears mounted on the vertical shafts and thus makes the vertical shafts rotate. The result is that rotational power is transferred from the main cam's center shaft to the vertical shafts that drive the dosing disc and segment turret.

1.3.3 Cams and Attachments

The machine's main cam is actually a center shaft with several disc-like devices attached to it. In its present configuration, the main cam has seven cams that drive the various process stations on the machine. Figure 19 shows the cams on the main cam.

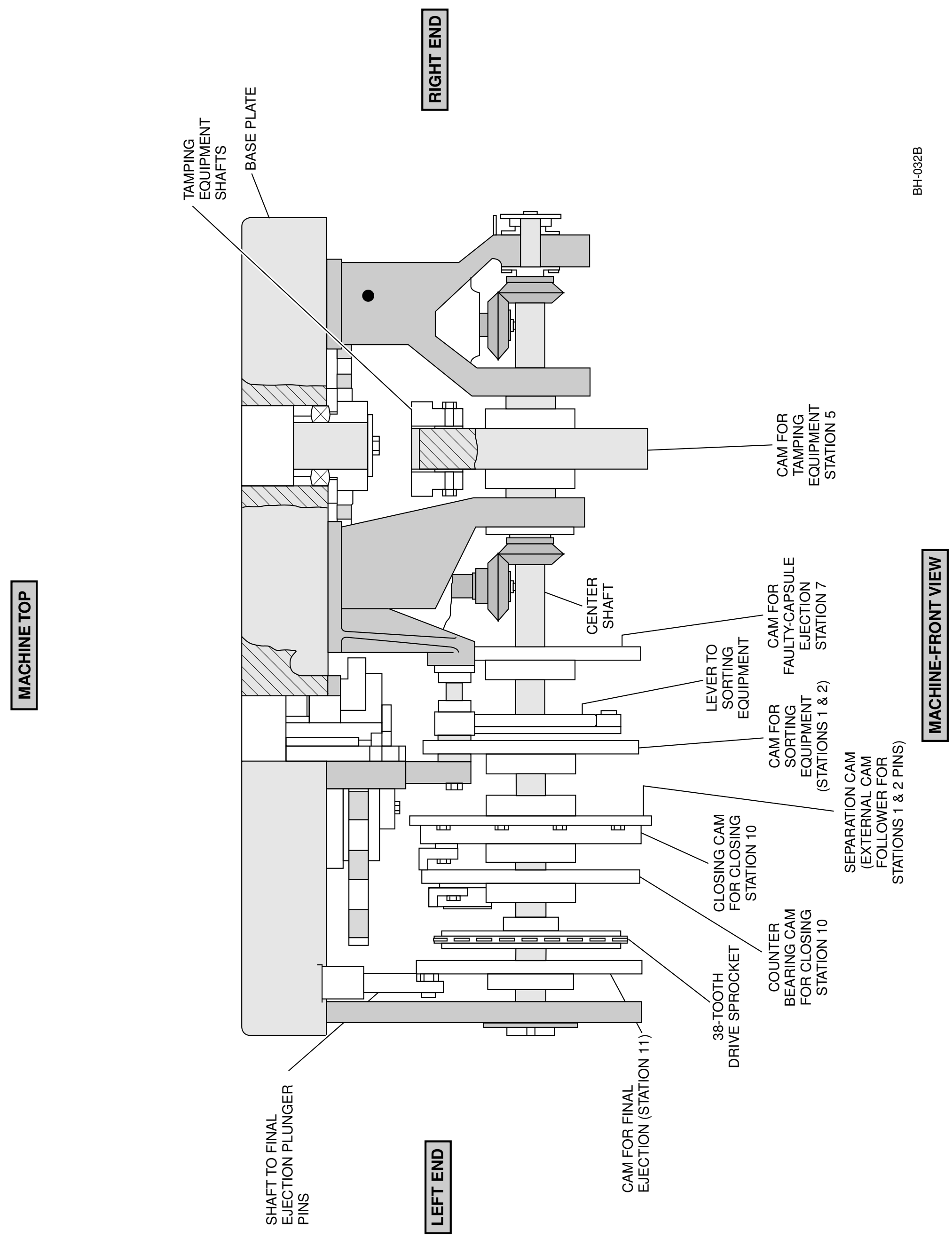

Figure 19. Cams on Main Cam

Starting at the left end of the cam, as seen from the front of the machine, the main cam includes the following cams:

- Cam for final ejection equipment at station 11
- Twin cams for closing station 10
- Cam (with an external cam follower) for separation pins at stations 1 and 2
- Cam for sorting equipment at stations 1 and 2
- Cam for faulty capsule ejection equipment at station 7
- Cam for tamping equipment at station 5

1.3.4 Cam Basics

Before anyone deals with the specific cams and cam followers used on the Index K120, they need to understand a few basic facts about cams, cam grooves, and cam-following devices.

Basic Cams - All of these cams are built as two-piece devices so that they can be removed and replaced without having to take the center shaft out of the yoke bearings, and without disturbing the timing of other devices still attached to the center shaft. Locking collars secure the cams to the shaft.

Cam Grooves - Most of the cams have a smooth surface on one side, and a surface area on the opposite side containing a ditch-like groove. This groove is circular in appearance, but is not a true circle. The grooved disc is often called a cam, but the oddly shaped groove in the cam is actually what creates the cam actions.

Cam Followers - A small roller, attached to a shaft or lever, is positioned to ride either along the outer edge of a cam, or inside the cam groove cut into the side of the cam. The rollers riding the outer surface of a cam are external cam followers, and those inside the grooves are internal cam followers. Figure 20 shows examples of cams and cam-following rollers.

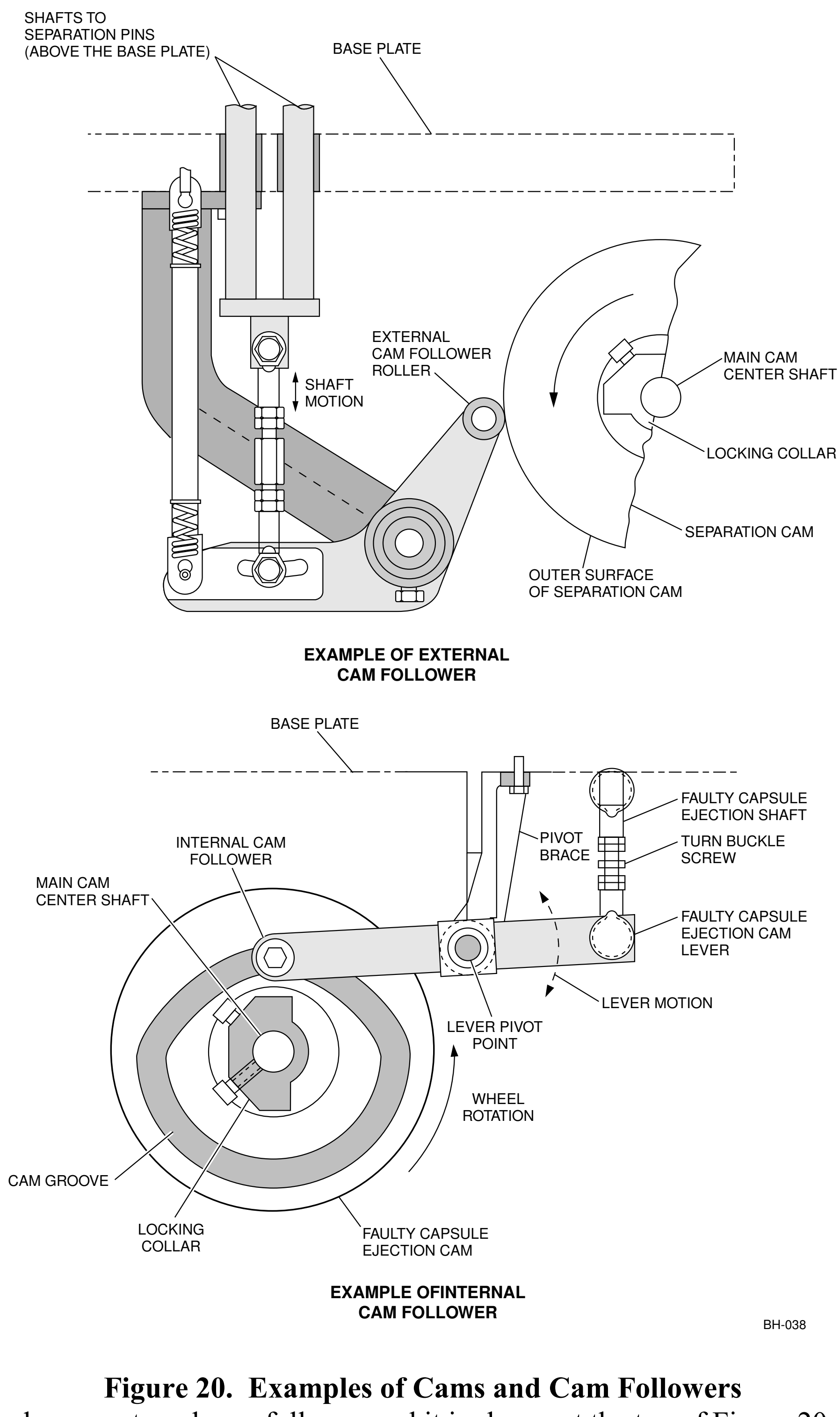

Figure 20. Examples of Cams and Cam Followers

The Index has only one external cam follower and it is shown at the top of Figure 20. This cam follower is used to drive the separation pins of process stations 1 and 2. The outside shape of the separation cam varies in distance from the center of the cam. As the roller follows the varying surface of the separation cam the arm attached to the roller causes the separation pins to lift and lower at selected times during the process.

All of the other cams used on this machine have a cam groove cut into their flat side so that the cam-following roller will fit down into the groove. As the cams are rotated, the roller on each cam follows the groove and makes the shaft or lever attached to it move up, down, forward, backward, or a combination of all these directions.

Wear and Tear - On the Index K120, these cam-following rollers and the devices attached to them are the components used to power most of the operational devices within the machine. Over time and use, the bearings inside these small rollers, and the rollers themselves, will wear out and start to affect the efficiency of the machine. The cam grooves themselves will also wear with use, but are less likely to wear as much as the cam-following rollers.

Cleaning and Lubrication - The cam-following rollers and cam grooves must be kept clean and lubricated to prevent excessive wear. Some of the rollers are fitted with grease fittings so that their bearings can be lubricated on a regular basis. Counting the bearings on the cam followers, and those bearings in the yokes supporting the center shaft of the main cam, there are ten grease fittings on the main cam assembly and the devices attached to it. Each component having a grease fitting needs to have a little grease visible, but not an excessive amount.

1.3.5 Movements and Adjustments for Cam Attachments

Movements - Many of the shafts or levers attached to the cam-following rollers move like a human elbow. As the center shaft of the main cam rotates the cams attached to it, the rotational movement makes the groove on each cam change location, coming closer to or farther away from the center shaft. As the cams are rotated, the rollers mounted on the ends of the elbow-like attachments follow the cams, and the result is that the shaft or lever attachments extend or retract like human arms and elbows. When these shafts or levers move, they in turn cause the process devices on their other ends to move. Figure 21 shows an example of such cam attachments, and their adjustment points.

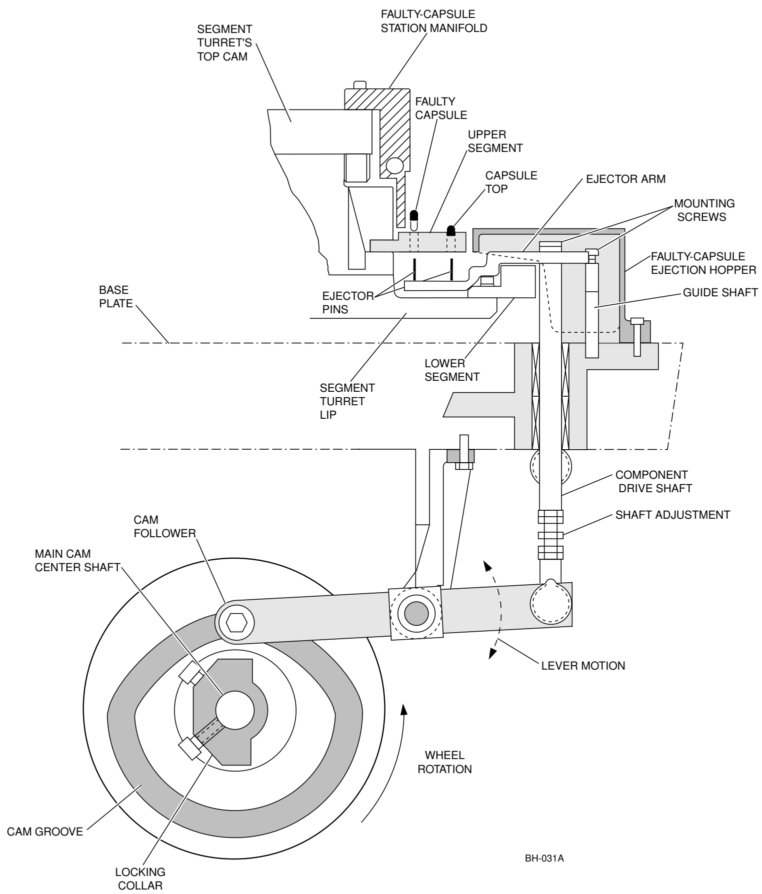

Figure 21. Examples of Cam Attachments and Adjustments

Stroke - The length or distance that a component moves from one extreme to the other is often called its stroke. Many of the components on this machine must move specific distances to accomplish their work. Some components such as ejector pins shown in Figure 21 must extend up into an opening such as the capsule tops held inside an upper segment. The pins must enter the capsule without touching the side walls, stop at the peak of their stroke without touching the capsule tops, and then back completely out of the capsule until the next set of segments arrive. The withdraw stroke must result in the pins being pulled completely out of the way before the segments holding the capsule ends are moved. If the stroke of the moving components (such as the pins) is too short, the components may not be doing their work correctly. If the stroke of the moving components is too long, they may enter into the work area too far and damage either themselves or the component into which they enter. Also, if the stroke is too long, the withdrawal process may not be quick enough to get the retracting component(s) out of the way before the component entered is moved.

Timing - Moving components must often be inserted into an area of the machine to do their work, and then must be retracted so that another component can get into the same area to do its work. The movements of these separate components must be synchronized so that the different components are not in the same work area at the same time. The coordination of one component's movements to the movements of another component is called timing.

Stroke and Timing Adjustments - On this machine, component stroke and timing is most critical. If the stroke is incorrect, the work will not be accomplished correctly, and the equipment or capsules may get damaged. If the timing is incorrect, the machine will both damage the machine components and make bad products. All timing and stroke adjustments need to be made by maintenance technicians, but operators need to be aware of these activities so that they can recognize when the machine is having a problem, and what the most likely cause of the problem may be.

Some of the attachment shafts and levers have adjustment screws (turnbuckles) built into them that allow the length of the shaft or lever to be changed. The mounting location of such shafts can also affect the stroke and timing of a process unit. Such adjustments may be needed to get the stroke of the moving components correctly set.

For the operational components driven from the main cam, the timing is primarily controlled by the associations between the cam-following rollers and their related cams. All of the cams can be loosened from the center shaft and moved around the shaft to adjust when a cam-following attachment starts or stops its movement.

> **CAUTION: To keep the cam followers from binding with the cams, care must be taken to ensure that the disc is not moved side to side on the shaft during timing adjustments. Such binding will cause excessive wear on the rollers and cam grooves, and may create enough strain on the cam-following attachments to cause them to break.**

Stroke and Timing Coordination - An additional issue to keep in mind is that the stroke of the moving components can affect the timing of the machinery. In some cases, the stroke and the timing may need to be changed slightly to reach a compromise condition that keeps the timing within acceptable limits, while at the same time having enough stroke to do the job.

1.4 SEGMENT TURRET DRIVE DEVICES

The segment turret, also called the large Geneva or star wheel, is located on top of the base plate and near the left front of the machine's operational area. The segment turret is the device that supports the components that carry the capsules as they are passed through the various processes. The operations of the segment turret components will be covered later in this manual. This section addresses only how the segment turret gets driven.

Within the Index, the segment turret is the one component to which all other process station devices must be aligned. All of the 12 process stations are arranged around this turret and all of the operating devices in the stations must be synchronized with the movements of the segment turret. Figure 22 shows the segment turret components as they appear out of the machine.

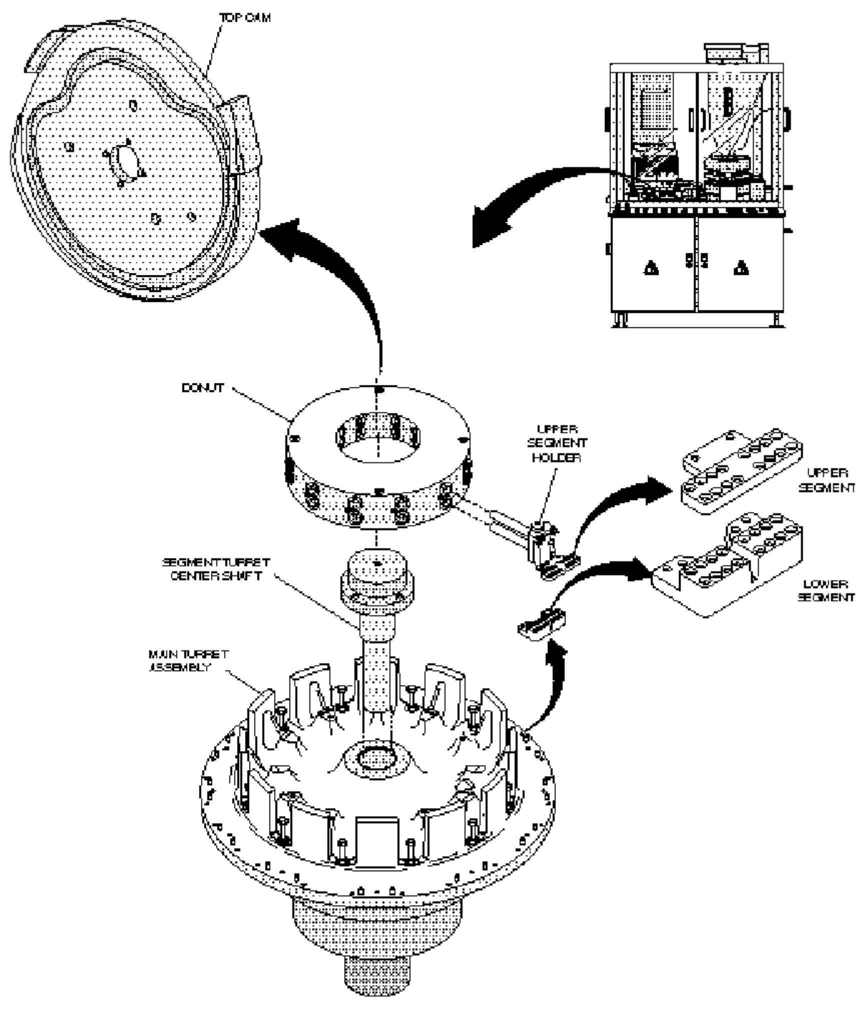

Figure 22. Segment Turret Components

1.4.1 Segment Turret Mounting

The segment turret has a shaft that extends down through a hole in the base plate when the segment turret is installed in the machine. Bearings inside the base-plate hole support the segment turret and allow the turret to freely rotate 360 degrees. The bottom end of the segment turret's center shaft is connected to a 12-point Maltese cross. Figure 23 shows a cut-away side view of the segment turret, base plate, bearings supporting the segment turret, Maltese cross, indexing cam and roller, and drive shaft from the center shaft.

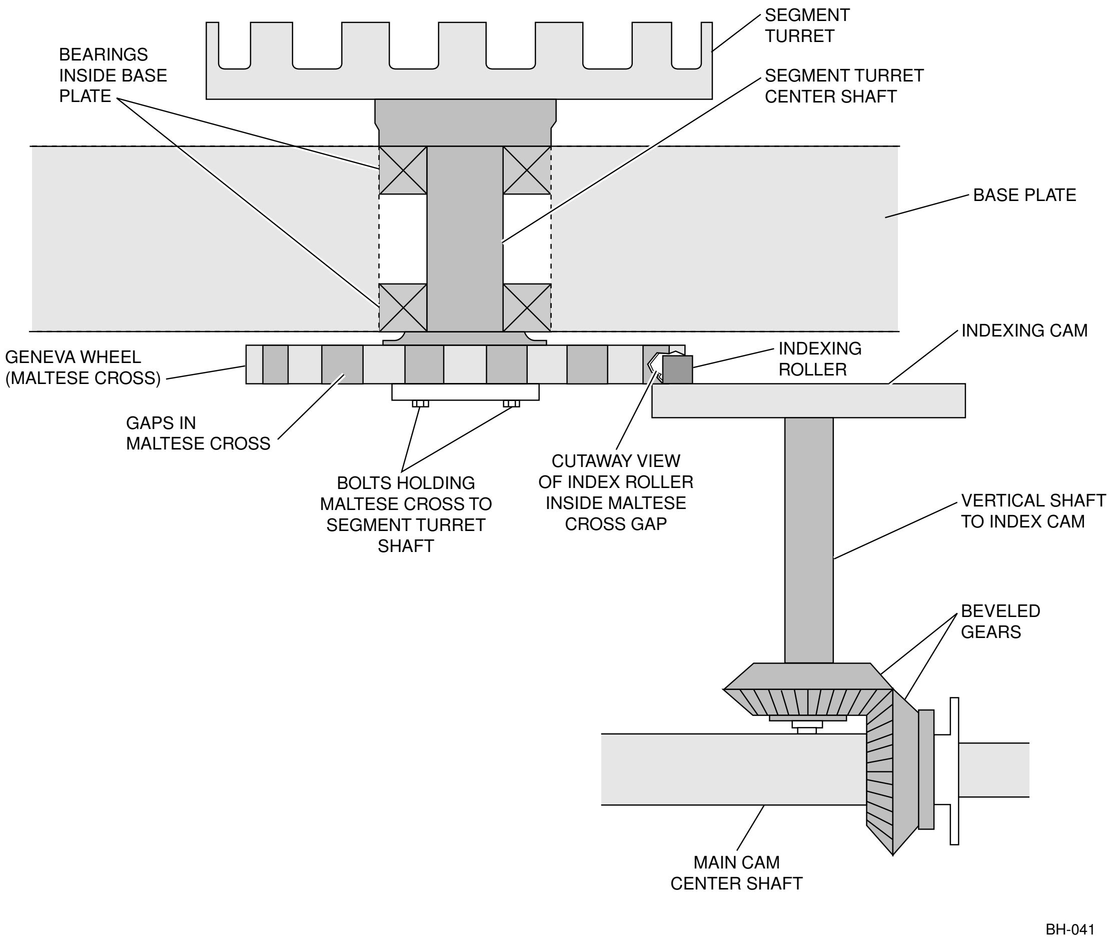

Figure 23. Side View of Segment Turret Drive Components

1.4.2 Segment Turret Drive Devices

Beneath the base plate, and above the main cam, are several devices that actually transfer and control the rotational power from the beveled gears on the main cam's center shaft to the turret itself. Those drive devices include a Maltese cross, an indexing cam, and its indexing roller.

Maltese Cross - The bottom end of the turret shaft is bolted to the center of a 12-pronged device called the "Maltese cross" or "Maltese wheel". The dosing disc also is equipped with a smaller Maltese cross.

The Maltese cross used with the segment turret is designed with the 12 prongs because of the 12 process-area gaps on the segment turret. During an operational cycle, the segment turret starts and stops 12 times at 12 different process stations surrounding the turret. These starts and stops are called indexing. The main cam must rotate 12 times to make the segment turret complete one full cycle. Figure 24 shows an overhead view of the Maltese crosses and indexing cams used for the segment turret and dosing disc.

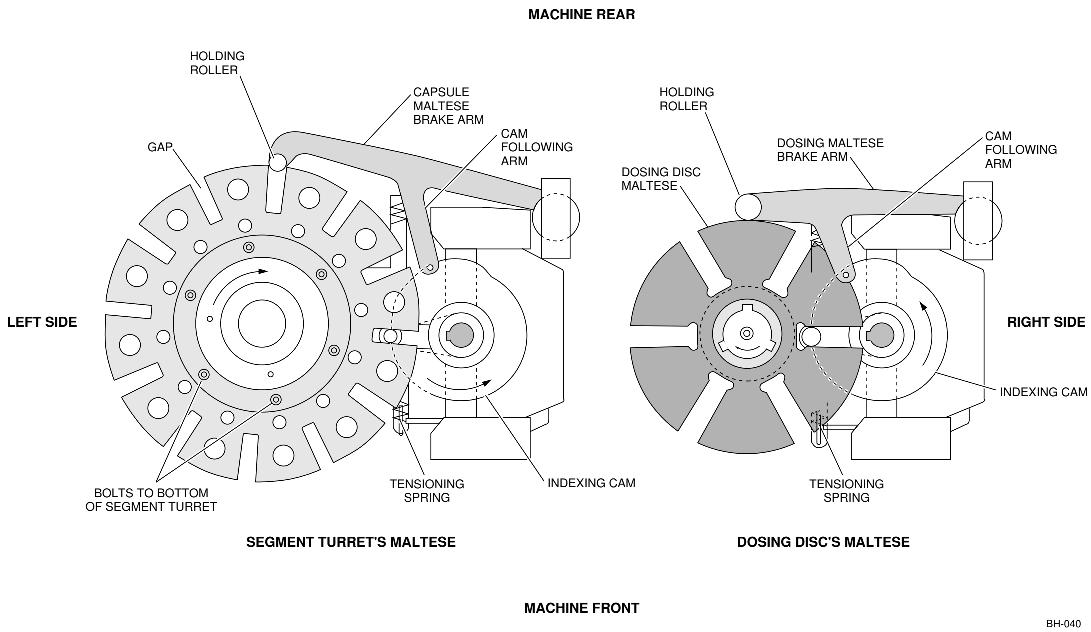

Figure 24. Overhead View of Maltese Crosses and Indexing Cams

The gaps in a Maltese cross work like the teeth of a sprocket. As with any sprocket, some type of device must be placed against the sprocket teeth to make the sprocket rotate. On chain-driven sprockets, the links of the chain are pulled against the sprocket teeth to make the sprocket rotate. On this machine, a roller similar to a cam-following roller is inserted into the gaps of the Maltese cross and pulled sideways to make the Maltese cross rotate. Of course when the Maltese cross rotates, it makes the component attached to it rotate. In this case, the segment turret will rotate when its Maltese cross is moved. The roller pushing and pulling against the Maltese cross gaps is attached to a device called an indexing cam. The roller is called an indexing roller.

Capsule Indexing Cam - Located a few inches to the right of the segment turret's Maltese cross is a smaller, cam-shaped disc positioned a little farther away from the bottom of the base plate than is the Maltese cross. This smaller disc is called the indexing cam for the segment turret. It is also called the capsule indexing cam because the segment turret deals with the capsules.
At the center of the indexing cam is the top end of the vertical shaft, which is connected through the beveled gears to the main cam's center shaft. When the center shaft is rotated, it transmits that rotational power through the beveled gears and into this vertical shaft. When the vertical shaft rotates, it also rotates the indexing cam. Figure 25 shows a side view of the segment turret, its Maltese cross, and its indexing cam.

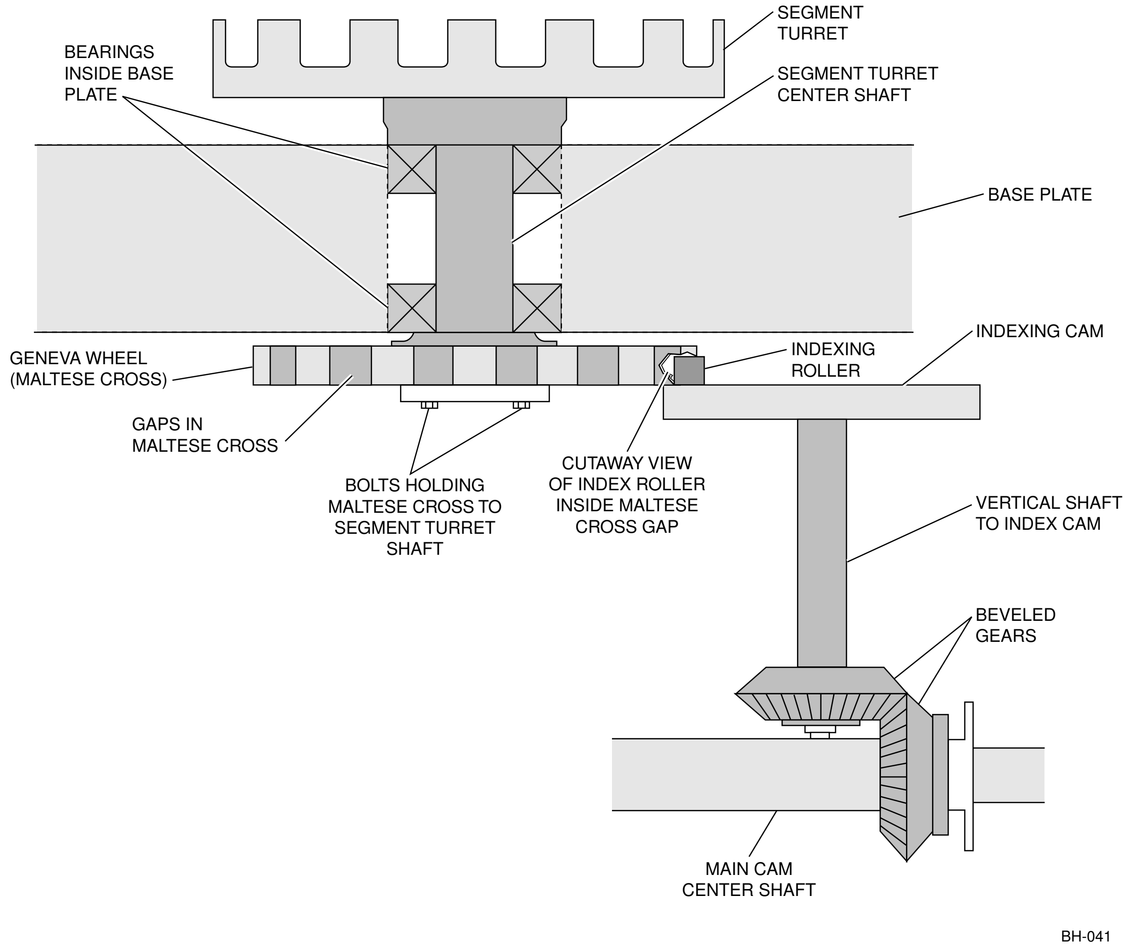

Figure 25. Side View of Segment Turret, Maltese Cross, and Capsule Index Cam

Near the outer edge of the capsule indexing cam is a roller similar to other cam-following rollers used on the machine's cams. On each complete rotation of the indexing cam, this roller is momentarily positioned into one of the gaps on the Maltese cross. As the indexing cam continues to rotate, it causes the roller to pull against the wall of the Maltese gap. The resulting pull (or push) causes the Maltese cross to rotate or index forward one position or station. The indexing cam must complete 12 full rotations for one by the segment turret.

Since the Maltese cross is attached to the bottom of the segment turret's shaft, the Maltese cross also causes the segment turret to move forward. As the Maltese cross rotates, the indexing roller comes closer and closer to the outer edge of the Maltese gap. As soon as the indexing roller exits the gap, the Maltese cross stops rotating, but the indexing cam continues rotating to bring the roller around for another encounter with the gaps of the Maltese cross.

Maltese Cross Brake - Positioned across the backside of the Maltese cross and the indexing cam is a device called a brake-arm assembly. This assembly is designed to place a holding roller into one of the Maltese cross gaps whenever the cross (and the segment turret) is not being rotated. This brake ensures that the segment turret does not move during a stop at one of the process stations. Figure 26 shows an overhead view of the Maltese cross and the location of its brake arm.

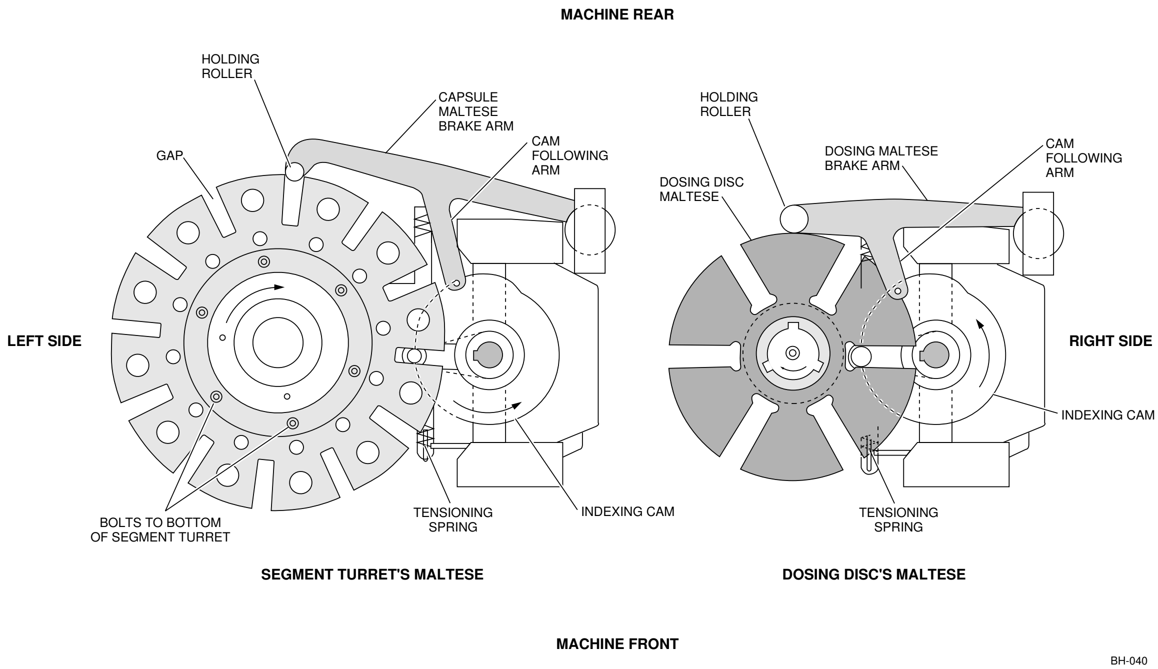

Figure 26. Overhead View of Maltese Cross and Location of Brake Arm

On the side of the brake arm closest to the Maltese cross is an extension that works like a cam follower and rides the outer edge of the indexing cam. Since the outer edge of the indexing cam varies in distance from the indexing cam's center, the cam follower makes the brake arm move in and out as it follows the irregular surface of the indexing cam. The result of these cam actions causes the brake arm (and its roller) to move away from the Maltese cross just as the indexing cam's roller is entering the next gap on the Maltese cross. A tension spring keeps pressure on the arm. After the indexing cam's roller has pulled the Maltese cross forward and starts exiting the Maltese cross's gap, the brake arm's cam follower start bringing the brake's roller back in toward one of the gaps on the opposite side of the Maltese cross. As the indexing roller finally exits the gap of the Maltese cross, the roller of the brake arm enters the opposite gap on the Maltese cross. The result is that the cross (and the segment turret) stays locked down during the process activities going on in the station.

Vertical Shaft and Beveled Gears - The vertical shaft connected to the center of the indexing cam extends down below the cam toward the main cam's center shaft. At the bottom end of the shaft is the beveled gear that meshes with the beveled gear of the main cam's center shaft. When the center shaft rotates, it causes these gears to turn the vertical shaft, and the indexing cam connected to it. Figure 27 shows a close-up view of the beveled gears used to power the segment turret.

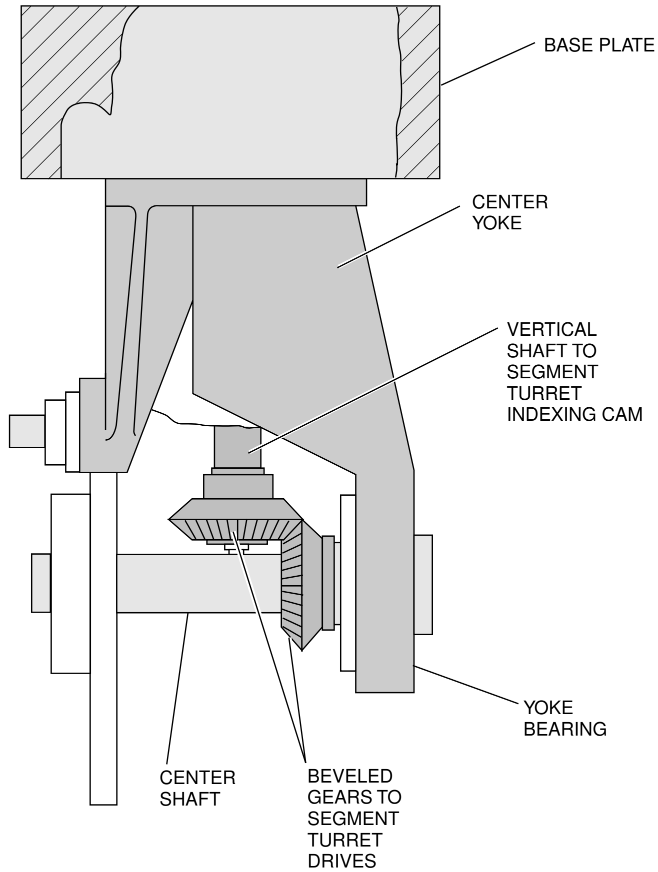

Figure 27. Segment Turret Beveled Gears

1.5 DOSING DISC DRIVE DEVICES

The equipment used to fill or dose the empty capsules with powder is located near the right side of the machine's operational area. The powder is supplied from the powder hopper mounted above the filling equipment. Figure 28 shows the location of the powder supply and capsule-filling areas.

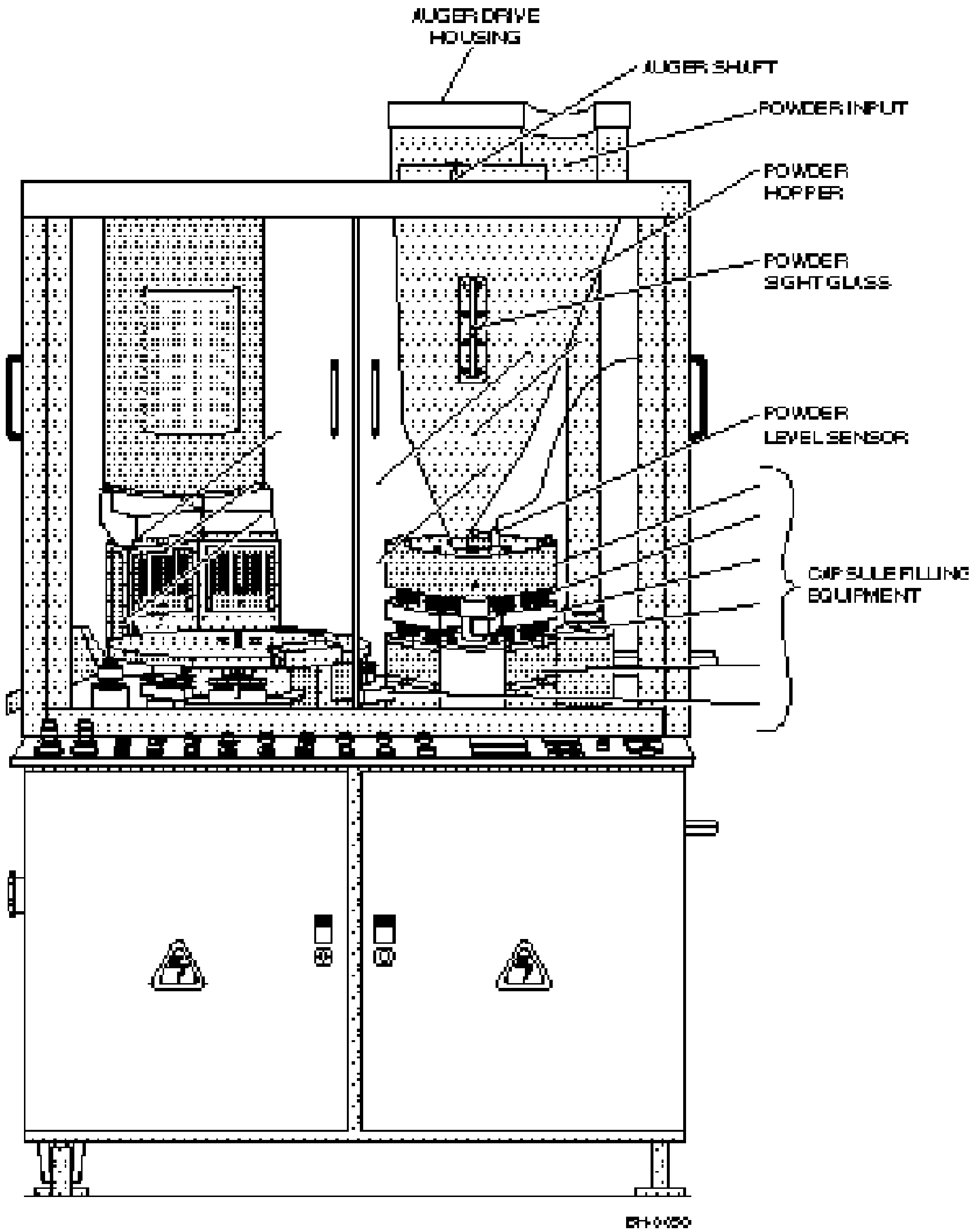

Figure 28. Location of Powder Supply and Capsule-Filling Areas

Within the capsule-filling area is a collection of devices that prepare and load the powder into the empty capsules. The capsule-filling equipment is separated into two groups: tamping equipment and dosing equipment. Of all the powder supplying and capsule-filling equipment, only the tamping and dosing equipment is powered from the main cam's center shaft. The dosing disc in particular is driven from gears connected to the main cam's center shaft. Figure 29 shows a close-up view of the beveled gears used to power the machine's dosing disc.

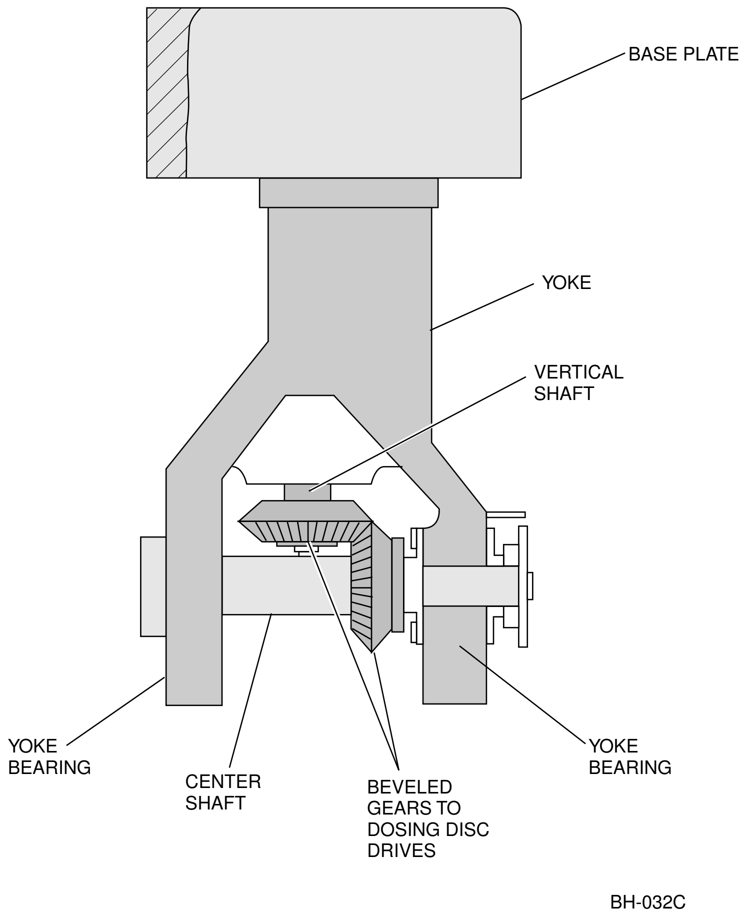

Figure 29. Dosing Disc Beveled Gears

1.5.1 Powder Supply Equipment

The equipment supplying powder to the capsule-filling area will be discussed in more detail later in this manual, but must be addressed here because it is associated with the tamping and dosing equipment.

Powder from the machine's powder hopper is fed down into the filling area's powder bowl where the powder is spread out over the top of the dosing disc located in the bottom of the bowl. The incoming powder lands on top of a cone that spreads the powder evenly across the dosing disc. During normal operations, this dosing disc rotates, which helps spread the powder out toward the outer edges of the disc. Figure 30 shows the cone and dosing disc inside the powder bowl.

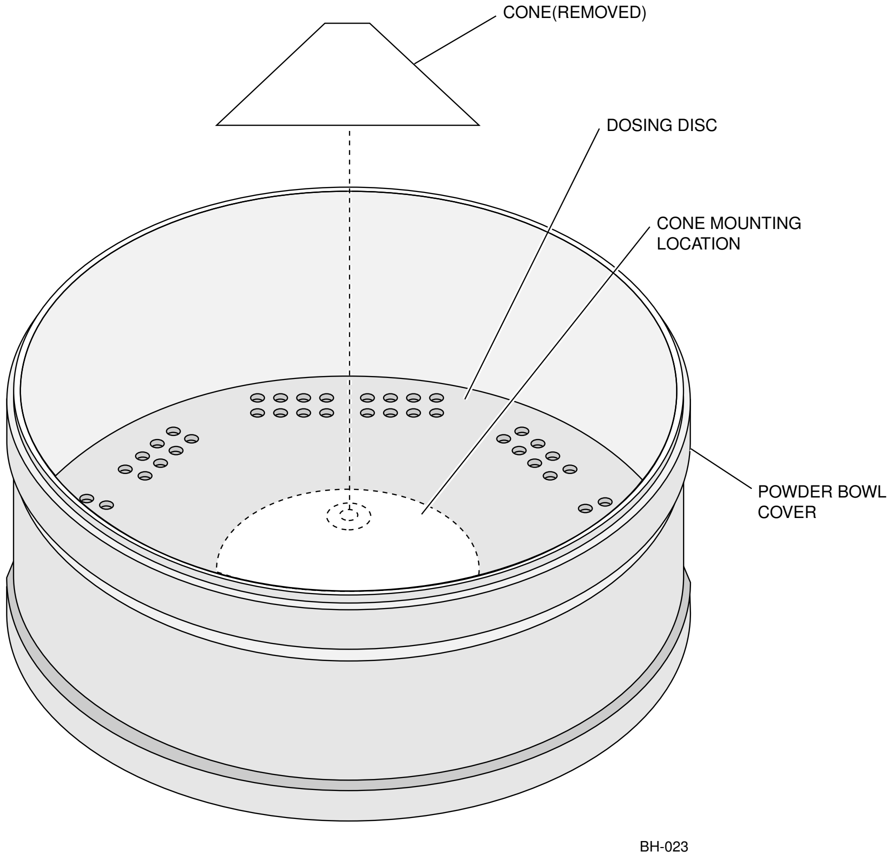

Figure 30. Powder Bowl Cone and Dosing Disc

The tamping and dosing area operations will be discussed in more detail later in this text. This section of text addresses how the rotational power gets transmitted from the main cam's center shaft to the dosing disc. Figure 31 shows an exploded view of the tamping and dosing area components.

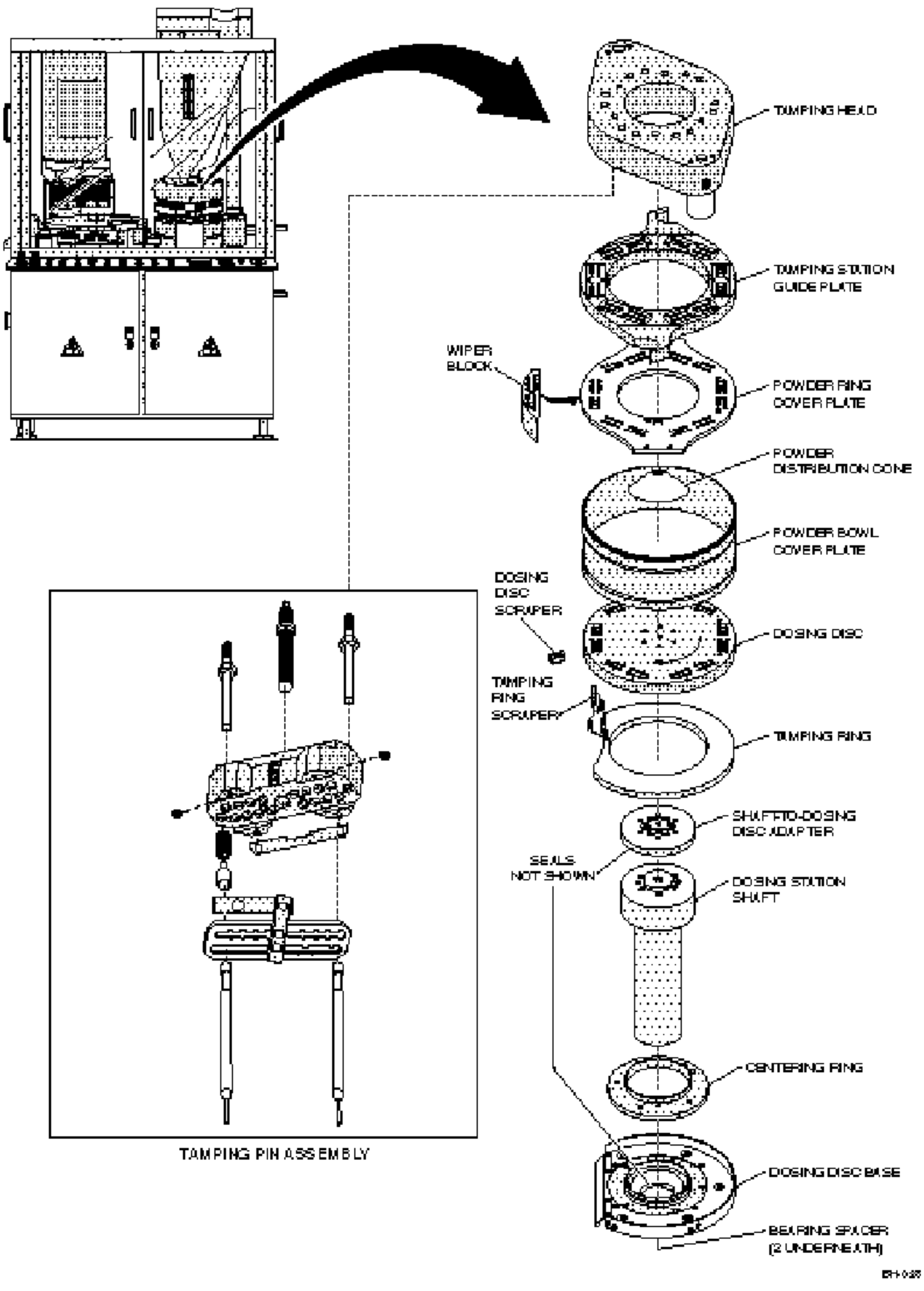

Figure 31. Tamping and Dosing Area Components

1.5.2 Dosing Disc Mounting

The dosing disc is the heart of the tamping and dosing process area. The dosing area equipment is located near the right side of the machine's base plate.

Dosing Disc Base - At the bottom of the tamping and dosing equipment is the dosing disc base that surrounds a vertical hole through the machine's base plate. All of the dosing area components are assembled on top of this base. Figure 32 shows the dosing disc base.

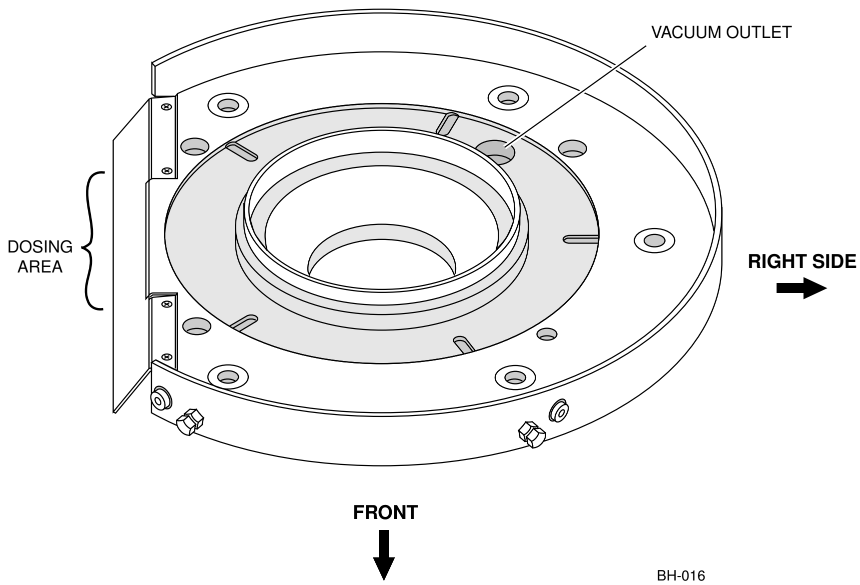

Figure 32. Dosing Disc Base

When seen from the front of the machine, the dosing disc base is positioned in the machine just as it appears in Figure 32. The non-circular part of the base on the left is where the segments with empty capsules are positioned to receive the powder doses. The base-plate hole is necessary because it is through this hole that the drive shaft from the main cam's center shaft to the dosing disc is mounted.

Centering Ring - Near the center of the dosing disc base is a centering ring that also surrounds the base-plate hole. The centering ring is secured to the center of the disc base and is used to keep the tamping ring in place. Figure 33 shows the dosing equipment center ring.

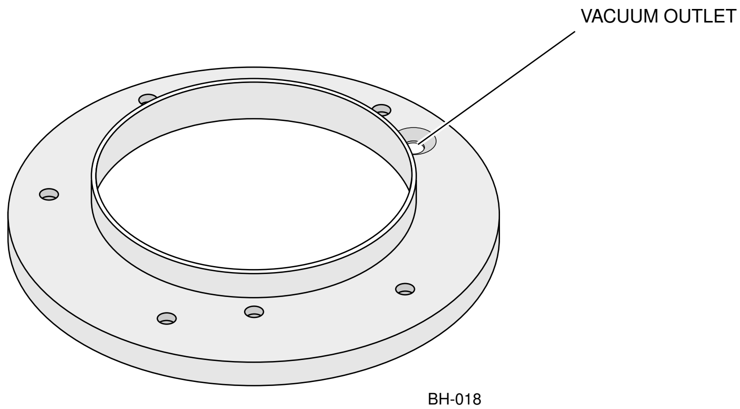

Figure 33. Dosing Equipment Center Ring

Dosing Station Shaft - A stainless steel shaft is installed down through the base-plate hole in the center of the dosing disc base. The shaft sits on top of bearings located near the top of the hole. Another set of bearing at the bottom of the hole keeps the shaft vertically aligned and allows it to rotate freely. Figure 34 shows a cutaway view of the dosing station shaft, adapter plate, dosing disc, and small Maltese cross.

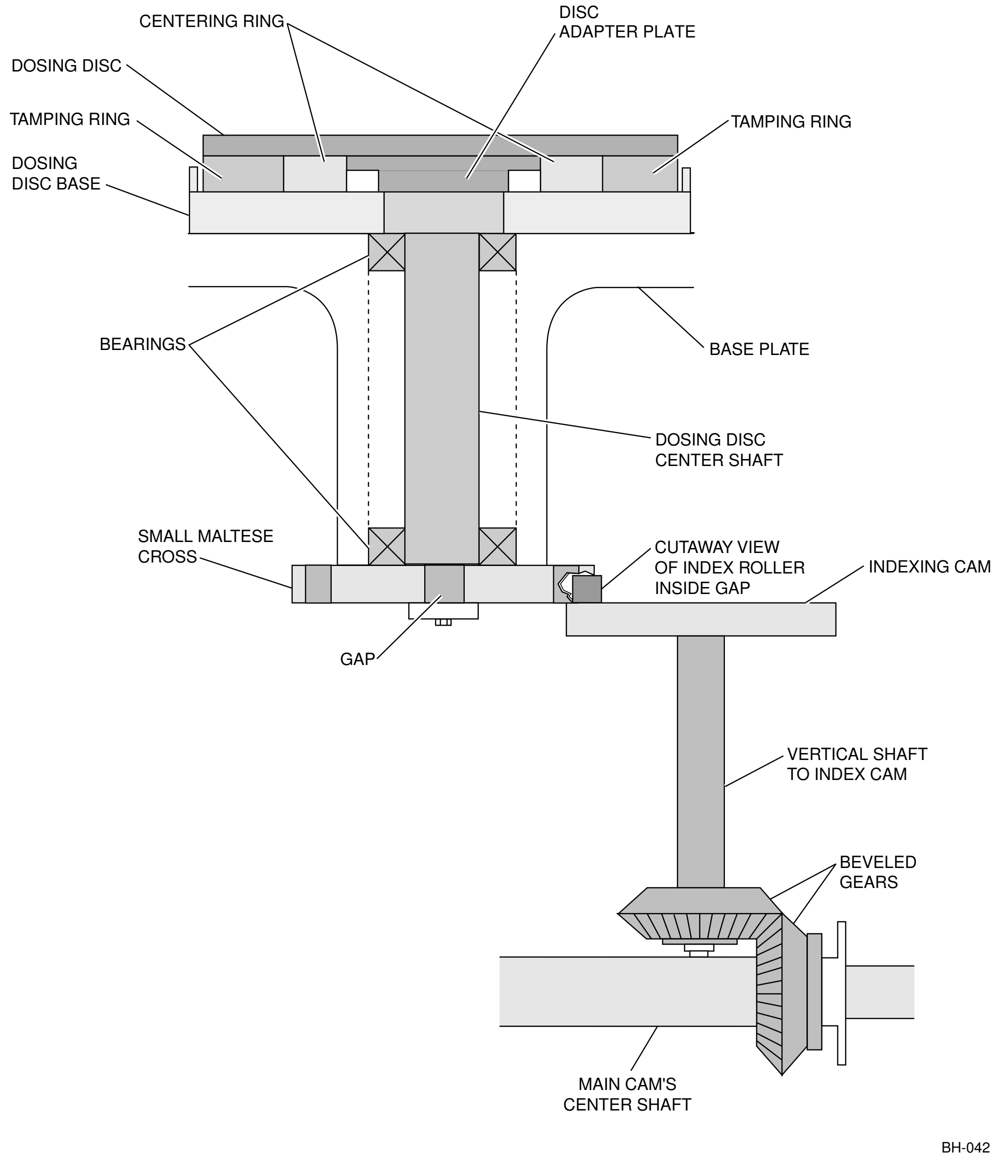

Figure 34. Cutaway View of Dosing Station Shaft, Adapter, Disc, and Maltese Cross

Adapter Plate - On top of the shaft is an adapter plate that allows the dosing disc to be mounted to the top end of the shaft. A rubber seal around the adapter plate will help keep powder from getting down into the bearings supporting the shaft.

Maltese Cross Connection - The bottom end of the dosing-station shaft extends out the bottom side of the base plate where a small six-point Maltese cross is securely fastened to the shaft's bottom end. This small Maltese cross is the device that will be used to turn the shaft and the dosing disc. The dosing disc makes two complete rotations to each full rotation by the segment turret. Figure 35 shows an overhead view of the Maltese crosses and indexing cams used for the segment turret and dosing disc.

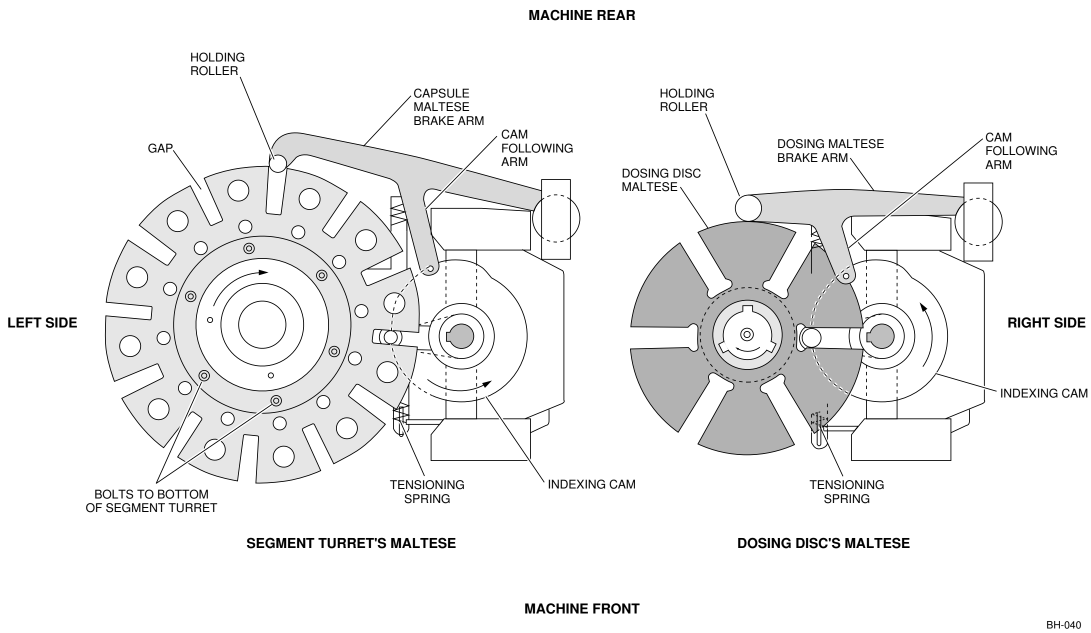

Figure 35. Overhead View of Maltese Crosses and Indexing Cams

Tamping Ring - Surrounding the shaft and sitting on top of the dosing disc base is a device called the tamping ring. The ring is made from either brass, Ertalyte TX or Delrin. Delrin and Ertalyte are special types of plastics that improve the production of tough to run products. Figure 36 shows the dosing area tamping ring.

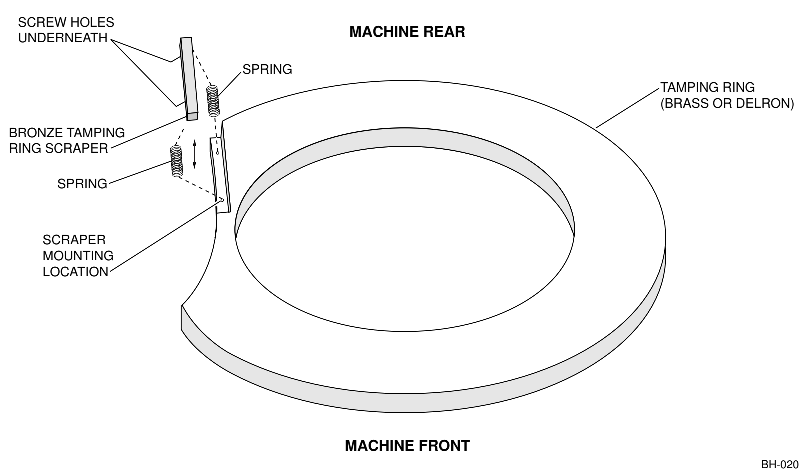

Figure 36. Dosing Area Tamping Ring

When seen from the front of the machine, the tamping ring is positioned in the machine just as it appears in Figure 36. The tamping ring provides a bottom to the holes of the dosing disc that is mounted on top of the tamping ring. (The dosing disc will be discussed next.) The ring is circular in shape except for the curved gap on its left side, which is where the segments position the empty capsules to receive the powder plugs.

Located toward the left side of the tamping ring, near the rear end of the curved gap, is a small bronze tamping-ring scrapper. The same type of scrapper is used on both brass and Delrin tamping rings. The scrapper rides on top of two springs that keep it pressed up against the bottom of the dosing disc. The purpose of the scrapper is to remove any powder residue from the bottom of the dosing disc.

Dosing Disc - After the dosing disc base, center ring, tamping ring, and the dosing station shaft (with adapter) have been installed, the dosing disc is mounted on top of the shaft adapter. When the dosing disc is installed, it sits with its bottom surface against the top surface of the tamping ring. ***(The other dosing and tamping components will be covered later.)*** Figure 37 shows a close-up view of the dosing disc's top and bottom sides.

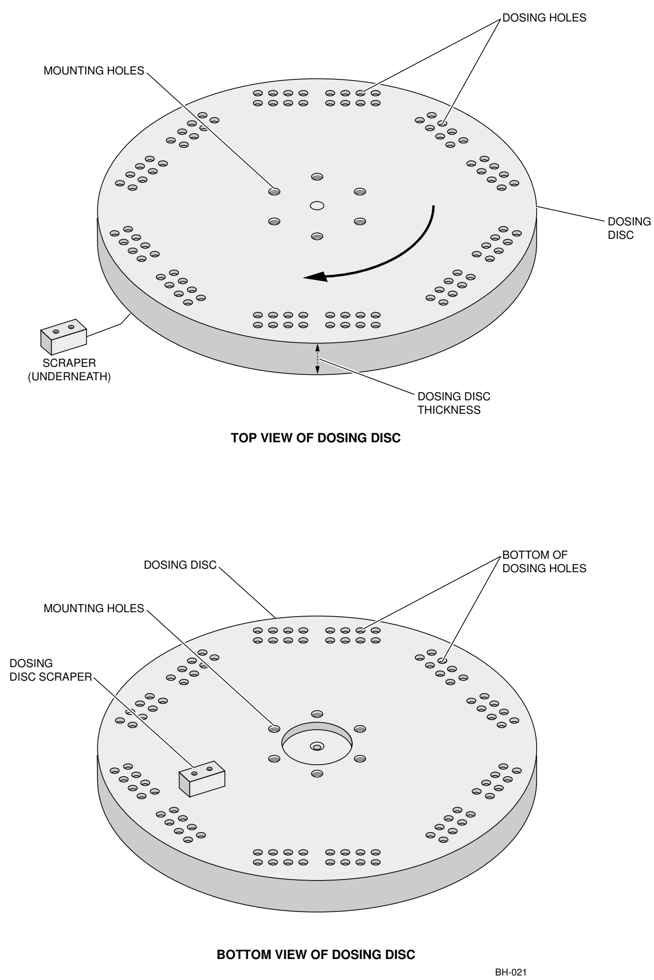

Figure 37. Dosing Disc Sides

1.5.3 Dosing Disc Movements

When the dosing area components are all installed, and the machine's main cam is rotated, the rotational movements of the main cam's center shaft are transmitted to the beveled gears of the vertical shaft connected to the dosing area indexing cam. The rotational movement of the indexing cam causes the indexing roller to engage and rotate the dosing equipment Maltese cross. Since the Maltese cross is attached to the bottom end of the dosing station shaft, the rotating Maltese cross causes the dosing station shaft to rotate. At the top of the rotating shaft is the dosing disc, which should be rotating. The Maltese cross used with the dosing disc also has a brake to hold it in place when the disc is stopped.

1.5.4 Dosing Disc and Tamping Activities

As the dosing disc is being rotated during normal operations, powder on top of the disc is falling into the dosing holes around the disc's outer edge. Above the disc are the vertically aligned tamping pins that will be moving up and down, inserting their ends into the dosing holes of the dosing disc. Figure 38 shows the location of the tamping components above the dosing area.

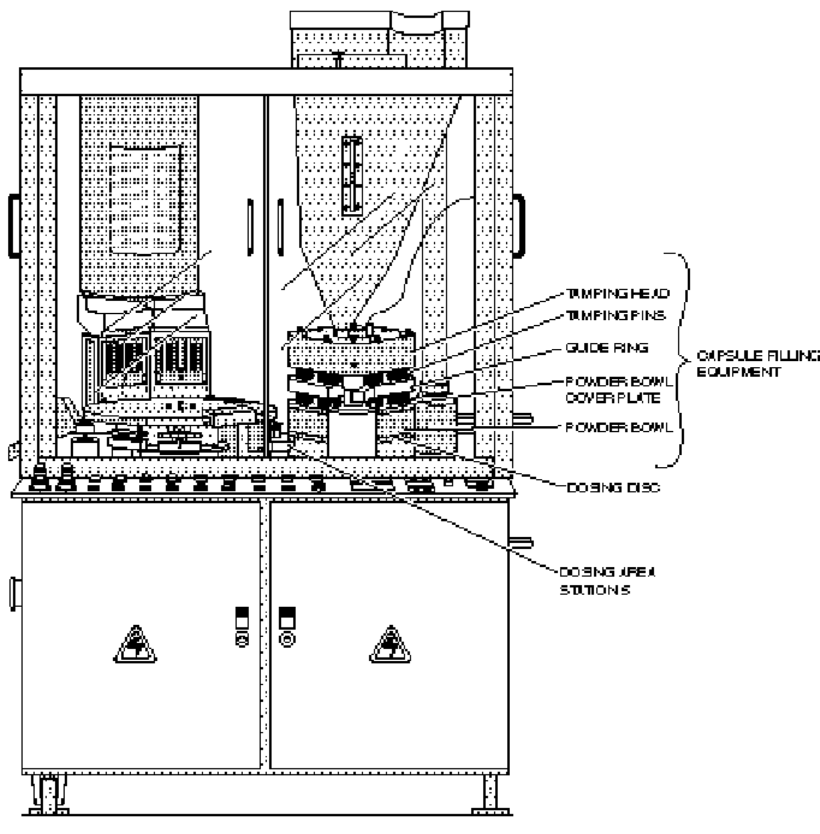

Figure 38. Location of Tamping Components Above Dosing Area

Tamping Pins, Blocks, and Head - The tamping pins within the capsule-filling area are grouped inside of six tamping blocks. Each block contains 16 tamping pins. The tamping blocks are mounted inside the tamping head, which is moved up and down by two vertical shafts attached to a drive assembly powered from the machine's main cam. ***(The tamping cam and tamping activities***

will be covered later in this text). Figure 39 shows a close-up view of the tamping and dosing components.

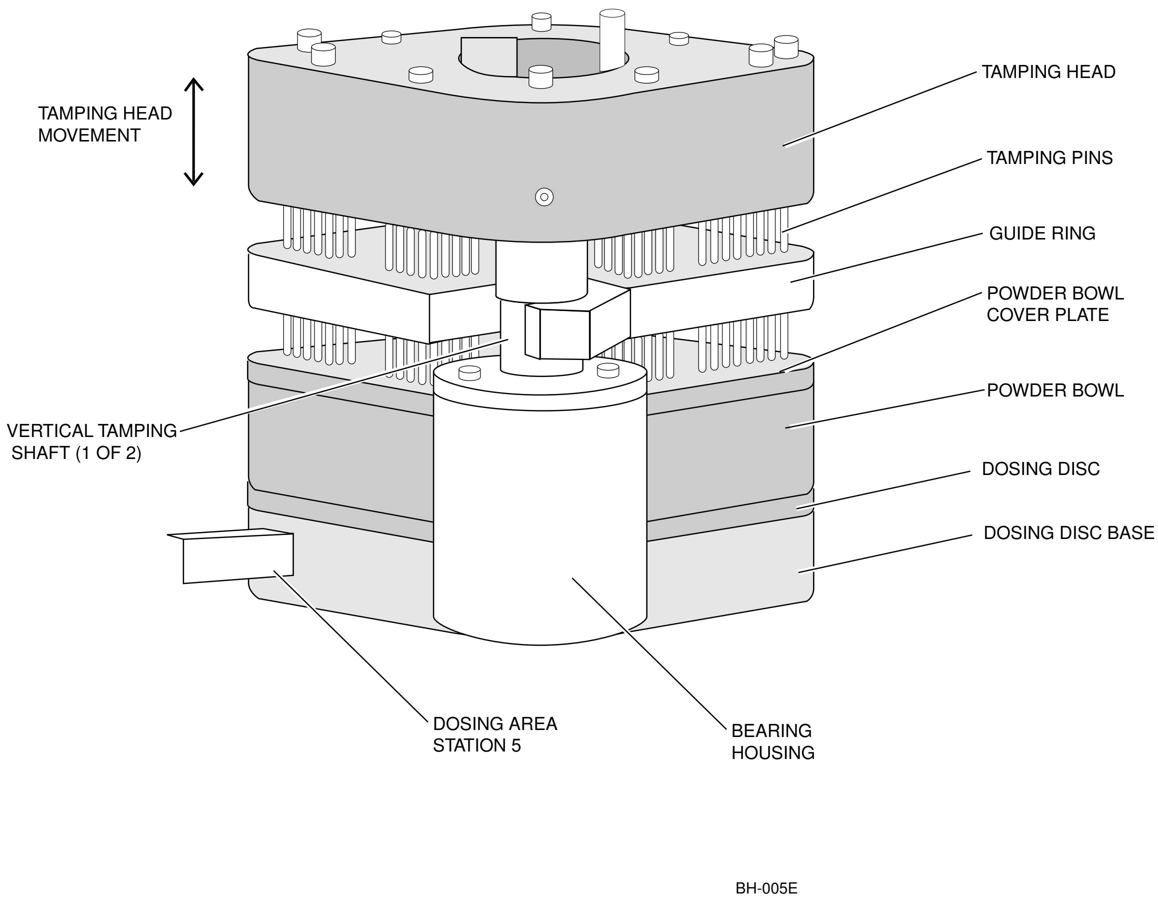

Figure 39. Close-Up View of Tamping and Dosing Components

Tamping Pin and Dosing Disc Coordination - The up and down movements of the tamping pins must be synchronized perfectly to ensure that the pins are lifted before the dosing disc is rotated one position. The tamping pins also must all be perfectly positioned in their tamping head so that they all will be clear when the dosing disc is moved. ***(The timing of these tamping activities will be addressed later.)***

1.6 SORTING EQUIPMENT, CAM, AND ASSOCIATED DEVICES

The segment turret discussed earlier carries capsules through the various processes of the machine, including the dosing area also discussed earlier. These capsules carried by the segment turret and filled from the dosing disc must first be placed correctly into the segment turret by the capsule sorting devices.

The empty capsules dumped into the capsule hopper at the left-rear of the machine may or may not be aligned correctly as they exit the capsule hopper on their way to the segments positioned in process stations 1 and 2. Process stations 1 and 2 are located below the hopper and sorting equipment. The function of the sorting equipment is to realign the capsules so that their smaller bottom ends enter the segments first.

Sorting and aligning devices located below the capsule hopper and above the segments in process stations 1 and 2, ensure that these empty capsules get correctly aligned. Figure 40 shows the locations of the capsule-supply and sorting equipment above process stations 1 and 2, as seen from the front of the machine.

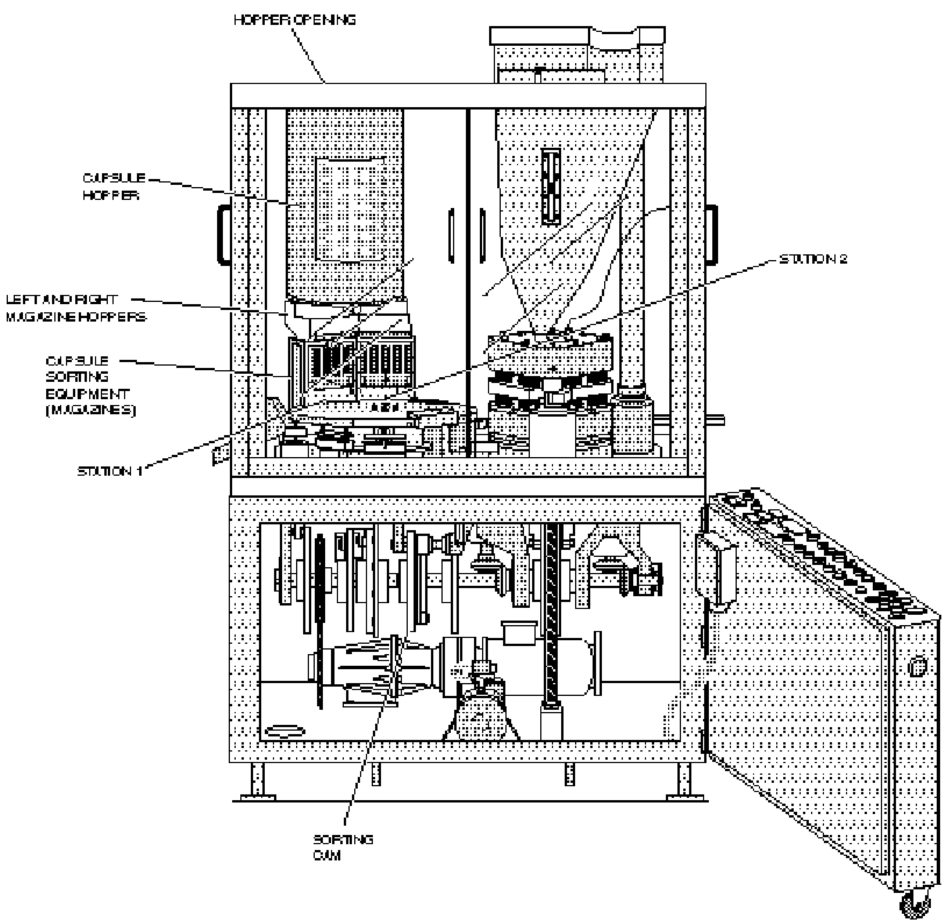

Figure 40. Locations of Capsule-Supply and Sorting Equipment

1.6.1 Locations of Specific Sorting Equipment

Magazine Components - The machine is equipped with two sets of capsule-sorting devices called magazines. The magazines are located near the left-rear corner of the machine. Each magazine assembly includes the magazine itself, an orientation block, and a set of horizontal fingers. A set of vertical fingers is mounted on the bottom end of the magazine itself. The capsules are fed into the top of the magazine by a magazine hopper positioned on top of the magazine housing. Figure 41 shows a left-side view of a capsule magazine's components.

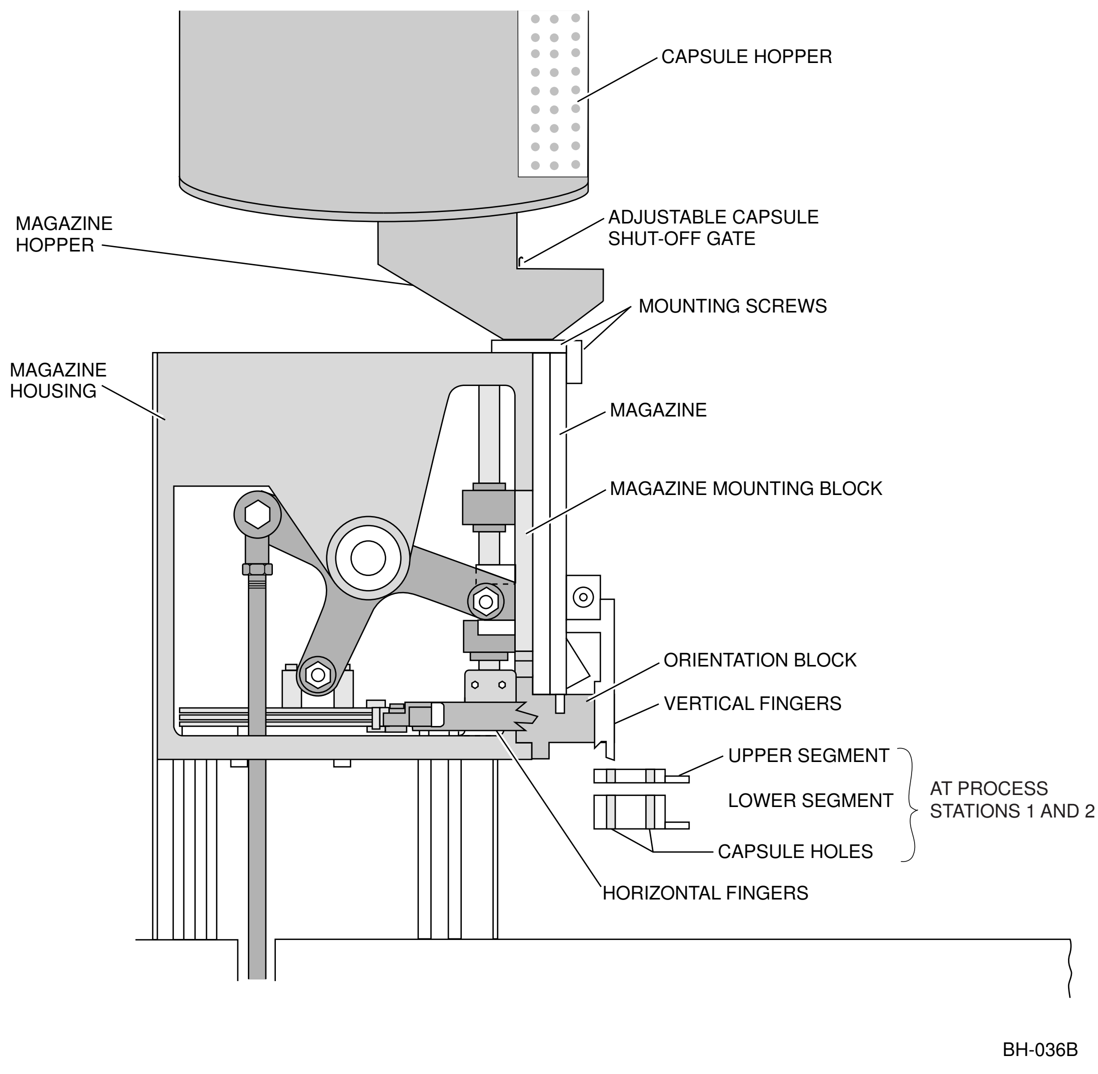

Figure 41. Magazine Components

The magazines are located on the front side of the magazine housings with their vertical fingers pointing down toward the orientation blocks located just below the magazines. The horizontal fingers are mounted behind the orientation blocks. The orientation blocks are also mounted directly above the segments positioned in process stations 1 and 2.

Magazine-to-Process Station Alignment - The left magazine is above process station 1 and the right magazine is mounted over process station 2. When observed from the front of the machine (as seen earlier in Figure 40), the left magazine (and orientation block) sorts and places empty capsules into the back row of segment holes while the segment is at process station 1. After the segment turret moves a segment from station 1 to station 2, the right magazine and its associated devices place empty capsules into the front row of segment holes.

Sorting Cam - The components used to sort, align, and insert empty capsules are all driven from the sorting cam which is part of the machine's main cam. The main cam and the sorting cam are all located under the base plate.

1.6.2 Sorting Equipment Mechanical Movements and Drives

The capsule sorting and aligning equipment is an assortment of mechanical devices moving in both the vertical and horizontal directions. The movements of the magazine components sliding back and forth in the horizontal direction must be synchronized with the magazine components moving in the vertical direction. The combined movements of these movements align the empty capsules inside the orientation blocks.

All of the moving devices inside the capsule magazines are powered by drive components attached to the sorting cam (shown earlier on Figure 40). Figure 42 shows a left-side view of the sorting cam and the related sorting equipment found at stations 1 and 2.

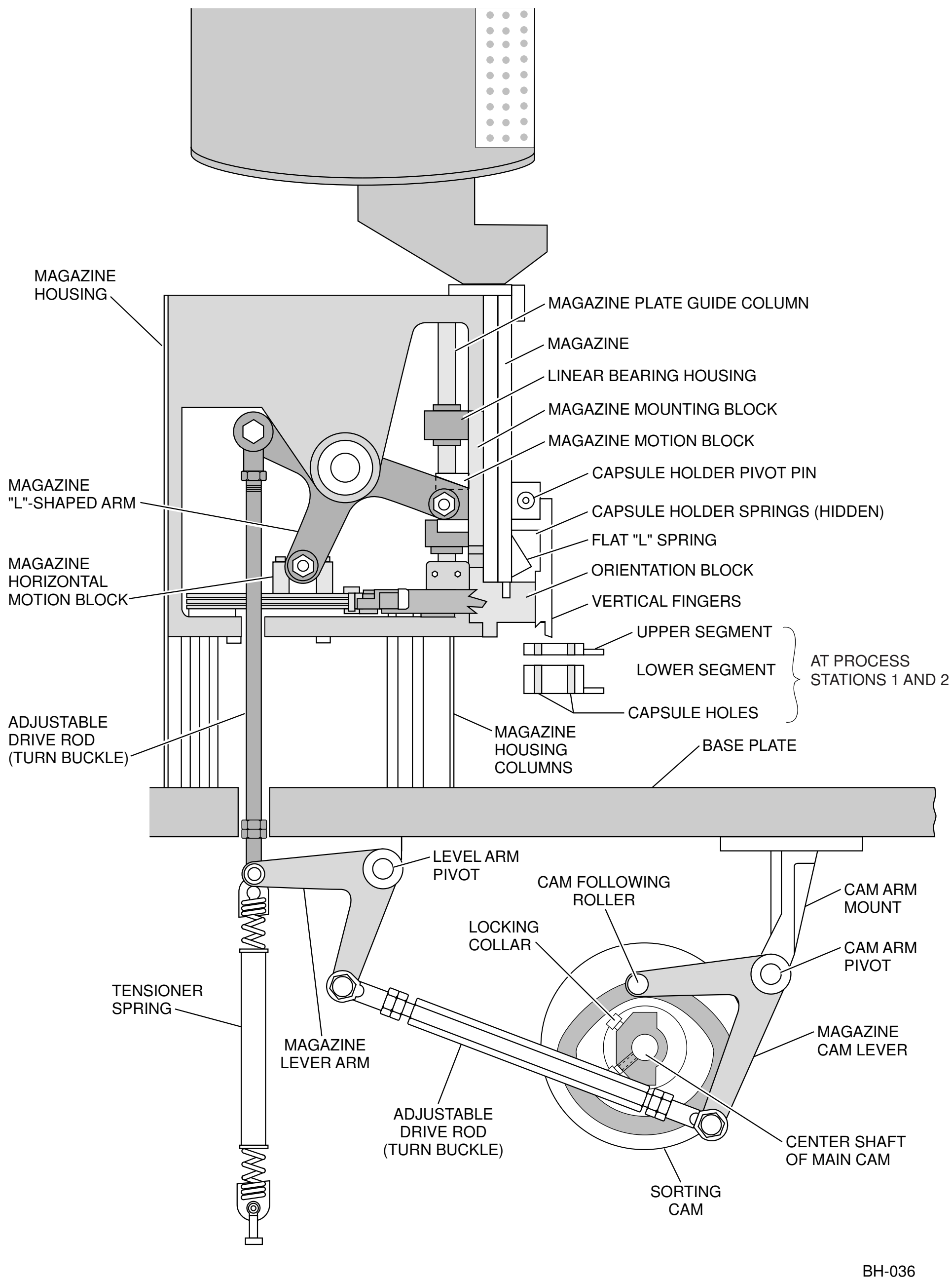

Figure 42. Left-Side View Of Sorting Cam For Station 1 Sorting Equipment

Drive Components to Sorting Devices - All of the capsule-sorting devices in each magazine are driven from a single drive rod extending up through a hole near the left-rear corner of the machine's base plate.

The bottom end of this adjustable drive rod is attached to the horizontal end of a magazine lever arm mounted under the base plate. The vertical end of the magazine lever arm is connected through an adjustable drive rod to another lever arm mounted beside the sorting cam. This second arm is called the magazine cam lever. A cam-following roller attached to the side of the magazine cam lever rides inside a groove cut into the left side of the sorting cam (as seen from the front of the machine). When the cam is rotated, the roller follows the cam groove and makes the magazine cam lever move up or down. When the magazine cam lever moves, the action is transmitted through the drive rods and other levers to move the components inside the feed and sorting magazines.

Drive Mating - The mechanical devices of these two magazines are mechanically tied together through mated gears located between the two magazine housings. The gears are only touching each other on one side because the two magazine housings are not positioned parallel to each other.

The single drive rod, extending up through the base plate from the sorting cam, is connected to the "L"-shaped arm inside the magazine closest to the center of the machine. From the left-rear corner of the machine, the center magazine appears to be on the left. Figure 43 shows a simplified rear-side view of mated gears and the drive rod to the magazines.

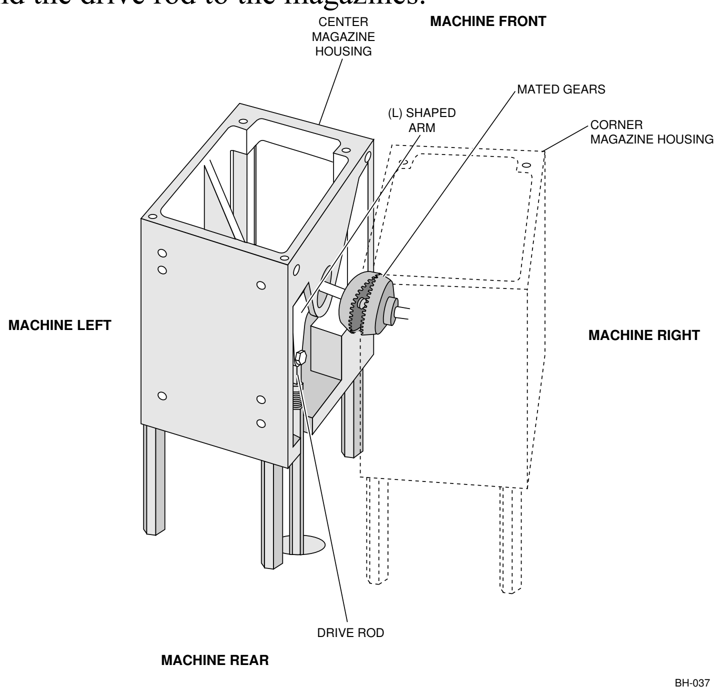

Figure 43. Rear-Side View of Magazine Gears and Drive Rod

Drive Sequence - When the machine's main camshaft is rotated, it in turn rotates the sorting cam. The rotating sorting cam causes these drive arms and rods to move the sorting equipment components.

When the vertical drive rod extending through the base plate is moved, it in turn causes the "L"-shaped arm of the magazine housing nearest the center of the machine to change position. When the "L"-shaped arm inside the center magazine moves, it moves the magazine components attached to the front of the magazine, plus it turns a shaft and a gear connected to the "L"-shaped arm inside the other magazine housing. The result of all this shaft and gear rotation is that the mechanical components of the two magazines operate together. When one is moving down, so is the other. The movement of the two magazines must be completely synchronized.

1.6.3 Magazine-Specific Drive Components

When the "L" arm of a magazine changes position, two things occur at the same time: the lower prong of the arm moves the horizontal motion block and the horizontal fingers in or out of the orientation block; and the right prong of the arm moves the magazine motion block and magazine up and down the two magazine plate guide columns at the front of the magazine housing. Figure 44 shows a closer view of the magazine components.

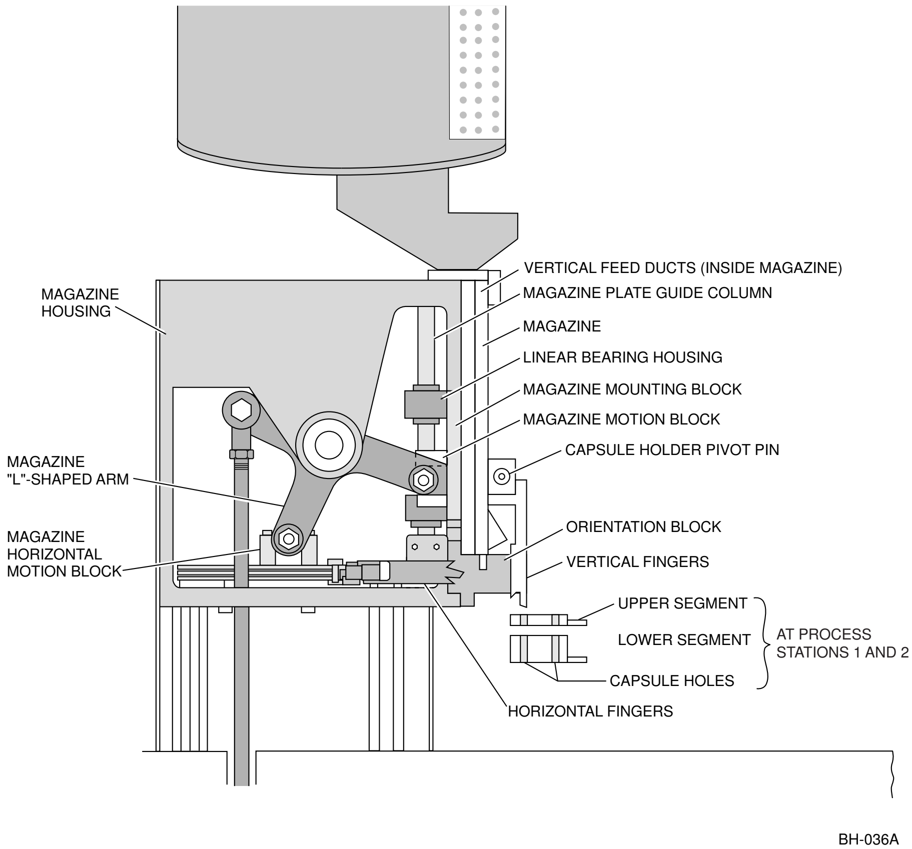

Figure 44. Close-Up View of Magazine Components

When the machine is being run, the shaft of the main cam will keep the sorting cam rotating. As long as the sorting cam is rotating, the magazine components should continue moving to sort and position the empty capsules into the empty segments.

1.6.4 Sorting and Loading Process

The empty capsules exiting the bottom of the magazines are positioned in front of the orientation blocks. The slots of the orientation blocks are positioned directly below the vertical fingers of the capsule magazines, and above the empty holes of the segments in the station. Figure 45 shows a close-up view of the orientation block and the vertical and horizontal fingers used for sorting and loading the capsules into the segments.

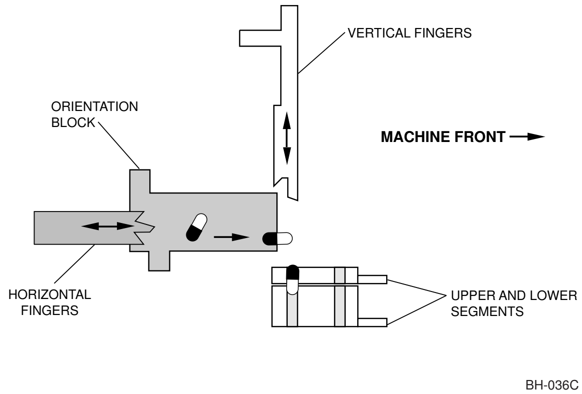

Figure 45. Orientation Block and Fingers for Sorting and Loading

After the capsules are positioned in front of the orientation block, the horizontal fingers are pushed out toward the slots of the orientation block. As the horizontal fingers continue to move out, they press against the capsules positioned in front of the block. If the capsules are correctly positioned, the horizontal fingers push them to the outer end the orientation block slots. If the capsules are incorrectly positioned, the tips of the horizontal fingers cause the capsules to flip over so that their smaller bottom ends are pointing out before the capsules reach the outer end of the slots. With the next downward stroke of the magazine, the small vertical fingers at the bottom of the magazine push the capsules out of the orientation blocks so that the capsules will drop bottom first into the segments below.

1.6.5 <u>Second Half of Sorting Cycle</u>

Just after the vertical fingers of the magazines have inserted the empty capsules into the segments, the sorting cam goes into the second half of its cycle. As soon as the cam starts its second-half cycle, it starts lifting the magazine (and its vertical fingers) up and away from the segments. The horizontal fingers are also retreating at this point. While the fingers are retracting, more empty capsules are being dropped into the orientation block area.

The sorting cam is timed to get the vertical fingers away from the segments just before the segment turret starts moving the segments from one station to another. As soon as the segment turret has relocated the segments, the sorting and loading cycle starts all over.

1.7 CAPSULE-SEPARATING EQUIPMENT, CAM AND ASSOCIATED DEVICES

After the empty capsules have been loaded into the segments at process stations 1 and 2, the capsule bottoms must be pulled vertically away from the capsule tops while the capsules are still in process stations. The capsule tops will be later temporarily shifted horizontally away from their capsule bottoms so that the bottoms can be filled with product. Vacuum within stations 1 and 2 separate the capsule bottoms from their tops.

During these separation processes at stations 1 and 2, small plunger pins are used to keep the capsule bottoms from being pulled completely out the bottom of the lower segments. These separation pins are lifted and lowered by attachments connected to the separation cam mounted on the machine’s main cam assembly. Figure 46 shows the location of the station 1 and 2 capsule-separation devices, and the machine's separation cam.

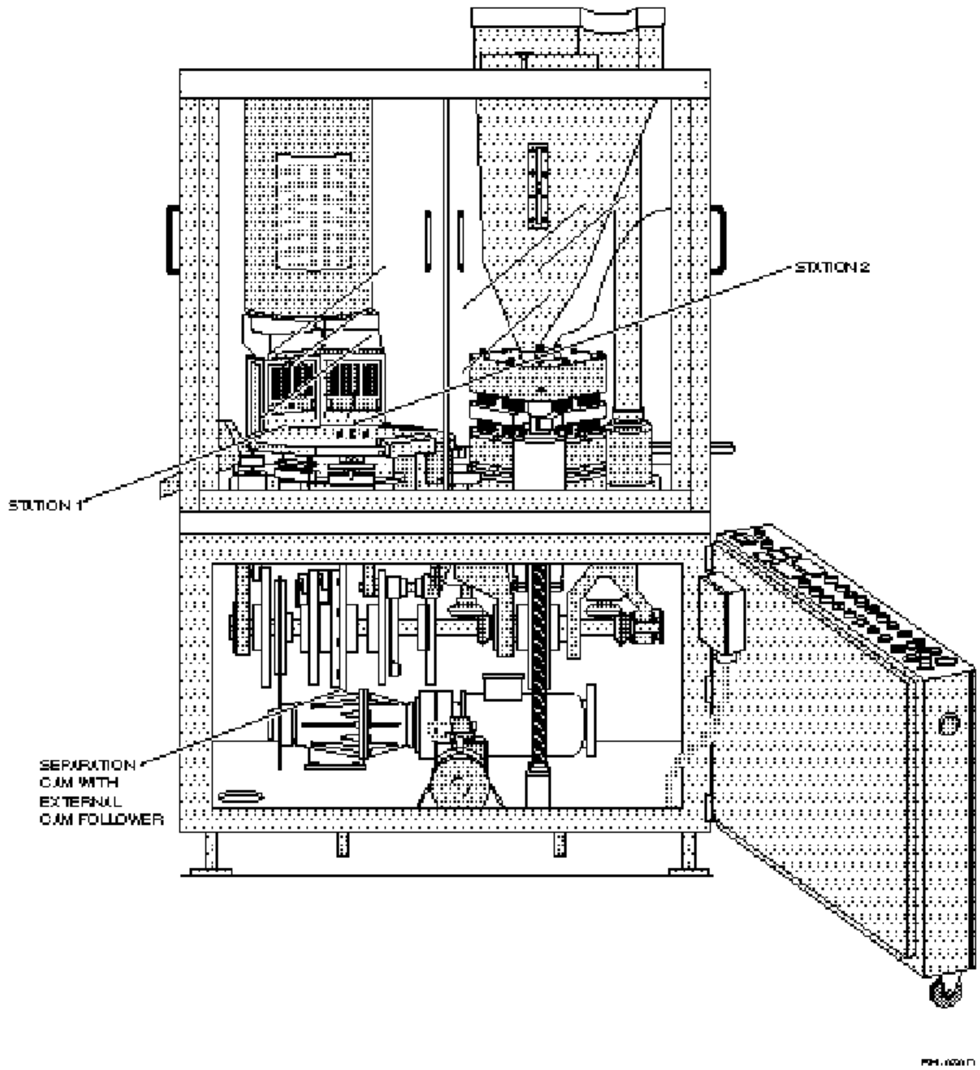

Figure 46. Location of Separation Devices

1.7.1 Suction Shoes

When the empty segments are moved into station 1 to be loaded with empty capsules, the bottom surface of the lower segment is positioned directly over top of a device called a suction shoe. The suction shoe fits closely up against the bottom of the lower segment. The lower segment positioned in station 2 is also positioned over a suction shoe. During the loading process, the empty capsule bottoms slide down through the capsule holes of the upper and lower segments. When vacuum is applied by the suction shoes, the suction will cause the capsule bottoms to pull away from the capsule top held in the upper segments. Figure 47 shows a left-side view of the segments, capsules, and suction shoes in station 1.

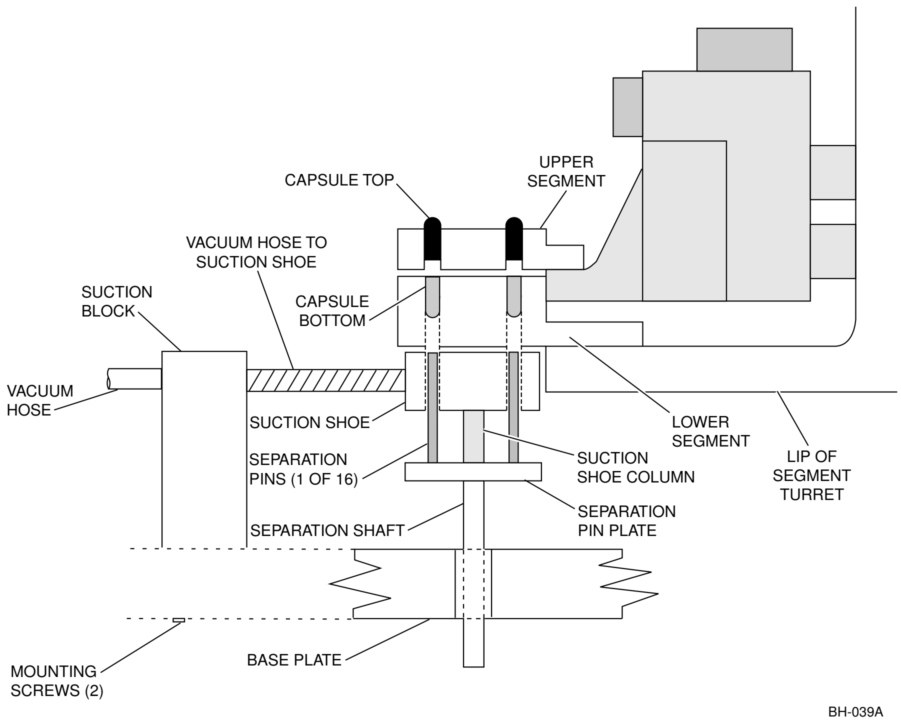

Figure 47. Left-Side View of Segments, Capsules, and Suction Shoes in Station 1

1.7.2 Capsule Positioning

After the empty capsules have loaded into the segments, the bottom edge of each capsule top sits down against a ring or lip inside the bottom of each upper segment hole. Since the capsule bottoms are smaller than their tops, the capsule bottoms easily pass down through the upper segment during the loading process. The capsule bottoms extend out the bottom of the upper segment and into the holes of the lower segment. The capsule bottoms are positioned just above the suction shoes located under the lower segment.

1.7.3 Separation Process

After the empty capsules are in the segments, vacuum is applied to the suction shoes through hoses connected to the suction blocks. The vacuum in the suction shoes pulls the capsule bottoms away from their capsule tops. Vacuum to the suction blocks and both sets of suction shoes is controlled by a small electronically controlled valve located beneath the capsule magazines. Two mounting screws in each of the two suction blocks securely hold them onto the top surface of the base plate.

1.7.4 Separation Pins

To keep the vacuum from pulling the capsule bottoms too far down into the lower segment holes, small plunger pins inside the suction shoes are lifted up to a position just below the lower-segment holes. These separation pins help support the capsule bottoms as the vacuum is pulling the bottoms away from their tops.

Sixteen of these separation pins are used in each process area of stations 1 and 2. The pins are mounted onto a separation pin plate that keeps them aligned directly below the center of the holes in the lower segment. The separation pin plate sits on top of a separation shaft controlled from the main cam.

1.7.5 Separation Pin Drives

The separation pins are lifted and lowered by devices connected to the separation cam installed on the center shaft of the main cam. The separation pin plate on which the pins are installed is mounted horizontally on top of two separation shafts that extend up through holes in the base plate.

Separation Shaft Bracket - Below the base plate, the separation shafts are attached to a horizontally mounted separation shaft bracket. The bottom of this bracket is connected through an adjustable drive rod to an arm containing an external cam-following roller. Figure 48 shows left-side and rear-side views of the separation shafts, separation cam, and external cam-following roller and arm.

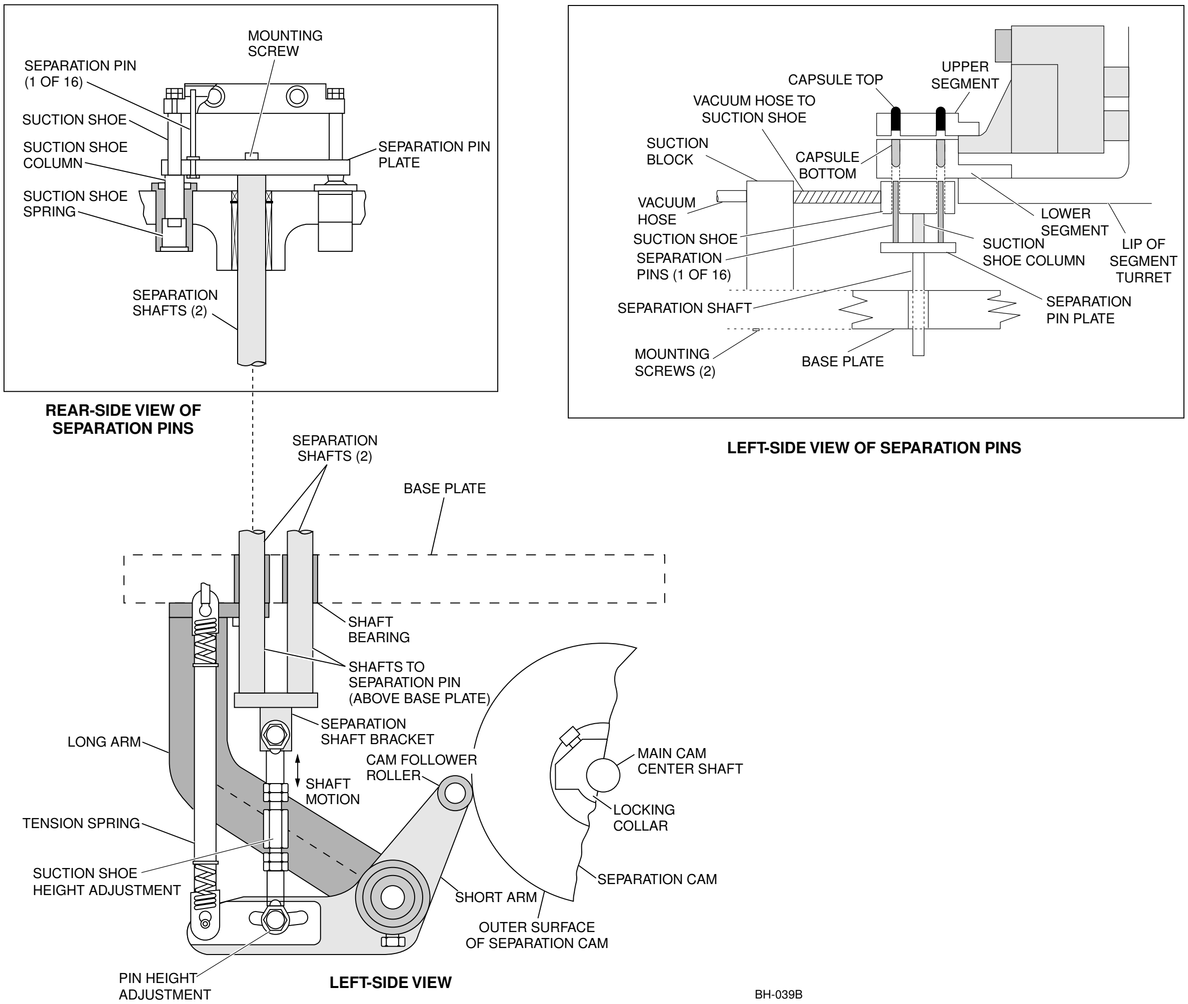

Figure 48. Rear-Side and Left-Side Views of Separation Shafts, Cam, and External Cam-Following Roller and Arm

Lifting Separation Pins - As the main cam is rotated, the exterior shape of the separation cam causes the roller and the other cam-following devices to lift the separation pins so that they are almost touching the bottom of the empty capsules inside the segments. A spring near the rear end of the long arm keeps tension on the lifting devices. When vacuum is applied to the suction shoes, the capsule bottoms get pulled down away from their tops, and should stop their downward movement when the capsule bottoms seat into the lower segment holes.

After the capsule bottoms have separated from their tops, they should be sitting with their open tops exposed at the top surface of the lower segment. Ideally at this point, the pins should be close to the capsule bottoms, but not pressing against them hard enough to cause a dimple in the capsule bottoms.

Separation Problems - If the level of vacuum is too strong, or the separation pins are extending too high, the bottom ends of the capsules will become dimpled. Dimpled capsule bottoms are not acceptable.

If the vacuum level is too strong, the capsule bottoms will become wedged down into the lower segment holes and will not come loose later when the capsule bottoms are reconnected with their tops at the closing station.

If the vacuum is not strong enough to separate the bottoms from the tops, the bottoms will stay with their tops as the capsule-filling processes continue. When these bottoms do not separate from their tops, the capsules become useless. These un-separated capsules are called “faulty capsules,” and will have to be ejected at process station 7.

Withdrawing Separation Pins - Almost immediately after the capsule bottoms have separated from their tops, the separation cam starts withdrawing the separation pins, lowering them inside the suction shoes. The lowering separation shafts will also allow the suction shoes to lower slightly away from the bottom of the lower segments. The tension spring attached to the horizontal part of the short arm makes sure that the arm pulls the pins back down inside the suction shoe. As the separation cam reaches the maximum distance from the main cam’s center shaft, the separation pins should be completely retracted and the suction shoes should not be pressing against the bottom of the lower segment. At this point, the segment turret can safely move the segments from process stations 1 and 2.

1.8 TAMPING EQUIPMENT, CAM AND ASSOCIATED DEVICES

After the empty capsules depart stations 1 and 2, the capsule tops should not be touching the capsule bottoms. As the segment turret moves the segments (and capsules) through station 3 and into station 4, devices inside the segment turret separate the upper and lower segments both vertically and horizontally. The upper segment is retracted back toward the segment turret's vertical wall so that the top of the lower segment will be exposed. When the top of the lower segment is exposed, so are the open tops of the capsule bottoms being carried in the holes of the lower segment. Figure 49 shows the aligned and separated upper and lower segments.

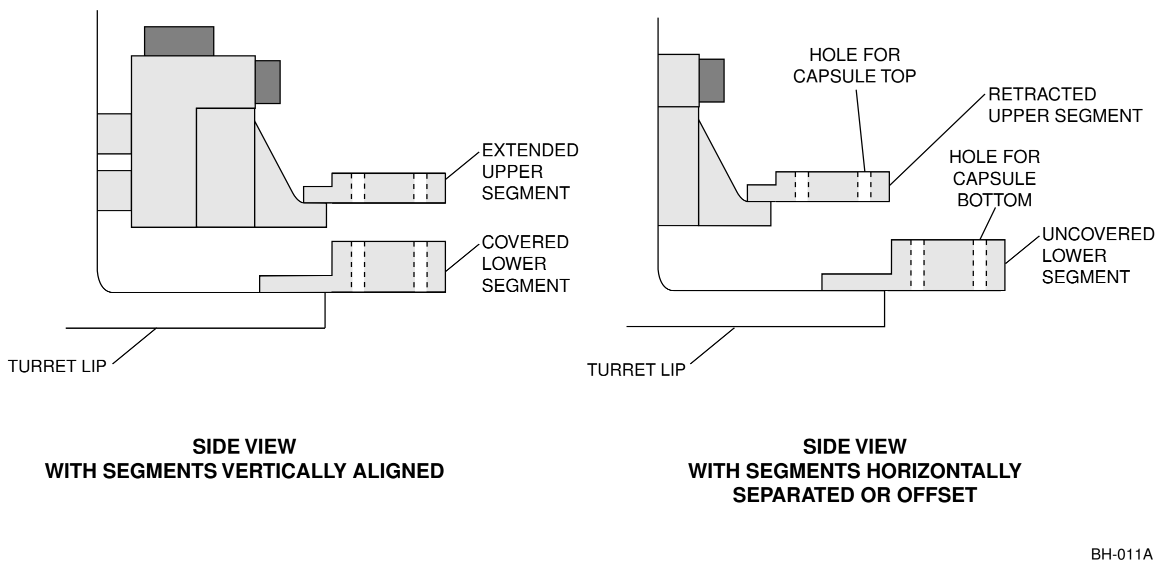

Figure 49. Aligned and Separated Segments

The main cam and its associated cams have nothing to do with separating the segments at stations 3 and 4, but the actions must occur before the capsule bottoms enter into station 5 to be filled with powder.

Before the capsule bottoms are moved into station 5 to be filled, the tamping and dosing devices above the station must prepare the slugs of powder that will be inserted into the capsule bottoms. The tamping cam and associated devices all play very important parts in the creation of these powder slugs, plus the insertion of the slugs into the empty capsules. The powder-forming process is called "tamping", and the insertion of the powder slugs into the capsule bottoms is called "dosing". Figure 50 shows the locations of the tamping cam and the components involved in the tamping and dosing activities.

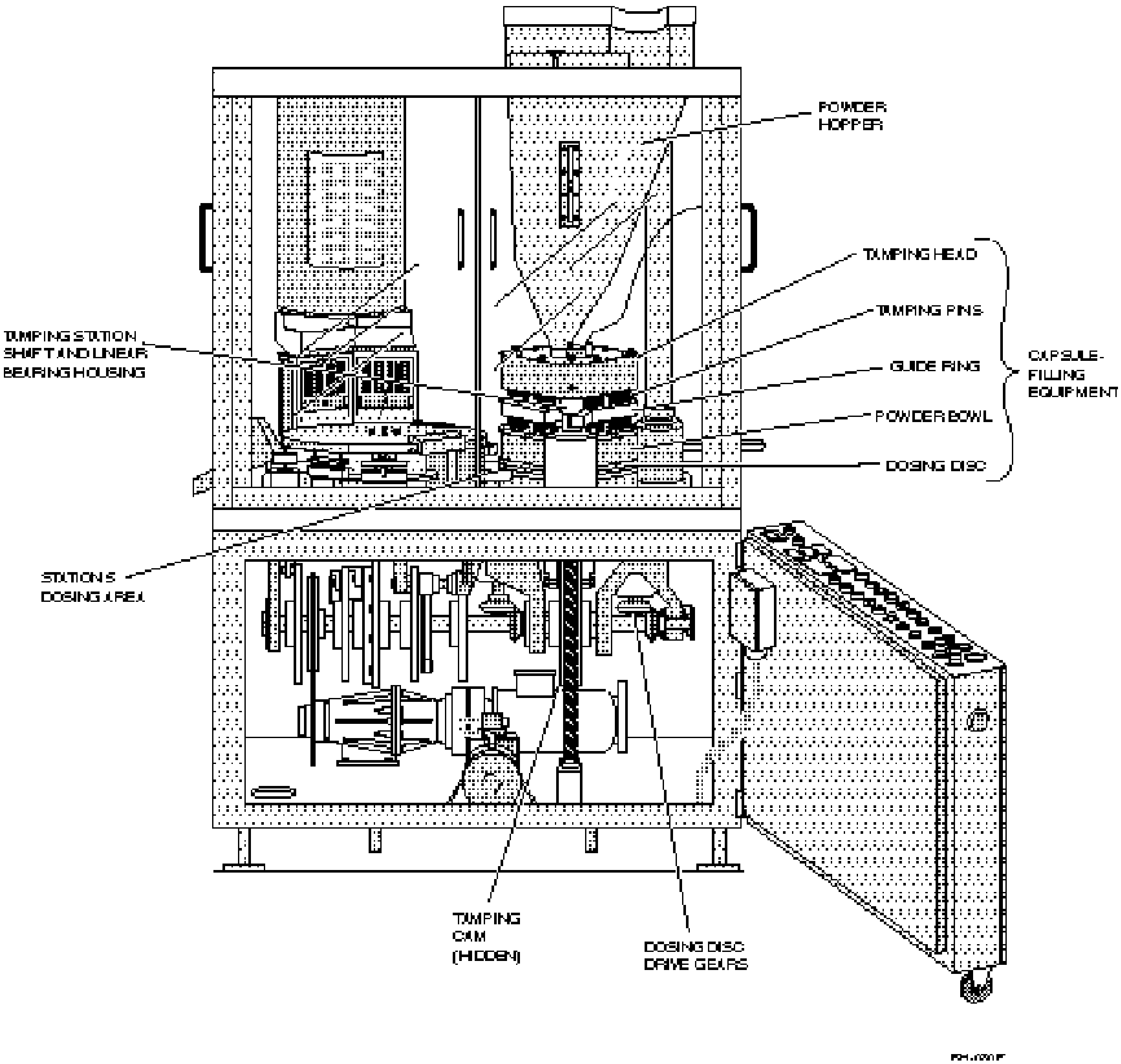

Figure 50. Locations of Tamping Cam and Associated Components

1.8.1 Tamping Process

The tamping process involves forming slugs of powder during a five-stage process that occurs inside the powder bowl area, and the dosing disc itself. The sixth process stage is for dosing the empty capsules with the slugs. While standing at the front of the machine, visualize the dosing disc inside the powder bowl. Figure 51 shows the dosing disc, cone, and tamping ring inside the powder bowl (with the tamping pins and other components not shown).

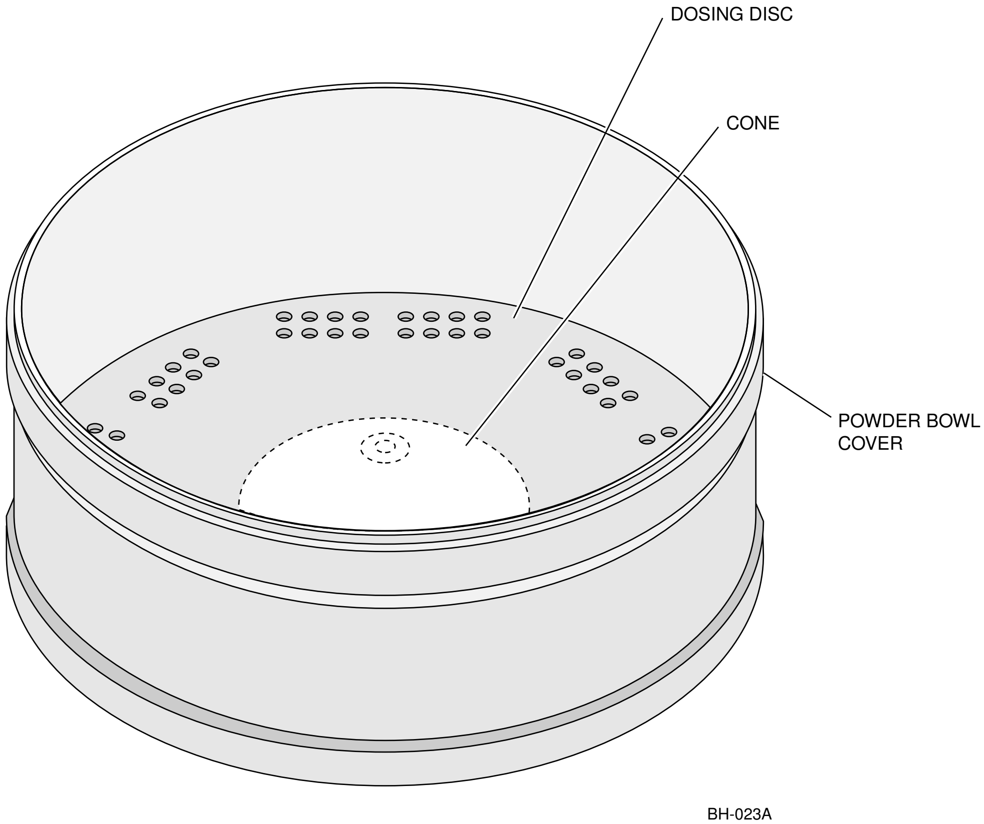

Figure 51. Dosing Disc, Cone, and Tamping Ring inside Powder Bowl

Powder Distribution - The first part of the tamping process starts with the powder spreading across the top of the dosing disc in the bottom of the powder bowl. A tamping ring under the disc closes off the bottoms of all the dosing disc holes except for the set of holes that will be over the gap at the left side of the tamping ring (as seen from the front of the machine). A cone is mounted in the center of the disc. When the powder is transferred from the powder hopper into the powder bowl, the powder hits the cone and spreads out across the top of the dosing disc. The spreading powder also covers the six sets of holes located near the outer edge of the dosing disc.

Figure 52 shows the dosing disc and the six process stages of the tamping and dosing process.

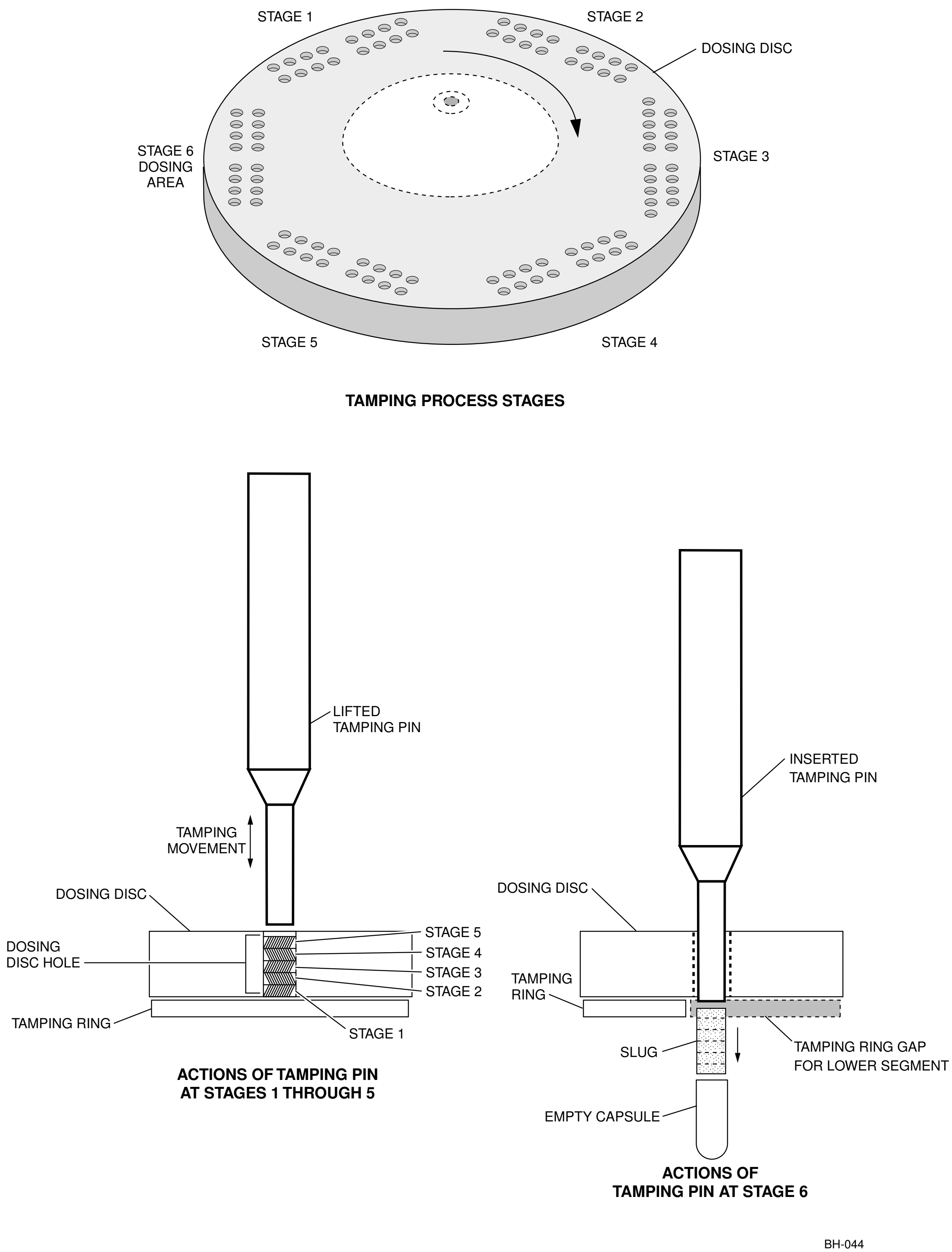

Figure 52. Six Process Stages of Tamping Process

Tamping Pins - The tamping process primarily involves six sets of tamping pins (not shown in Figure 52) packing the powder down into five sets of dosing disc holes. When the pins are inserted into the sixth set of holes, they push the slug of powder down into the empty capsules positioned in the dosing area below the stage 6 of the dosing disc. In between each tamping action, the pins are retracted and the dosing disc is rotated one position or one set of holes. After the each shift of the dosing disc, the tamping pins again drop down into the holes of the dosing disc. The tamping pins used at stages one through five have springs between the pins and the blocks holding them. The pins used at stage 6 for the dosing are slightly different in that they have no springs.

Tamping in Layers - While the tamping pins are up, and the dosing disc is shifting, additional powder covers the holes. When the disc stops and the pins drop, the result is that more powder gets tamped into each set of holes. By the time a given set of holes have been tamped five times, a slug of powder will have been formed inside the dosing disc holes. The slug is made of five layers of powder.

On the sixth shift of the dosing disc, the set of the holes containing the compressed slug of powder gets positioned over the gap at the left of the tamping ring. Since the dosing disc has no tamping ring below it at this point, the slugs should easily slide out of the holes when the tamping pins are next lowered into the holes. Stage 6 is also called the transfer station because the slugs of powder get transferred from the dosing disc into the empty capsule bottoms.

Figure 52A shows the lower segment and capsules receiving a powder slug at stage 6.

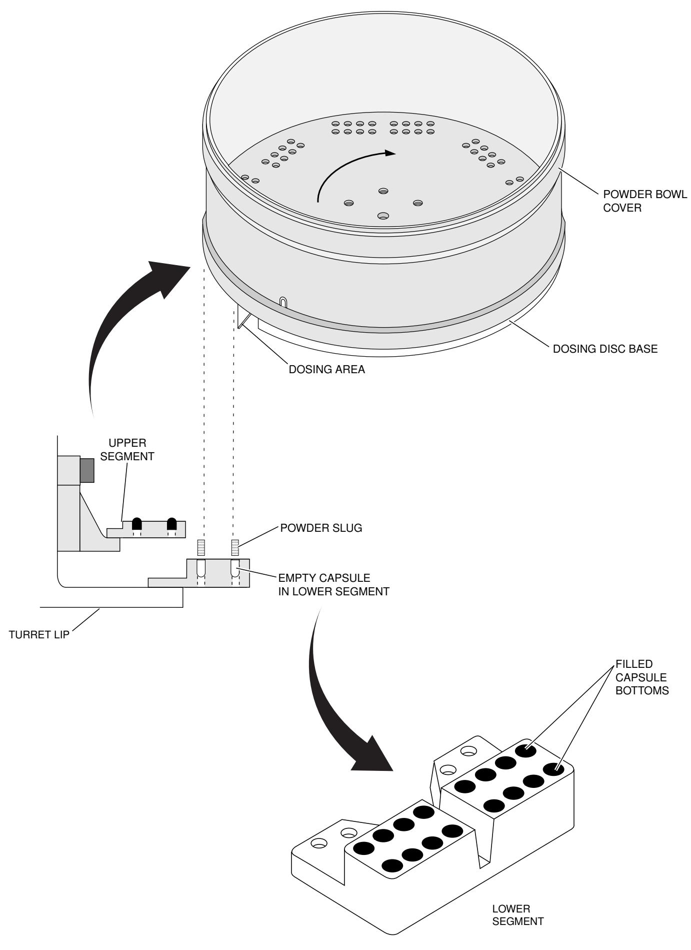

Figure 52A. Stage 6 Capsule Dosing

Dosing at Stage 6 - When the pins push the compressed slug of powder out the bottom of the dosing disc holes positioned at stage 6, the slugs should slide into the empty capsules waiting below the dosing area. This dosing action completes the tamping and dosing cycle. After the pins are lifted out of the dosing disc holes, the dosing disc shifts the empty holes over to dosing-disc stage 1 so that the cycle can begin again.

1.8.2 Tamping Equipment Drives and Movements

Tamping Head and Pins - The long thin tamping pins used to tamp the powder into the dosing disc holes are attached to blocks mounted inside the tamping head located above the tamping and dosing components. These pins are attached to the tamping head so that they point directly down into the holes of the dosing disc. Located below the tamping head and above the powder bowl are two tamping-area components that keep the tamping pins aligned as they are lowered and lifted. These two components are called the guide ring and powder-bowl cover plate. Figure 53 shows a close-up view of the assembled tamping head and pins, guide ring, cover plate, powder bowl, and dosing area parts.

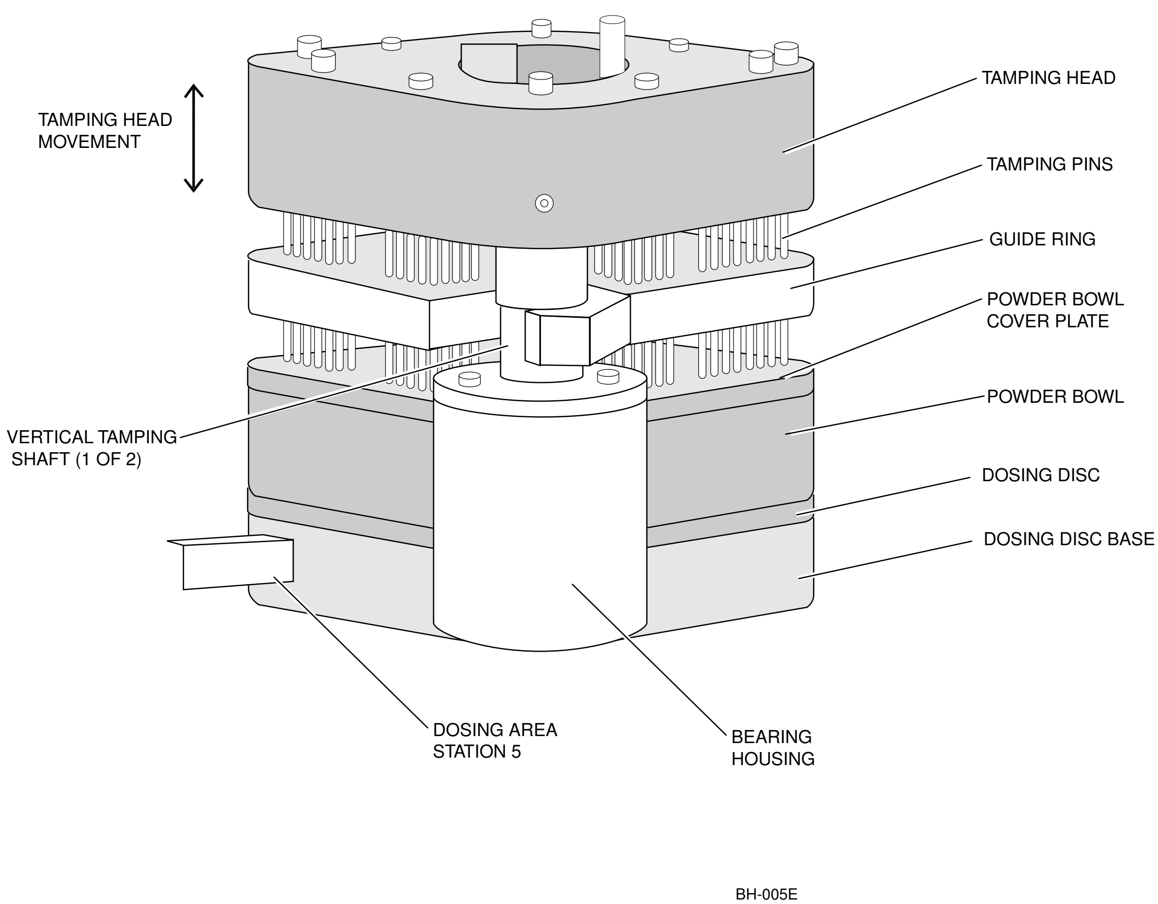

Figure 53. Tamping Head and Pins, Powder Bowl, and Dosing Area Parts

Tamping Station Shafts - The tamping head itself is mounted on top of two tamping station shafts held vertically inside linear bearings mounted inside bearing housings. The bearing housings are mounted in and above the base-plate holes near the front and rear of the machine's tamping and dosing area. During normal operations, the shafts are designed to lift and lower the tamping head (containing the tamping pins) to make the tamping pins tamp the powder into the holes of the dosing disc.

Tamping Cam and Arm - The bottom ends of the tamping station shafts are attached between two parallel rails that form what is called the tamping cam arm. The rails are mounted left and right of the tamping cam (as seen from the front of the machine). A cam-following roller, mounted near the center of each rail, rides inside the cam grooves cut into each side of the tamping cam. Figure 54 shows the tamping cam equipment as seen from the right side of the machine.

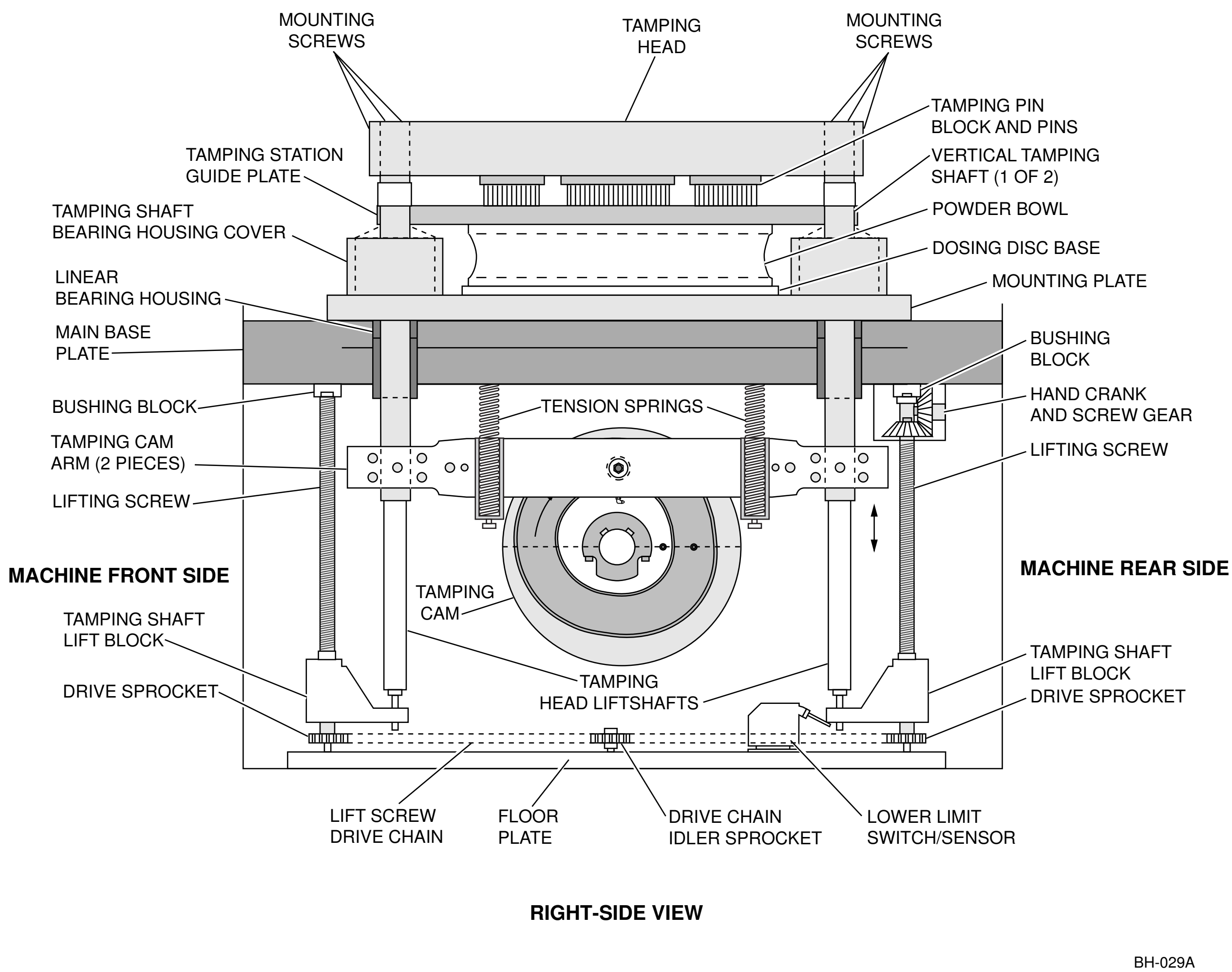

Figure 54. Right-Side View of Tamping Cam Equipment

The tamping cam is located below the base plate, and near the right end of the main cam's center shaft (as seen from the front of the machine). The tamping cam is the largest of the cams mounted onto the center shaft, and has a large groove cut into both of its sides. This cam, like the others on the main cam's center shaft, is a two-piece disc. A locking collar holds the cam onto the center shaft. The tamping disc on newer machines will have holes drilled through the thicker areas of the tamping cam. These holes are for balancing the tamping cam.

Tamping Actions - When the center shaft rotates, the tamping cam rotates. As the cam rotates, the grooves in its two flat sides cause the cam-following rollers attached to the cam arm to lift or lower the arm. The lifting and lowering cam arm in turn lifts or lowers the tamping shafts supporting the tamping head. When the tamping head is lifted or lowered, it causes the tamping pins to go down into and back up out of the dosing-disc holes.

Tamping Stroke - The lifting and lowering distance or stroke of the tamping head is short. The head must lift the pins far enough above the dosing holes for more powder to fall into the holes as the dosing disc is being rotated. On the down stroke of the tamping cam, the tamping head must lower the tamping pins enough to correctly tamp the powder into the dosing disc holes. On the other hand, the movement of the tamping head must not extend the tamping pins so far down into the dosing disc holes that the bottoms of the pins hit the tamping ring, or that the pins bend under the pressure as they are pushing down against the compressed powder inside the dosing disc holes.

Figure 55 shows an exploded view of all the tamping and dosing area components.

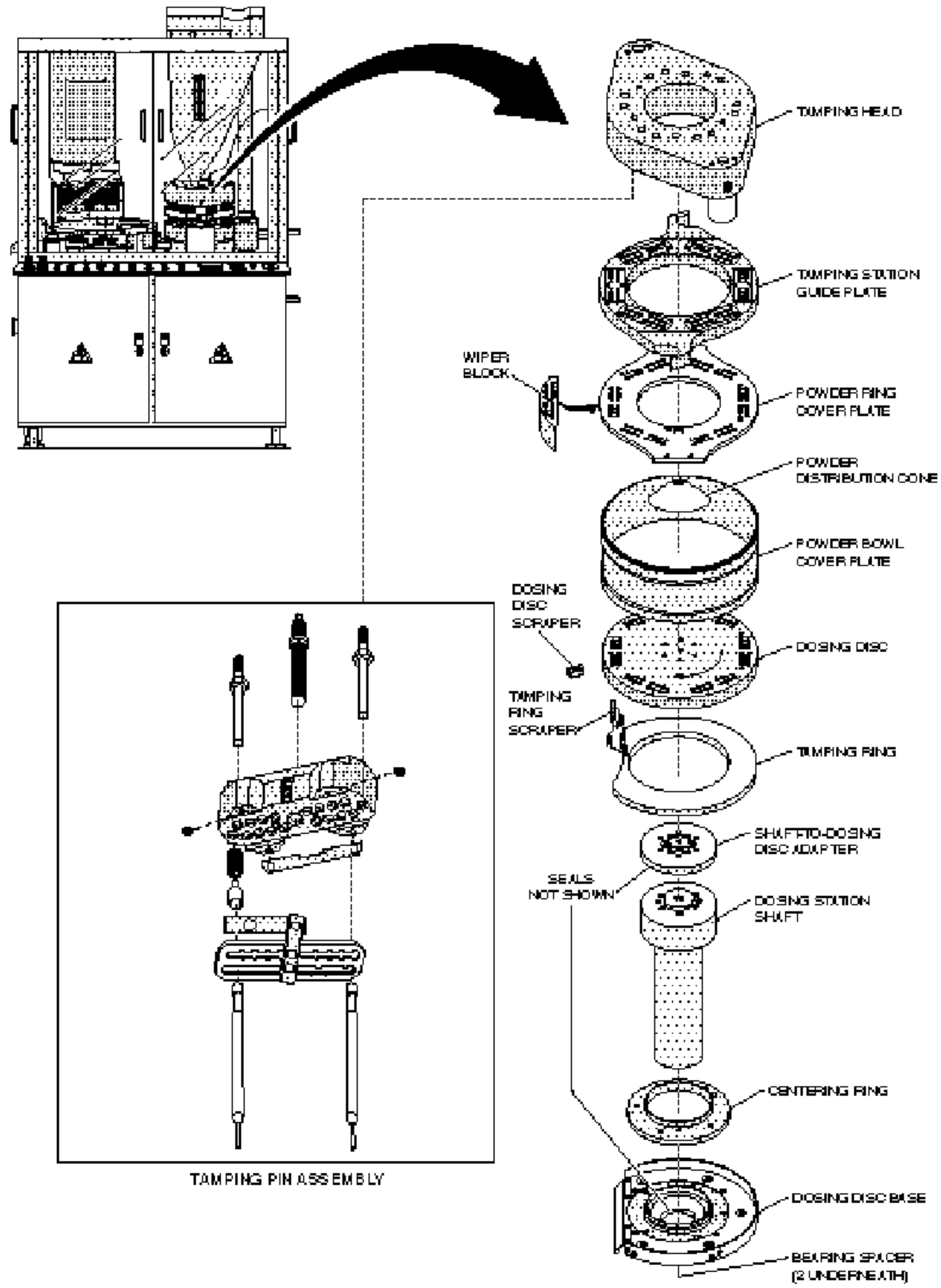

Figure 55. Tamping and Dosing Area Components

Tamping Head Adjustments - The positioning of the tamping pins starts with the two tamping station shafts inside the rails that make up the tamping cam arm. When these shafts are correctly positioned in the cam arm, the tamping head should be correctly positioned above the tamping area because the head is located on the top ends of these two tamping station shafts.

Adjustments to Tamping Pin Blocks - If the tamping head is correctly positioned in the vertical direction, the next concern is the location of the six blocks that hold the tamping pins inside the head. The blocks holding the tamping pins are mounted up inside the tamping head. Two guide columns keep each block aligned and level inside the tamping head. An adjustment screw between a block and the interior of the tamping head can be used to move the block vertically inside the tamping head. Such a vertical adjustment can be used to control the depth to which the pins of a block enter the dosing disc. The pins at each of the five tamping stages are set for different depths. These various tamping pin settings cause the layered packing of the powder inside the dosing disc holes.

Figure 56 shows the tamping pin block, its associated components, and the block adjustment screw.

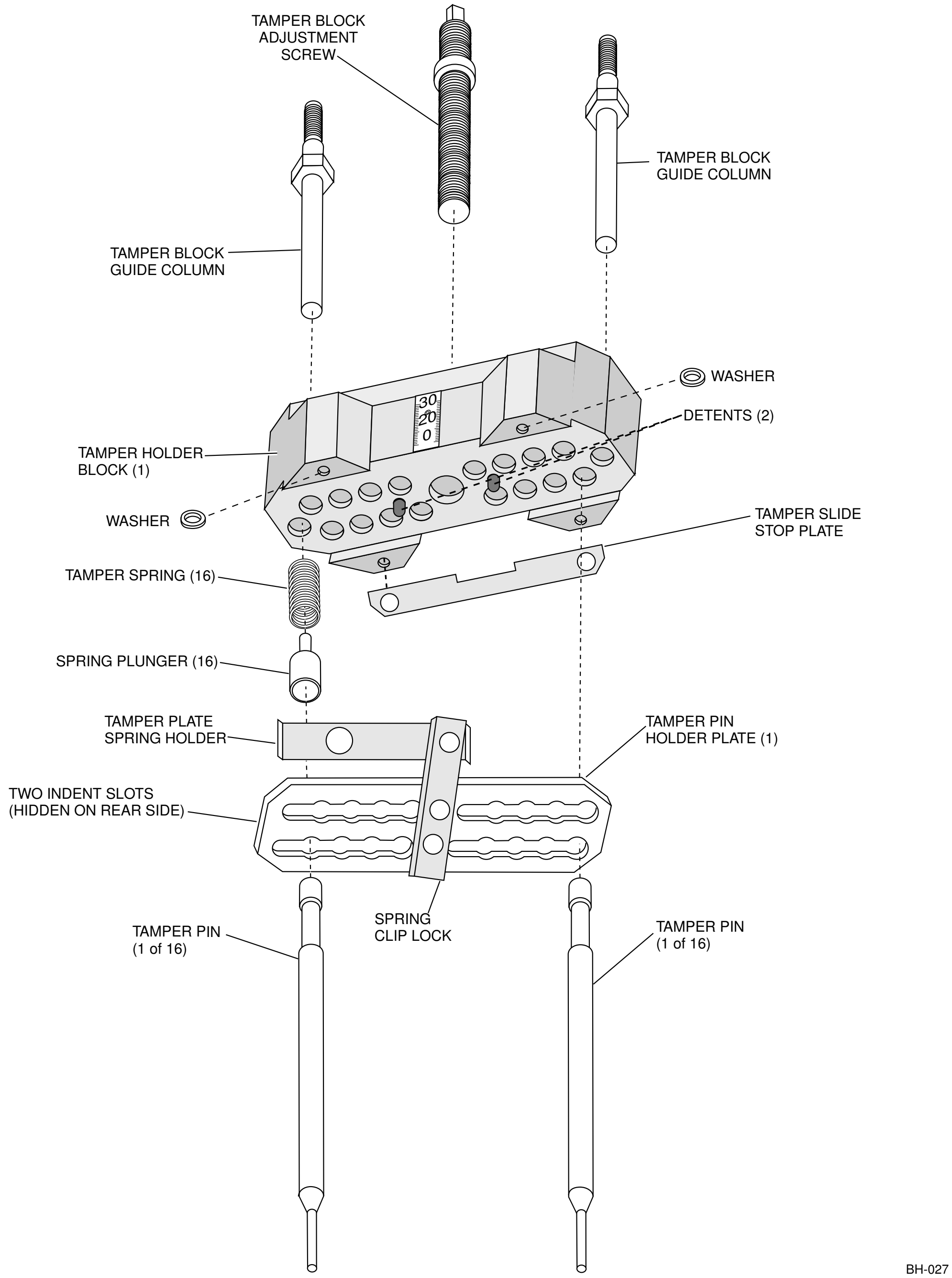

Figure 56. Tamping Pin Block Components and Adjusting Screw

NOTE: The tamping pin components shown in Figure 56 are for stage 1 through 5 pins only. The pins used at stage 6 for dosing do not use a tamper spring plunger and spring.

Coordination of Tamping Pins to Dosing Disc - The tamping pins (and their blocks) are fixed within the tamping head and can only be moved in the vertical direction by the adjustment screws. The dosing disc is mounted on top of a shaft driven by devices connected to the center shaft of the main cam. When the main cam is turned, the disc rotates in a clockwise pattern (as seen from the front of the machine). Also when the main cam turns, the tamping head lifts and lowers the tamping pins. The movements of the tamping cam and its associated equipment must be synchronized to the movements of the dosing disc. Each time the tamping pins lift out of the dosing disc holes, the dosing disc shifts around by one set of holes. The five tamping actions and one dosing action occur while the dosing disc is making one complete rotational cycle.

Dosing Station Coordination - The rotational movements of the dosing disc and the tamping pins inside the powder bowl must also be timed to rotational movements of the segment turret. The set of dosing disc holes containing the tamped slugs of powder must arrive in process station 5 (dosing area) just as the segment turret is moving a lower segment of empty capsules into the dosing area. Just after the dosing disc holes (with the slugs) have stopped over top of the segment of empty capsules in the station, the tamping cam must be timed to make the tamping pins drop into the stage 6 holes of the dosing disc. If all components have been correctly timed, the tamping pins should push the slugs out of the dosing disc holes and into the segment capsules below.

Figure 57 shows the segment and capsule bottoms in the dosing area of station 5.

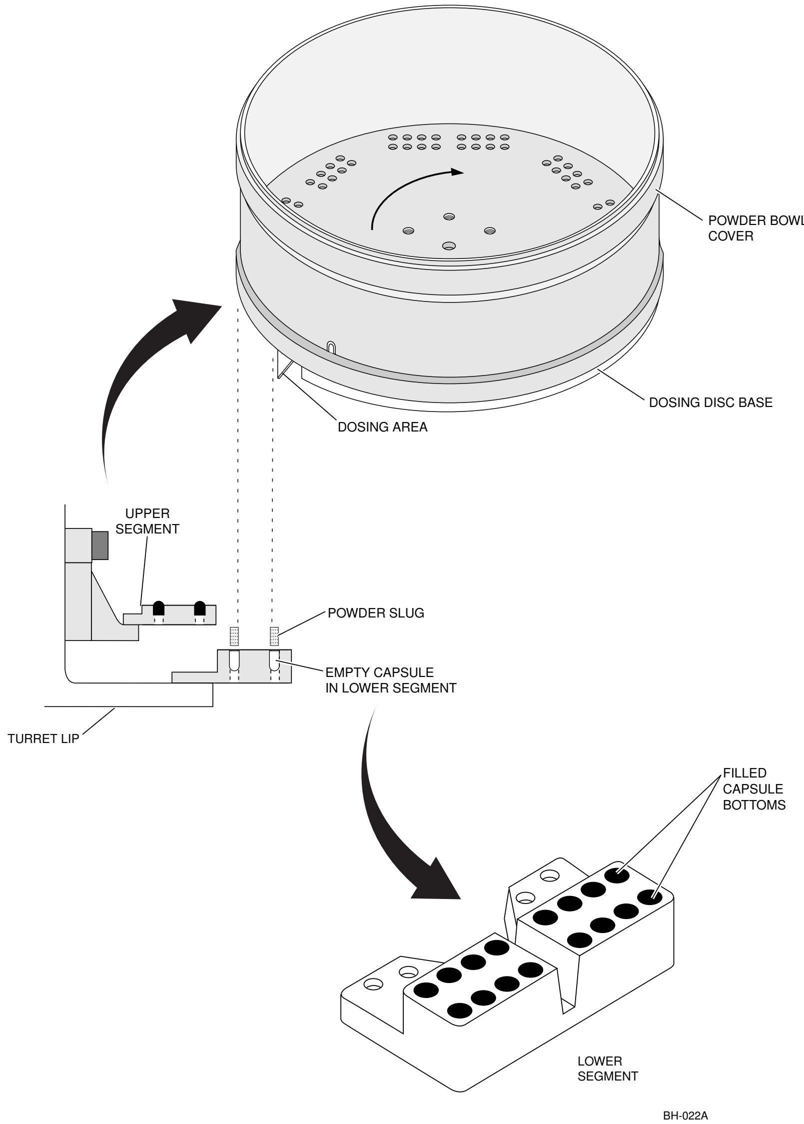

Figure 57. Segment and Capsule Bottoms in Dosing Area

The stroke of the tamping pins must be long enough to push the slugs into the empty capsules, but at the same time not so long that the pins push the slugs too far into the capsules.

As soon as the tamping pins have reached the peak of their downward stroke, the tamping cam must start lifting the pins out of the way. The dosing disc and segment turret must be timed to shift another position as soon as the tamping pins clear the tops of the dosing disc holes. The segment turret will actually start its horizontal movements just a split second before the dosing disc starts to move.

1.8.3 Factors Controlling Slug Size and Weight

Although timing issues related to the drive components of the dosing disc and tamping head may have some affect on the overall amount of powder placed into a given capsule bottom, the more likely factors affecting the slug size and weight will be the thickness of the disc, the width of the disc holes, and the density or compressibility of the product (powder).

Disc Thickness - The size and weight of the powder plug is controlled by the size of the holes in the dosing disc. A thicker disc means that the holes in the disc are deeper, and deeper holes means that more powder can be packed into them during one tamping cycle. The dosing disc must be selected to create a slug of the desired length. Disc thickness is measured at its outer edge. Figure 58 shows a typical dosing disc.

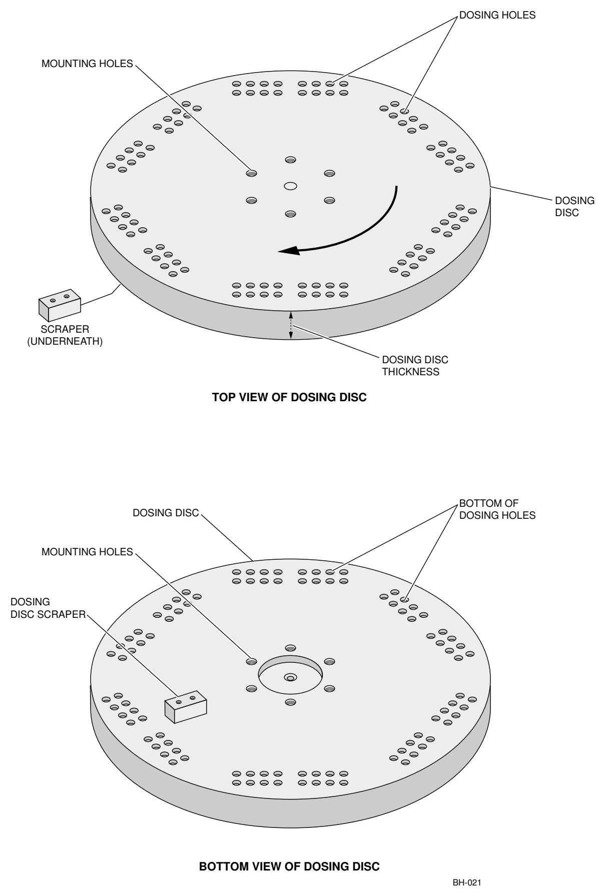

Figure 58. Typical Dosing Disc

Bore Width - The width of the dosing bores in the disc also must be addressed when selecting a dosing disc. If size “0” capsules are being run, then the bores in the disc need to be creating slugs narrow enough to fit into “0” capsule bottoms. The tamping pins selected also must match the bores in the disc.

Powder Density - Another factor controlling the size and weight of the powder plug is the density of the powder being run. Some powders compress more easily than others. In situations where a powder is fluffy, a dosing disc with smaller holes may be needed to get the fluffy powder compressed into a slug that will weigh the desired amount.

DOSING DISC SELECTION CHART

DOSING DISC THICKNESS (mm)	SIZE "00" (mm^3)	SIZE "0" (mm^3)	SIZE "1" (mm^3)	SIZE "2" (mm^3)	SIZE "3" (mm^3)	SIZE "4" (mm^3)
25.00	1.005					
24.50	972					
24.00	955					
23.50	935					
23.00	917					
22.50	900					
22.00	882	688				
21.50	865	670				
21.00	845	654				
20.50	820	639				
20.00	810	623	500			
19.50	790	607	488			
19.00	775	592	476			
18.50	730	576	463			
18.00	705	561	451			
17.50	695	545	438	370		
17.00	670	529	426	360		
16.50	650	514	413	350	300	
16.00	630	498	401	339	290	
15.50	610	483	388	329	280	
15.00	600	467	376	318	271	
14.50	575	452	363	307	262	210
14.00	550	436	351	297	253	203
13.50	525	420	338	286	244	196
13.00	508	405	326	276	235	188
12.50	490	389	313	265	226	181
12.00	475	374	300	254	215	174
11.50	450	358	288	244	208	167
11.00	430	342	275	233	199	159
10.50	410	327	263	222	190	152
10.00	395	311	250	212	180	145
9.50	375	296	238	201	171	137
9.00	355	280	225	191	162	130
8.50	335	264	213	180	153	123
8.00	315	249	200	169	144	116

NOTE 1: ***The numbers in the DOSING DISC THICKNESS column are mm values for disc thickness, and the numbers below the capsule (size) columns are the fill volumes measured in*** mm^3.

NOTE 2: ***Index recommends using this chart for reference only. Required disc thickness will vary depending on properties of each specific product. If the current disc is yielding weights above or below the target, use the following equation to determine the required thickness where "x" is the required thickness:***

"CURRENT THICKNESS" / "CURRENT WEIGHT" = "x" / "TARGET WEIGHT"

1.9 FAULTY-CAPSULE EJECTION EQUIPMENT, CAM, AND ASSOCIATED DEVICES

After the capsule bottoms have been filled at process station 5, the segment turret carries the segments clockwise through process station 6 (where nothing happens) and into process station 7, which is the faulty-capsule ejection station. The function of this station is to remove any capsules from the upper segments if the capsule bottoms are still attached to the capsule tops. Figure 59 shows the location of the faulty-capsule ejection cam and the faulty-capsule ejection equipment at process station 7.

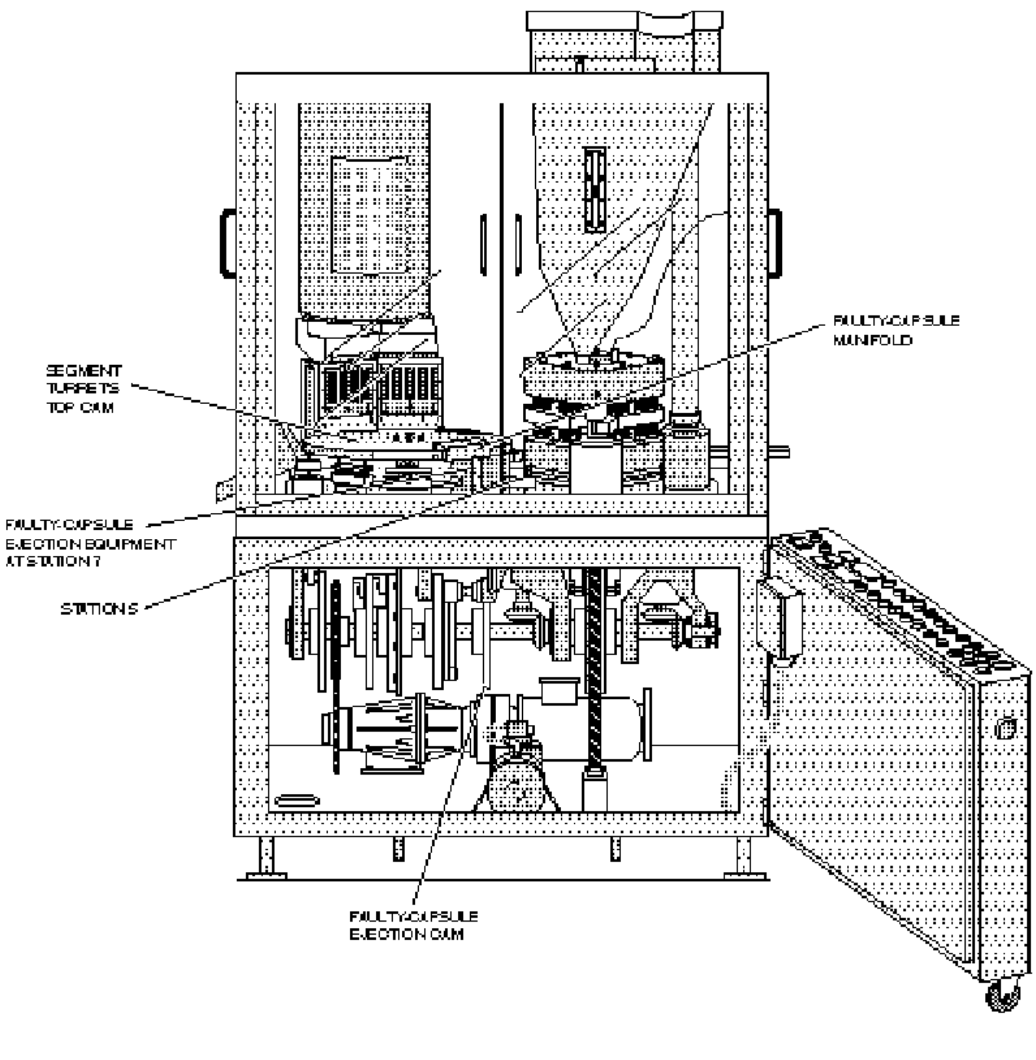

Figure 59. Locations of Faulty-Capsule Ejection Cam and Process Station 7

When empty capsules have been incorrectly inserted into the segments at process stations 1 or 2, or when capsule bottoms have not properly separated from their tops at those stations, those capsules are considered to be unusable or faulty capsules. Rather than have these faulty capsules exit the machine and get mixed in with the finished products, they are removed from the segments by ejection equipment located at process station 7. Figure 60 shows a cut-away, left-side view of the faulty-capsule ejection equipment at station 7.

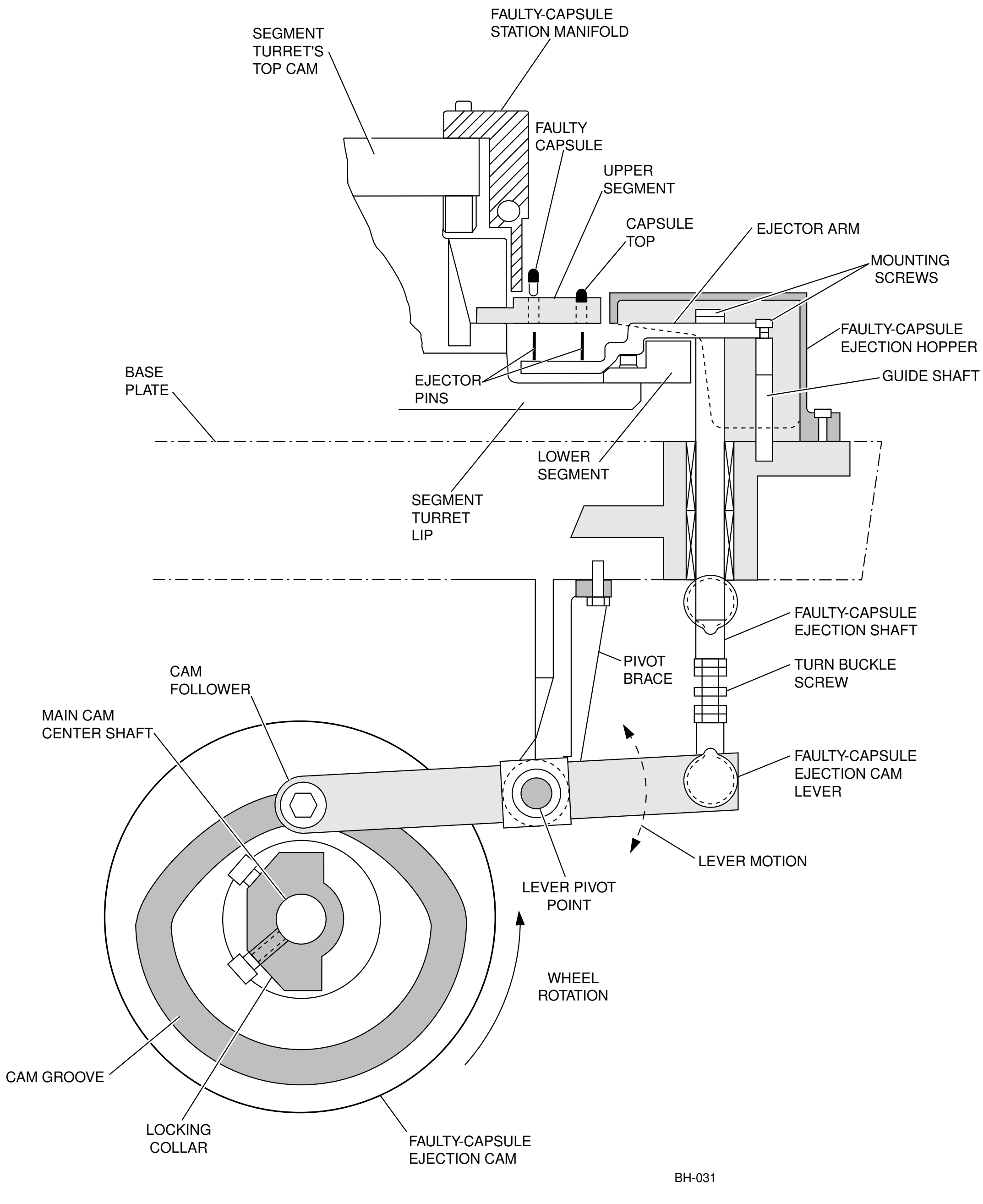

Figure 60. Left-Side View of Faulty-Capsule Ejection Equipment

1.9.1 Station 7 Ejection Process

After the segment turret has positioned a set of segments in station 7, a set of plunger (ejector) pins are pushed up into the capsule holes of the upper segment. If capsule bottoms are still attached to the capsule tops held by the upper segment, the ejector pins will push them and the capsule tops out the top of the upper segment. Compressed air blows the rejected capsules off the segment and into the ejection hopper while the segment is still in the station. The compressed air comes from the faulty-capsule manifold mounted onto the right-front edge segment turret's top cam.

1.9.2 Cam Drive to Faulty-Capsule Ejection Equipment

Ejector Arm and Shaft - The vertically positioned ejector pins used in station 7 are attached to an ejector arm inside the ejection hopper housing. The arm is mounted on top of a vertical ejection shaft that extends through a hole near the front of the machine's base plate. The bottom end of this ejection shaft is attached to the end of an ejection cam lever. The ejection cam lever is mounted to a pivot brace near its center. The other end of the cam lever is connected through a cam-following roller to a groove of the faulty-capsule ejection cam.

Ejection Cam - The faulty-capsule ejection cam, like others used on this machine, is a two-piece cam attached to the main cam's center shaft. A locking collar secures the cam to the shaft. As the shaft rotates the ejection cam counterclockwise, (as seen in Figure 60) the cam-following roller must follow the groove of the cam.

Movements of Ejection Devices - When the cam groove is nearest the center of the cam, the cam-following roller will pull that end of the ejection cam lever down toward the center shaft. Since the lever is pivoting near its center, the opposite end of the cam lever will go up as the cam-follower end of the lever goes down. When the end of the lever connected to the ejection shaft is moved up, it causes the shaft to rise. When the ejection shaft is lifted, it in turn causes the ejection arm and pins to lift.

As the ejection cam continues to rotate, the groove in the cam starts to get closer to the outer edge of the cam. As the cam-following roller follows the groove toward the top of the cam, the opposite end of the lever begins to lower. The downward motion of the ejection cam lever causes the ejection shaft to pull down out of the ejection hopper, and that action causes the ejection pins to retract from the upper segment. As the groove of the ejection cam carries the ejection lever to its highest point, the ejection shaft should have the ejector pins fully retracted from the upper segment. At this point, the segment turret will rotate to move the present set of segments out of station 7, and another set into the station. After the next set of segments enters station 7, the faulty-capsule process is repeated.

Adjustments to Ejection Equipment - The turnbuckle screw at the bottom of the ejection shaft must be adjusted so that the shaft lifts the ejection pins to where they will go up into the capsule tops (held by the upper segment), but will not touch the capsule tops. If the capsule bottoms are still attached to their tops, the pins must extend far enough up to push both the capsule top and bottom out the top of the upper segment. On the down stroke, the ejector arm must be lowered enough to retract the pins completely out of the upper segment while at the same time not hitting the lower segment below the arm.

1.9.3 Faulty-Capsule Ejection Manifold and Hopper Housing

On the right-front edge of the segment turret's top cam is a small bracket with a compressed air hose attached to its left side, as seen from the front of the machine. This small bracket is the faulty-capsule manifold which has tiny air nozzles aimed outwardly toward the faulty-capsule ejection hopper. As the machine is running, jets of air from this manifold blows the dust and ejected capsules away from the segment turret and into the faulty-capsule ejection hopper. The machine operator needs to occasionally clean out the ejected capsules from the hopper. The machine can be run without the hopper housing installed, but the housing should be installed at all times since the hopper collects all the ejected faulty capsules.

When the machine is being disassembled for cleaning or maintenance, this hopper housing must be removed to reach the mounting screw holding the ejector arm onto the top of the faulty-capsule ejection shaft.

1.10 CAPSULE-CLOSING EQUIPMENT, CAMS, AND ASSOCIATED DEVICES

After the bad capsules have been taken out of the segments at the faulty-capsule ejection area of process station 7, the segment turret moves the segments on toward process stations 8 and 9. Between process stations 7 and 8, the shape of the cam groove under the segment turret's top cam and the cam-following roller on top of the upper segment holder makes the upper segment realign horizontally until the upper segment is over the lower segment. Figure 61 shows the cam groove under the top cam, and the cam-following roller on top of an upper segment holder.

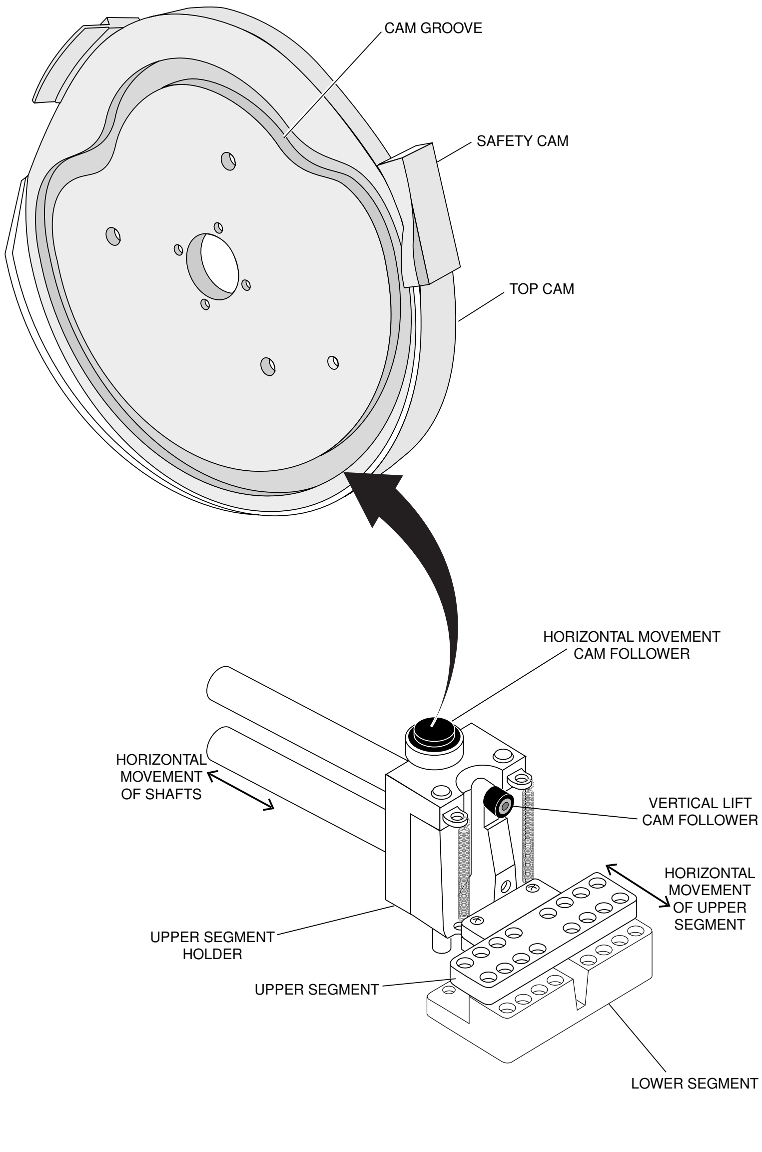

Figure 61. Segment Turret's Top Cam and Horizontal Cam-Following Roller of Upper Segment Holder

After the upper and lower segments have been realigned over each other between stations 7 and 8, they are brought vertically closer to each other between stations 8 and 9. As the segment turret moves the segments out of station 8, the cam-following roller attached to the upper segment holder rides along under the outer edge of the top cam. As the turret moves the segment holder and its vertical roller into process station 9, the roller pushes the holder down which in turn makes the upper segment move down until it is almost touching the top surface of the lower segment. Figure 62 shows where the upper segment holder's vertical cam-following roller contacts the outer edge of the top cam.

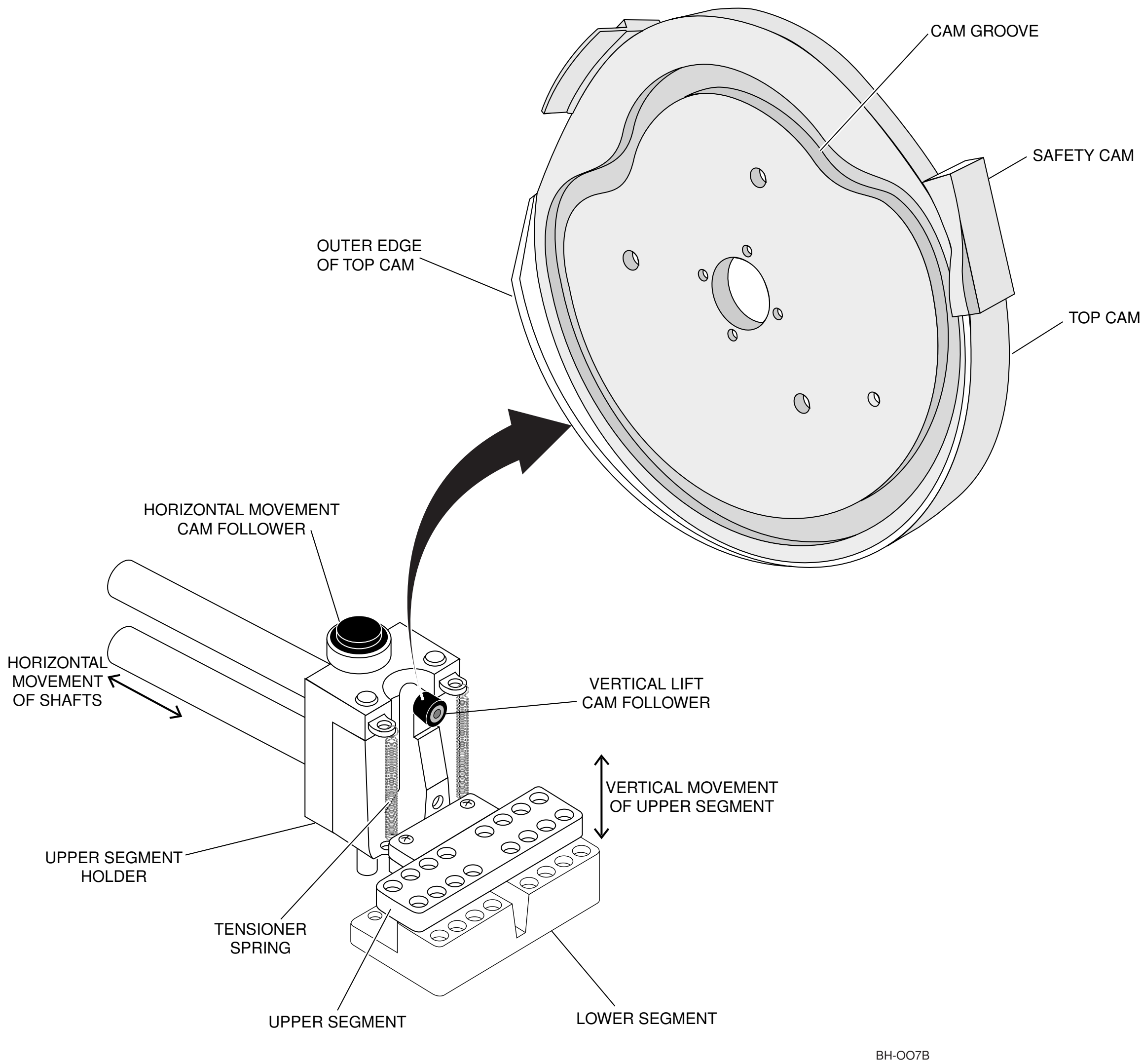

Figure 62. Segment Turret's Top Cam and Vertical Cam-Following Roller of Upper Segment Holder

After the segments leave process station 9, the capsule tops and bottoms are very close to each other and are ready to be reconnected. The capsule tops and bottoms are reconnected or closed in process station 10. Figure 63 shows the location of process stations 8, 9, and 10, along with the closing cam used with the capsule-closing equipment in station 10.

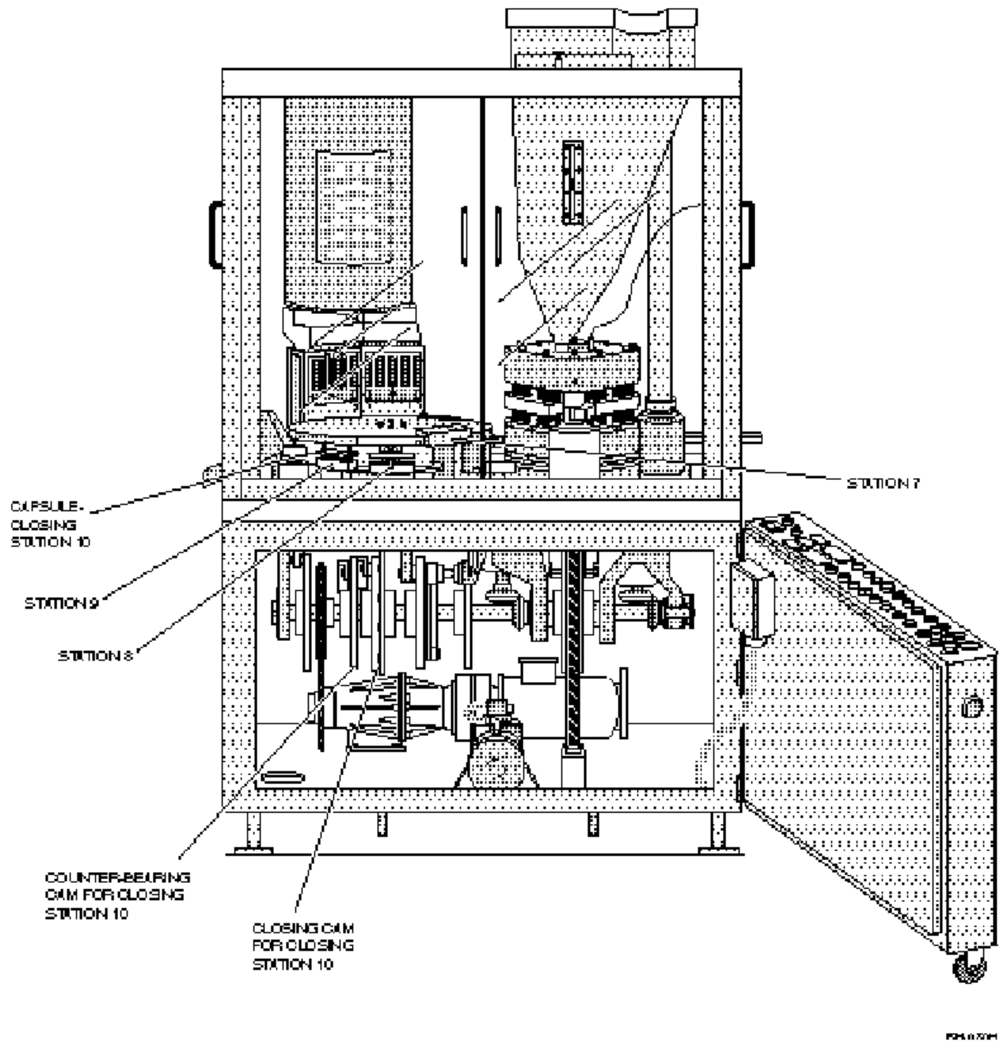

Figure 63. Locations of Closing Cams and Process Stations 8, 9, and 10

1.10.1 Station 10 Capsule-Closing Process

After the segment turret moves a set of capsule-filled segments into the machine's closing station 10, the closing devices within the station push down and up on the capsule ends to lock the capsule ends together.

The closing action is accomplished by two groups of mechanical devices working together, somewhat like a pair of pliers, to press the capsule tops onto the capsule bottoms. All of the closing devices are driven from two cams mounted on the left-center of machine's main cam. The closing equipment at station 10 is the only process station using two cams.

1.10.2 Capsule-Closing Devices

The station 10 closing devices are identified with one of the following groups:

- Counter-bearing devices
- Closing plunger (pin) devices

Figure 64 shows the location of the different components associated with station 10 and the closing cams.

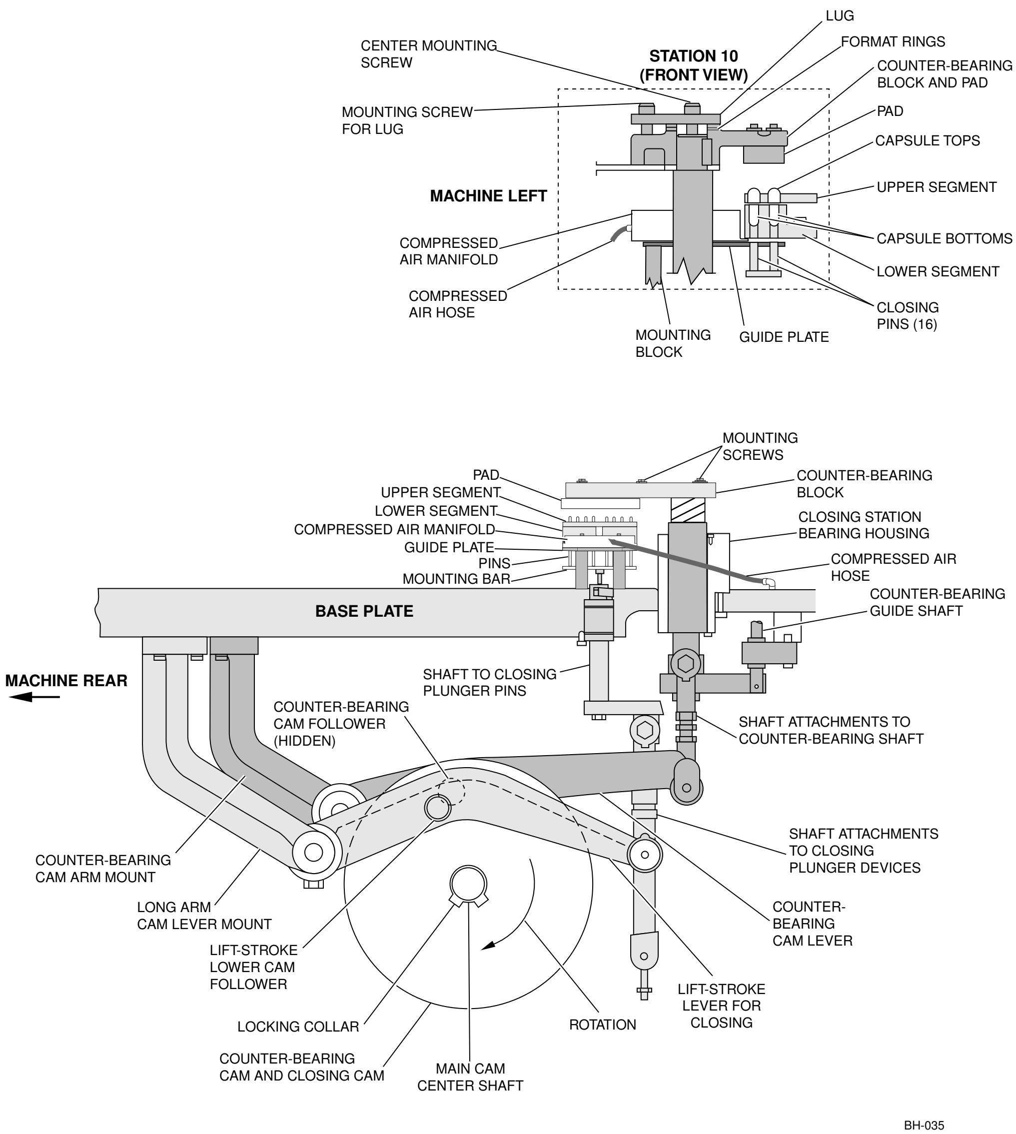

Figure 64. Location of Different Components Associated with Station 10 and Closing Cams

NOTE: The closing components at the bottom of Figure 64 are being viewed from the left side of the machine while the station 10 components shown at the top of the figure are viewed from the front of the machine.

Counter-Bearing Devices - The devices pressing down on top of the capsules are called the counter-bearing devices. The component that actually contacts the capsule tops is a flat pad connected to a mounting block positioned over the stopped segments. The counter-bearing block is attached to the top of a shaft mounted vertically through a bearing housing installed on top of the machine's base plate. An assortment of attachments links the bottom end of the counter-bearing shaft to a lever aligned horizontally along the right side of the counter-bearing cam, as seen from the front of the machine. *(The counter-bearing devices in Figure 64 are the darker devices.)* A cam-following roller attached to the counter-bearing lever rides inside a groove cut into the side of the counter-bearing cam. The end of the counter-bearing cam lever, nearest the rear of the machine, is connected to an arm mount bolted onto the bottom the base plate. The arm is called a counter-bearing cam arm mount. The lever-to-mount connection is the pivot point for the counter-bearing cam lever.

When the machine's drive motor rotates the center shaft of the main cam, the counter-bearing cam rotates (clockwise as seen in Figure 64), making the cam-following roller move inside the groove of the cam. When the groove of the cam is closest to the top of the disc, the counter-bearing block should be at its highest above the segment in station 10. As the cam continues to rotate, the cam groove is cut closer to the center of the cam, and further away from the top edge. As the roller continues following the groove, the groove pulls the roller further and further down. As the roller is being pulled down by the counter-bearing cam, the roller is pulling down on the counter-bearing cam lever. When the cam lever moves down with the roller, the lever also pulls the counter-bearing shaft down. When the counter-bearing shaft moves down, it in turn pulls the counter-bearing block and pad down toward the top of the upper segment. By the time the cam groove has pulled the cam follower roller to its lowest point, the pad should be down against the top of the upper segment. The result is that the pad will be in place to keep the capsule tops inside the upper segment from moving up and out the top of the segment during when the capsule bottoms get pushed up during the closing activities.

Closing Pins - Just below the lower segment (inside station 10) is a set of plunger pins pointing up toward the capsule bottoms held inside the lower segment. The tops of the plunger pins are close to, but not touching the lower segment itself. The closing station pins are timed to be lifted just after the counter-bearing pad comes down onto the top of the capsule tops inside the upper segment.

The lifting plunger pins are mounted onto a bar installed horizontally across the top of a vertically aligned shaft. The vertical shaft extends through the base plate and connect to another horizontally positioned bar below the base plate. The lower bar is mounted on top of a vertical shaft connected at its bottom end to a lever also aligned horizontally along the left side of the closing cam, as seen from the front of the machine. This lever, called the lift-stroke lever, also has a cam-following roller that rides inside a groove cut into the side of the closing cam. The opposite end of the closing cam lever is connected to a long arm mount bolted onto the bottom-rear area of the base plate.

Notice (in Figure 64) that the cam-following roller on the lift-stroke lever is positioned slightly to the left or behind the cam-following roller used with the counter-bearing cam lever. The purpose of off-setting these rollers is to make the lift-stroke lever start its upward movements just after the counter-bearing lever has lowered the counter-bearing pad onto the top of the capsule tops inside the upper segment.

Full-Cycle Closing Action - To see what happens with the two closing cams and their associated devices, one must watch a full cycle of closing actions. The cycle starts with the segment turret moving a set of segments into station 10.

As soon as the segments stop inside the station, the closing actions start with the counter-bearing devices lowering the counter-bearing pad onto the top of the upper segment. Almost immediately after the counter-bearing devices start their downward movements, the lift-stroke lever starts the upward movement of the closing plunger pins. The lift of the plunger pins must be adjusted precisely to ensure that the pins push the capsule bottoms up far enough to make them connect with the capsule tops, while not pushing so hard and so far that the pins indent the bottoms of the capsules being closed.

By the time the counter-bearing and closing cams have rotated half way, the plunger pins should have reached their highest movement. As the cams start into the second half of the rotational cycle, the groove of the closing cam will start moving the cam-following roller in the opposite direction to start retracting the plunger pins. Just after the closing cam starts retracting the plunger pins, the counter-bearing cam and associated devices start lifting the pad from the upper segment. As soon as the plunger pins have been retracted from the bottom segment, the main cam will cause the segment turret to rotate and move the set of segments out of the station.

Different Capsules - The closing pins used at station 10 are cupped at their top ends. Differently sized capsules will require differently sized closing pins. The length of all closing pins is the same, but the outer diameter of the pins differ, depending upon which capsules are being run. The cupped tops of the pins must fit the bottom ends of the capsules.

Adjustments - The position of the counter-bearing pad is critical to the closing process. It must be low enough to hold the capsule tops in place until the bottoms can be connected, but at the same time not too low or the capsules will get crushed. The format rings at the top of the counter-bearing shaft can be mixed and matched to adjust the position of the counter-bearing block and pad. On the opposite side, the closing pins can be adjusted by the turnbuckle on the closing shaft.

1.11 FINAL CAPSULE-EJECTION EQUIPMENT, CAM, AND ASSOCIATED DEVICES

After the capsules are closed in station 10, the segment turret shifts again to carry the segments and closed capsules into station 11 where the finished capsules are removed from the segments and ejected out a discharge chute located on the left side of the machine. Figure 65 shows the location of both the final-ejection cam and the capsule-ejection equipment at station 11.

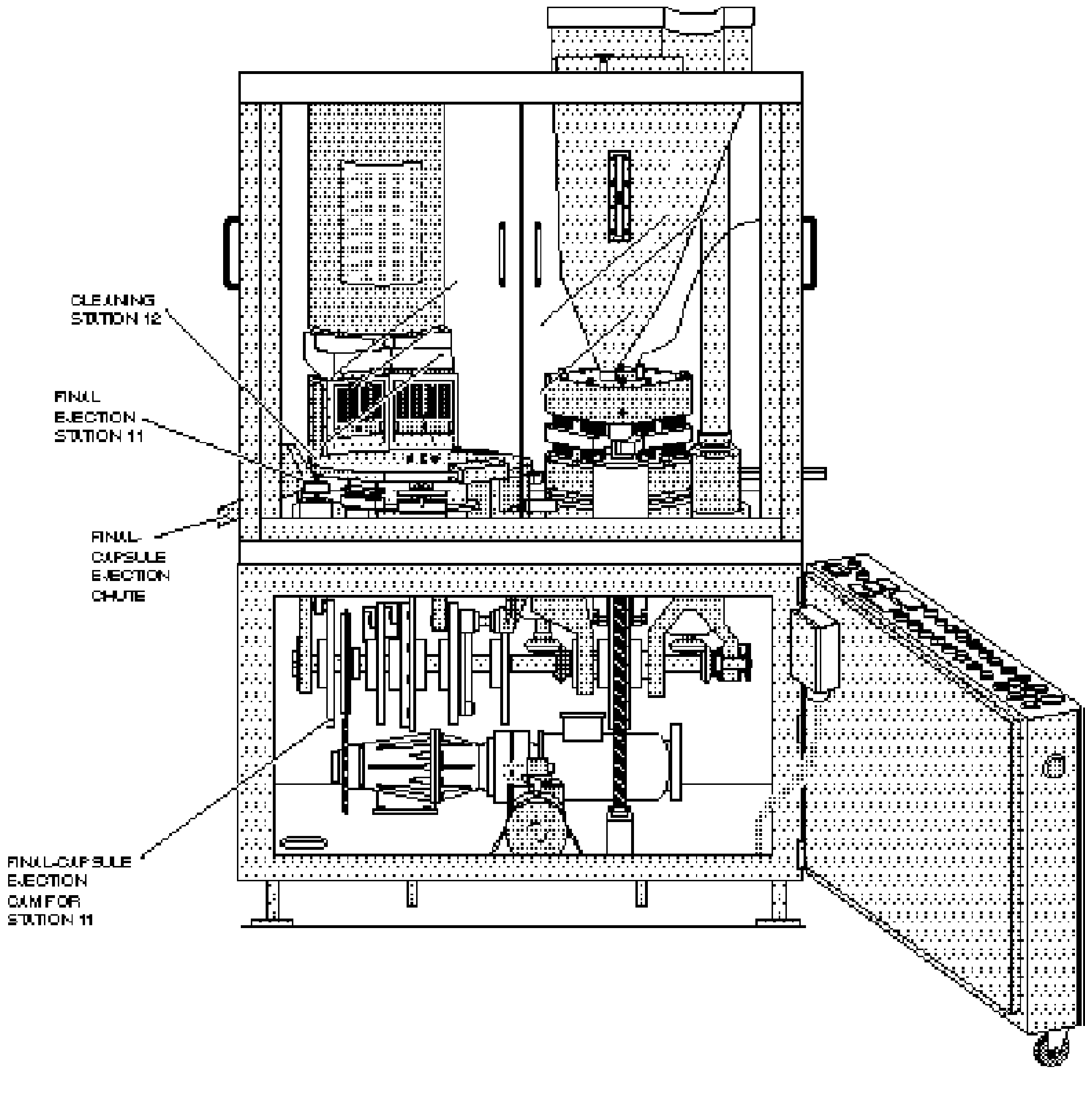

Figure 65. Location of Final-Ejection Cam and Station 11 Equipment

When observed from the front of the machine, the final-ejection cam is mounted at the extreme left end of the main cam. This cam is used with its cam-following roller and shaft to move the ejection plunger pins up and down within the capsule-ejection equipment located at process station 11. Figure 66 shows a close-up view of the final-ejection station 11 components, as seen from the front of the machine.

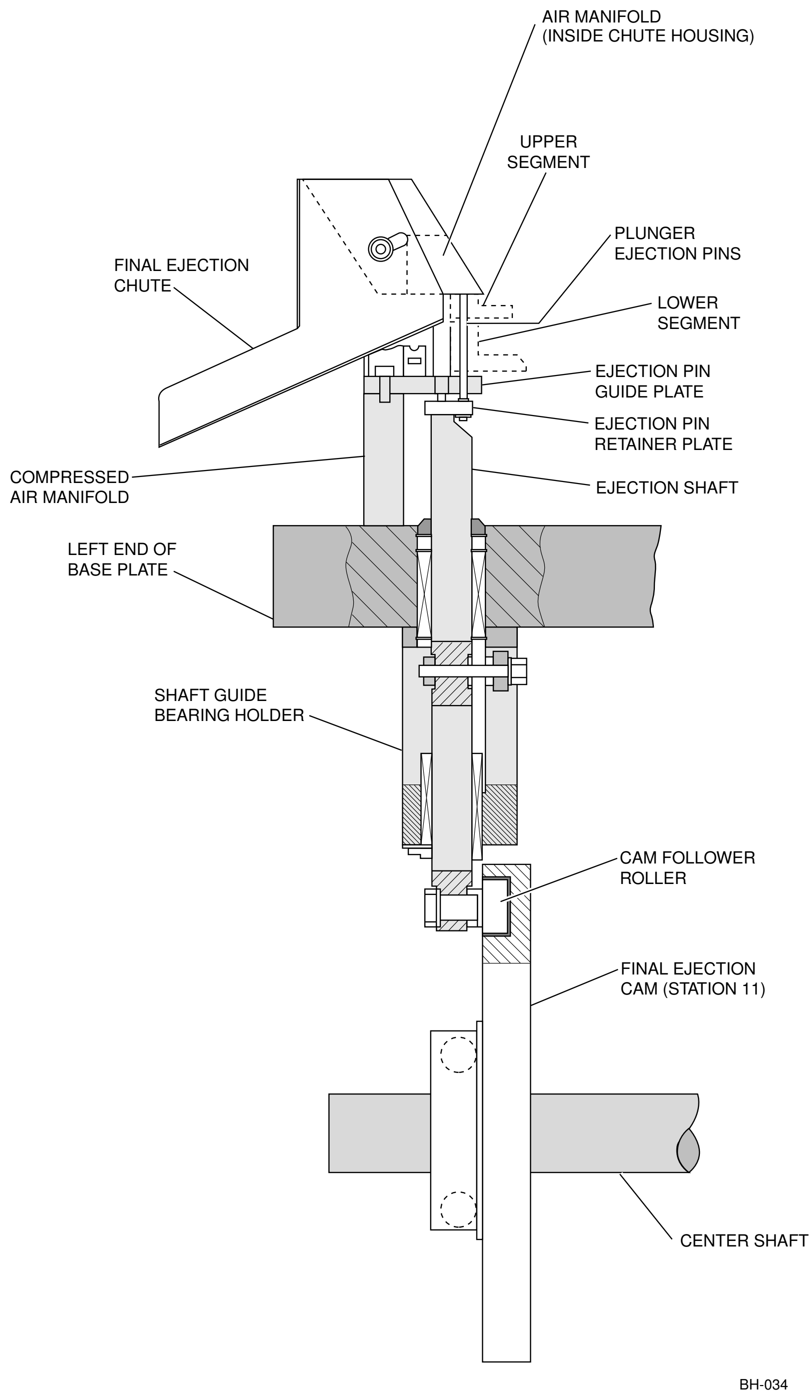

Figure 66. Final-Ejection Station 11 Components

1.11.1 Ejection Process

After the segment turret has moved the segments containing the filled capsules into the station, the center shaft of the main cam will cause the ejection cam to start moving the ejection shaft in an upward direction. On the upward stroke, the components driven by the ejection shaft lift the small plunger pins up through the lower and upper segments. The tops of the plunger/ejection pins will be pushing against the bottoms of the capsules in the segments. At the peak of the upward movement, the plunger pins will have pushed the finished capsules out the top of the upper segments. A flow of air from an air manifold inside the chute housing carries the capsules out of the process station, down the ejection chute, and out of the machine.

1.11.2 Ejection Pin Withdrawal

As the main cam rotates the ejection cam past the point of top-dead center, the cam starts pulling the cam follower back down. As a result of the cam and cam follower actions, the plunger-pin devices move in a downward motion, causing the pins to withdraw from the upper and lower segments.

After the pins have fully withdrawn from the segments, the main cam rotates the segment turret forward one position, moving the set of empty segments out of the station 11 area, and another set of loaded segments into the ejection station. The empty segments are move from the station 11 area to the station 12 area where they are cleaned before being reused. Station 12 has no association to the main cam.