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Selvamanickam et al.

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(54) **REEL-TO-REEL SUBSTRATE TAPE POLISHING SYSTEM**

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Related U.S. Application Data

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(51) **Int. Cl.**[7] **B24B 7/13**

(52) **U.S. Cl.** **451/28**; 451/57; 451/176

(58) **Field of Search** 451/176, 105, 451/107, 109, 110, 28, 57, 59

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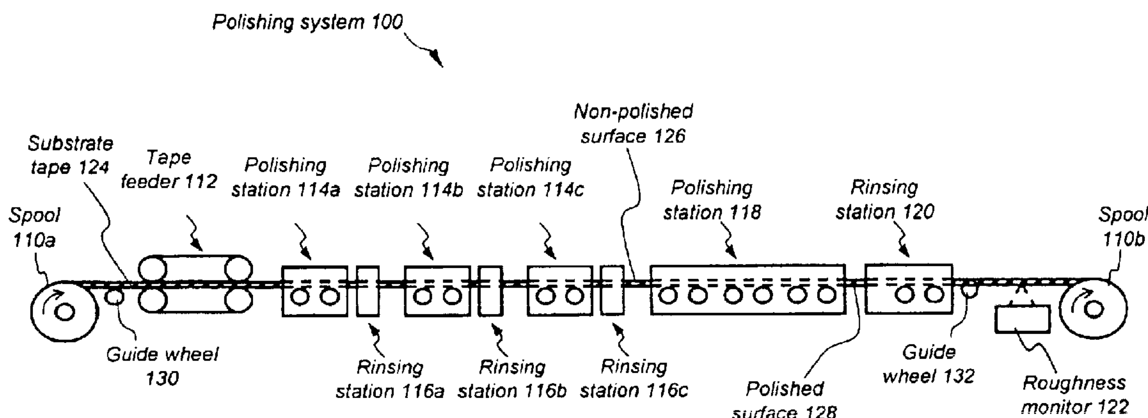
(57) **ABSTRACT**

Disclosed is a reel-to-reel single-pass mechanical polishing system (**100**) suitable for polishing long lengths of metal substrate tape (**124**) used in the manufacture of high-temperature superconductor (HTS) coated tape, including multiple instantiations of a polishing station (**114**) in combination with a subsequent rinsing station (**116**) arranged along the axis of the metal substrate tape (**124**) that is translating between a payout spool (**110***a*) and a take-up spool (**110***b*). The metal substrate tape obtains a surface smoothness that is suitable for the subsequent deposition of a buffer layer.

16 Claims, 11 Drawing Sheets



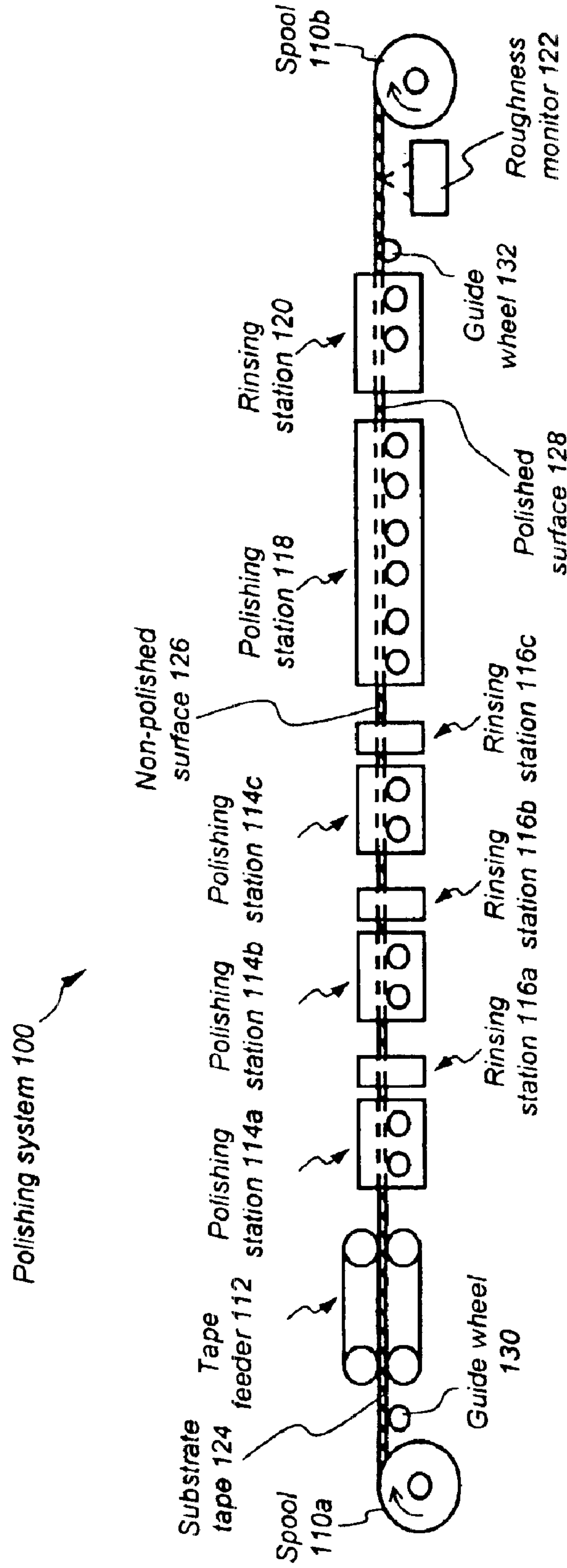


FIG. 1

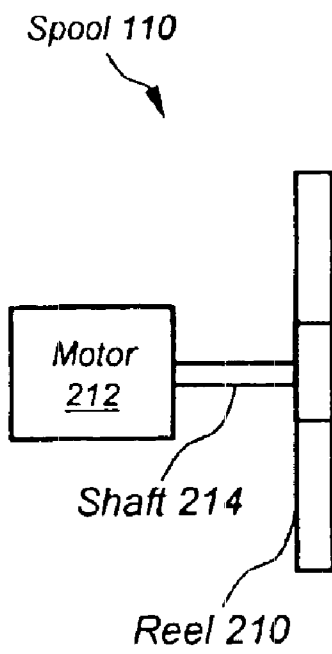


FIG. 2A

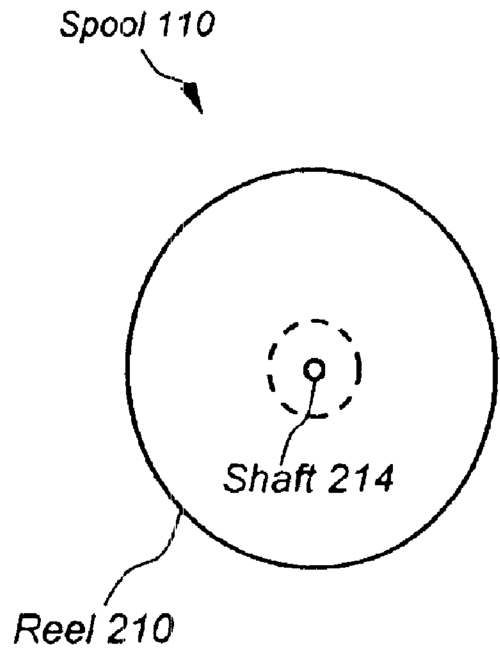


FIG. 2B

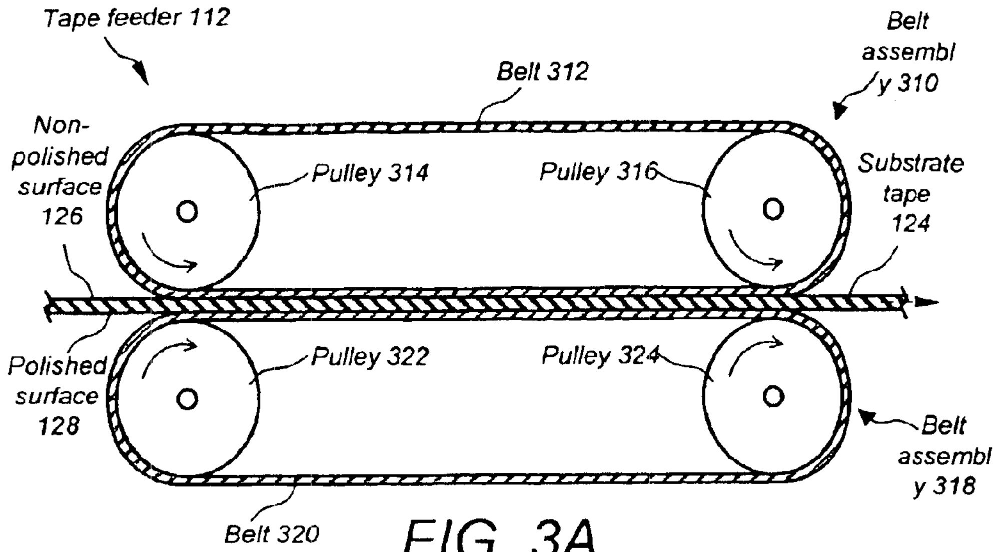


FIG. 3A

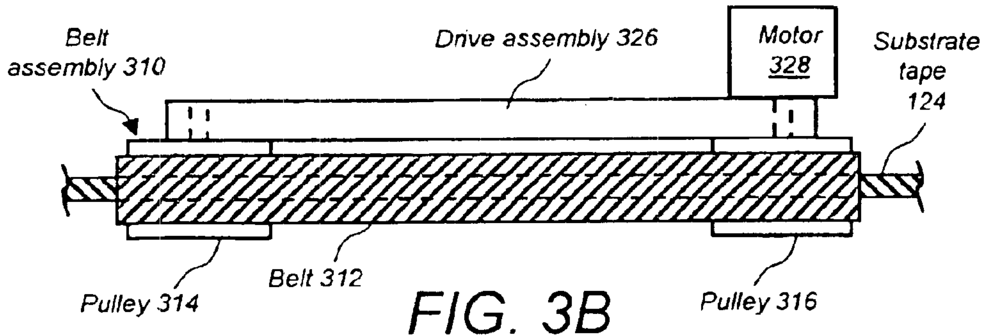


FIG. 3B

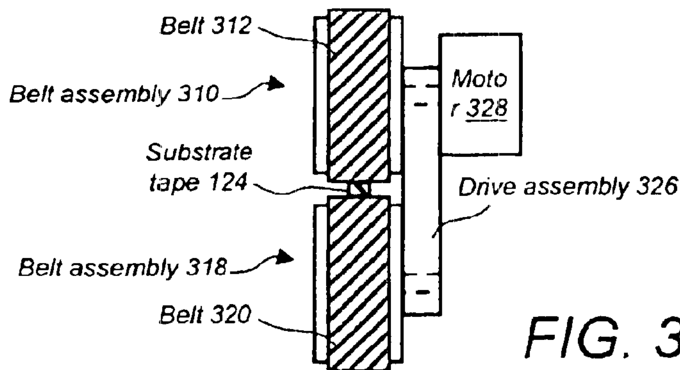


FIG. 3C

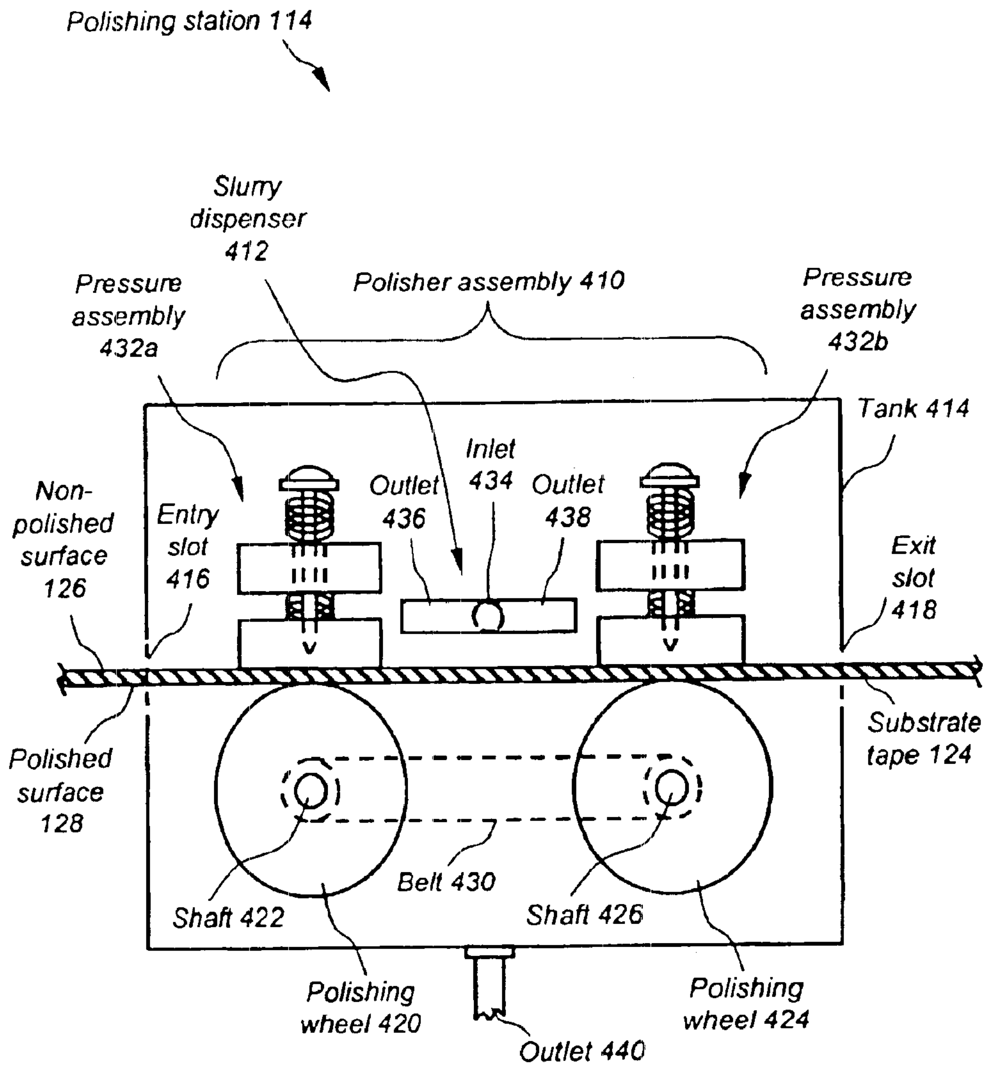


FIG. 4A

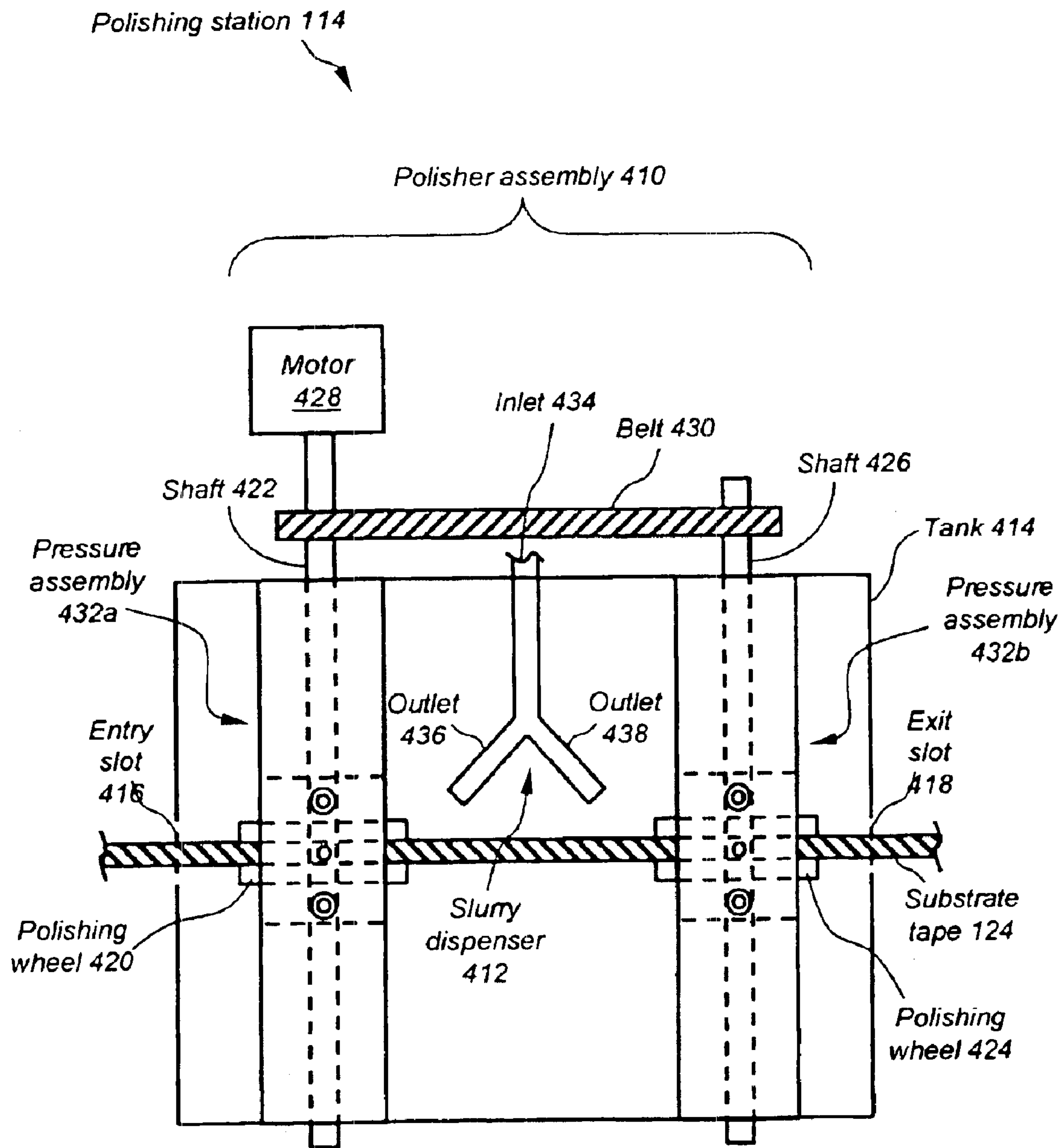


FIG. 4B

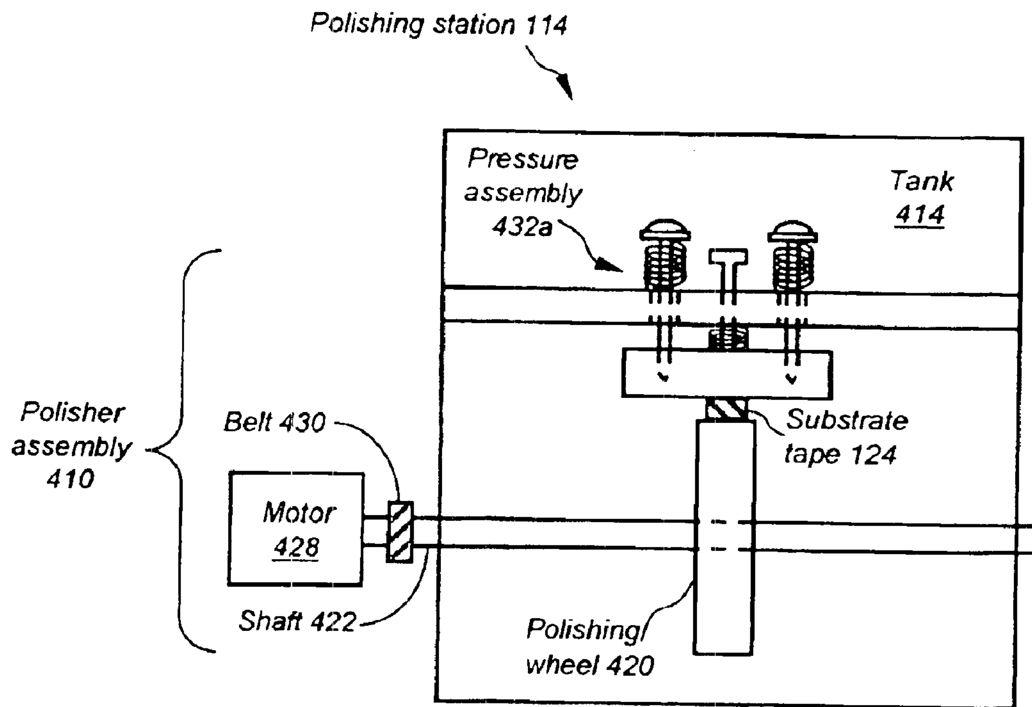


FIG. 4C

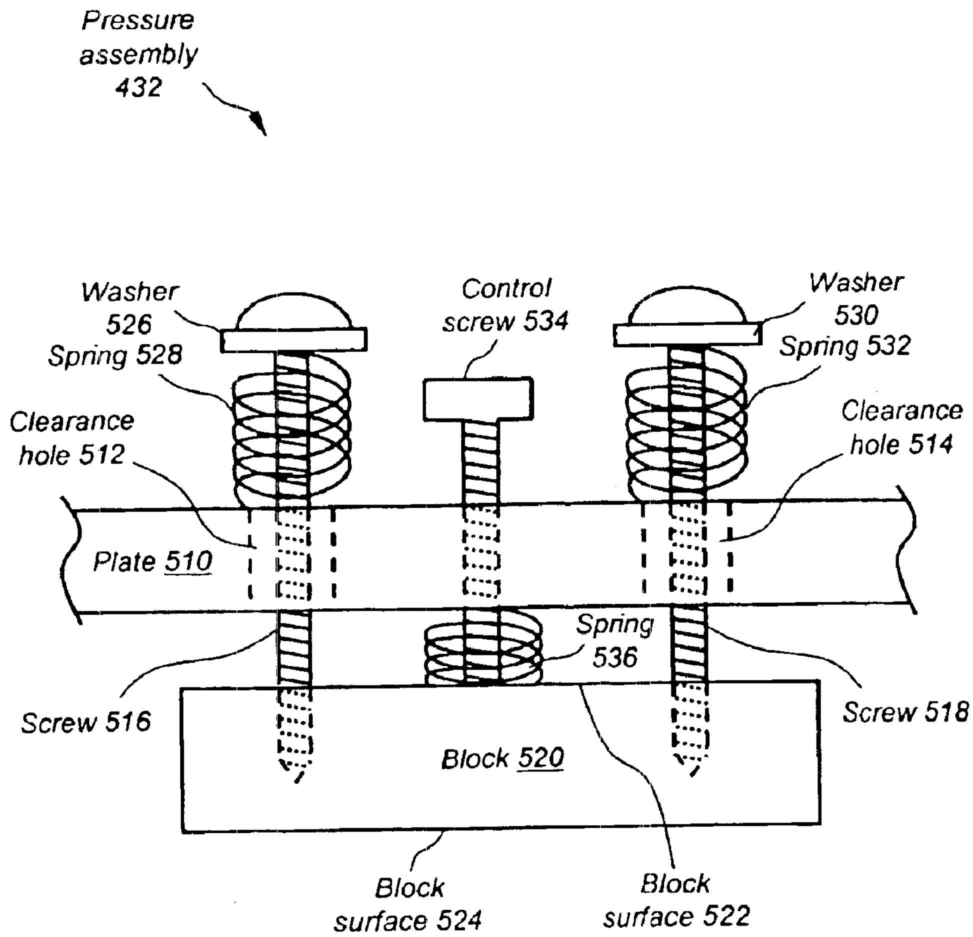


FIG. 5

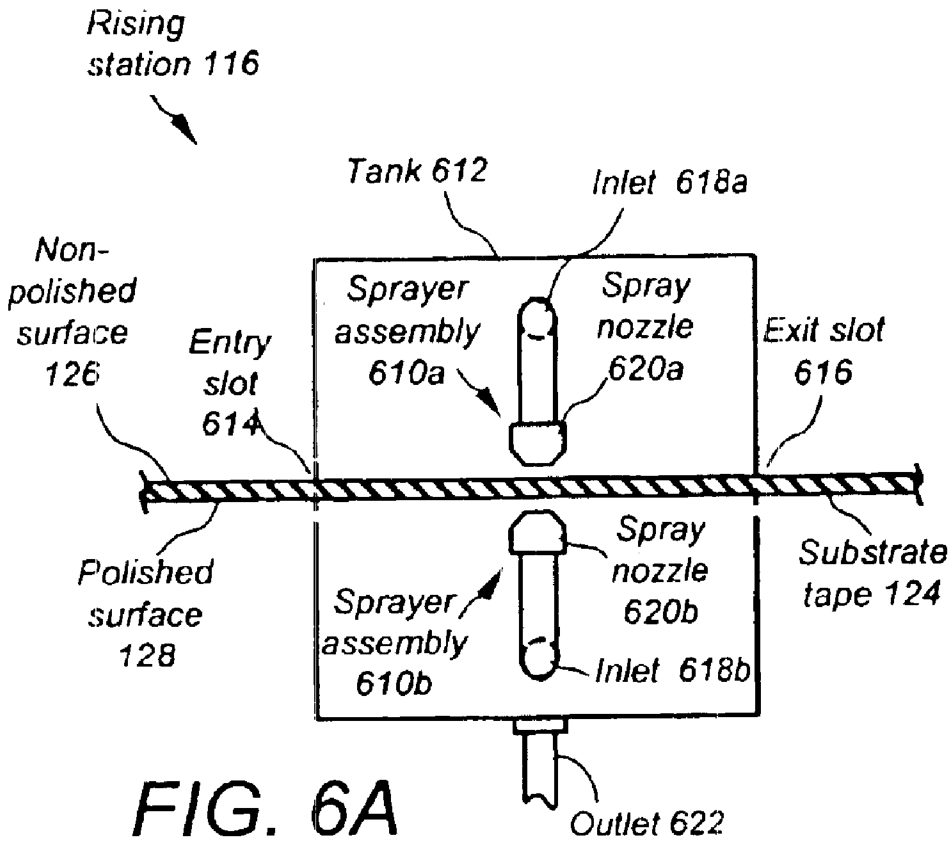


FIG. 6A

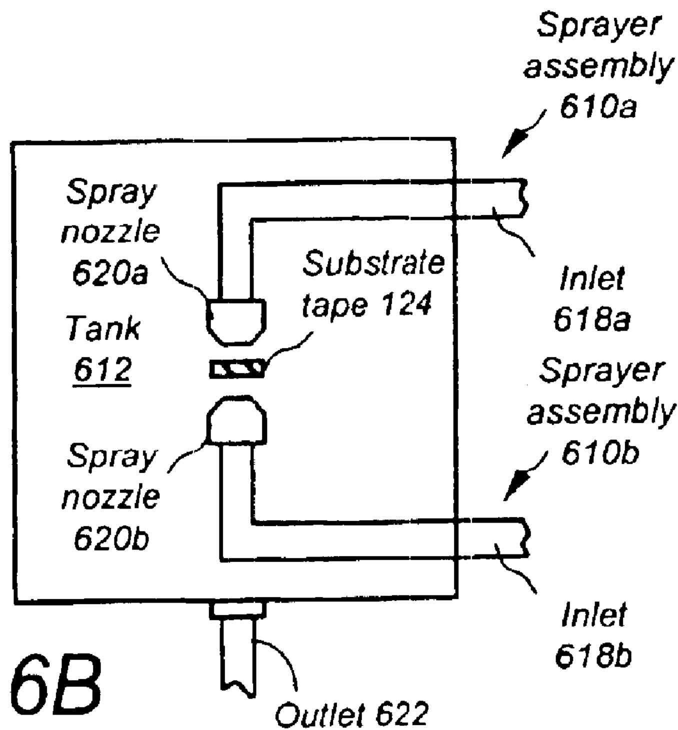


FIG. 6B

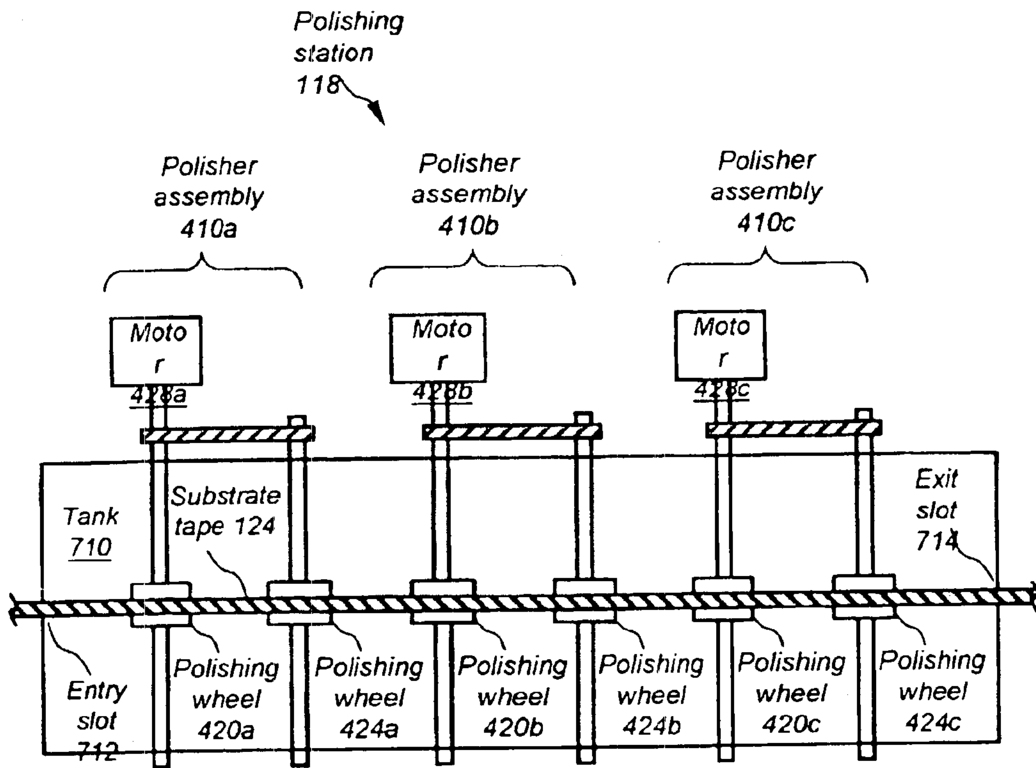


FIG. 7

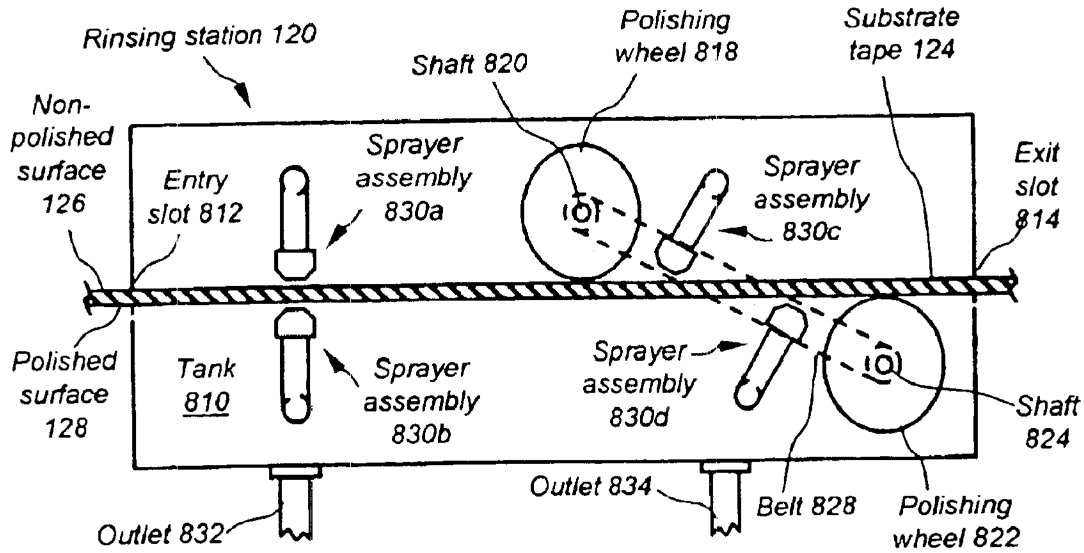


FIG. 8A

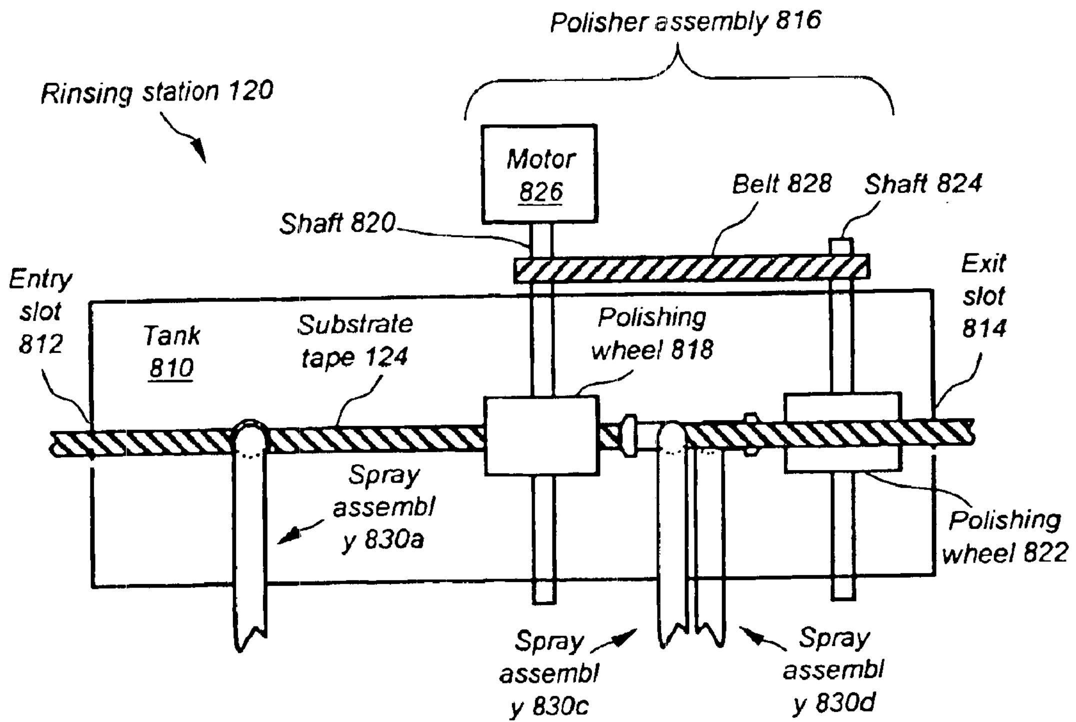


FIG. 8B

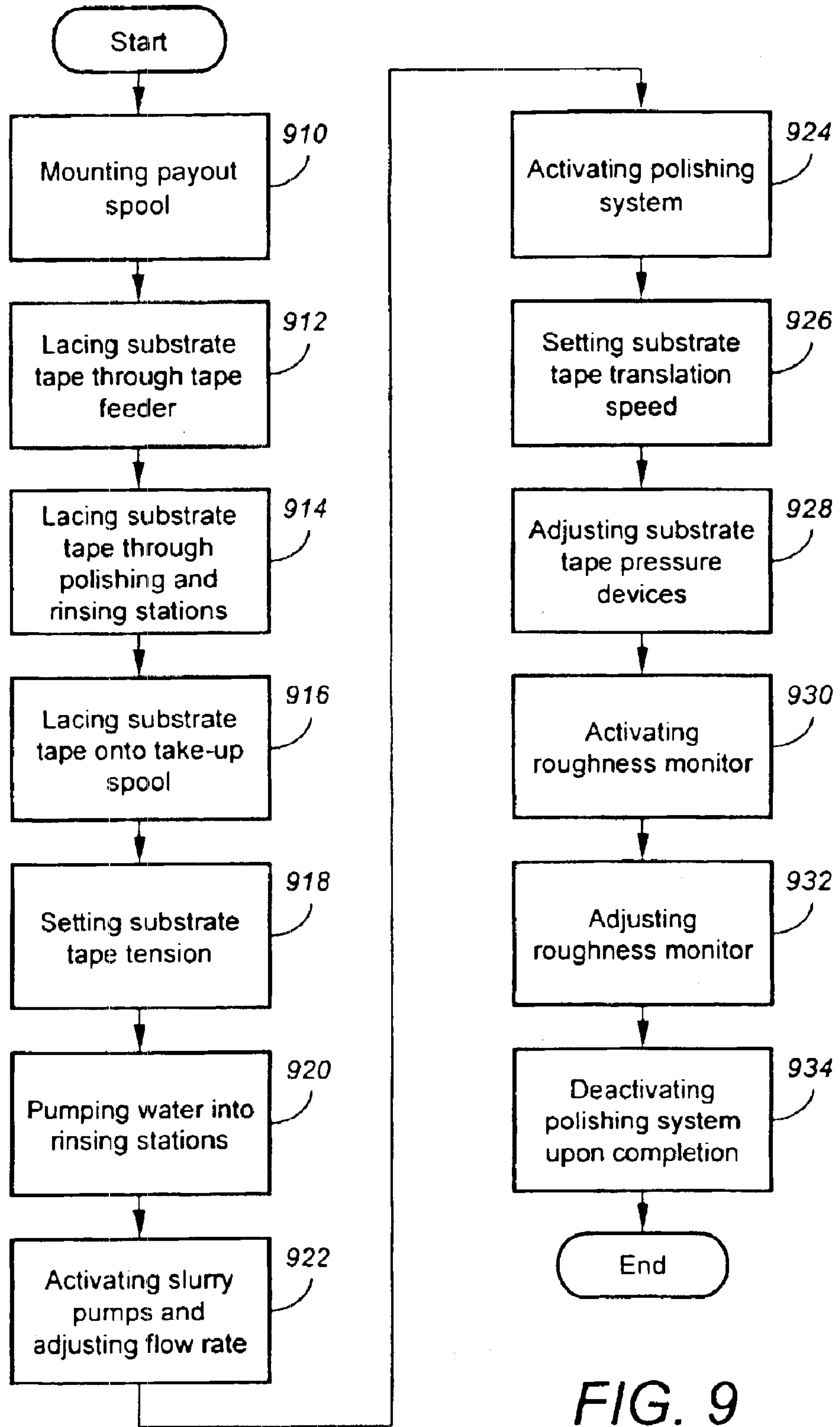


FIG. 9

REEL-TO-REEL SUBSTRATE TAPE POLISHING SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from provisional application U.S. Ser. No. 60/273,195 filed Mar. 2, 2001.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

This invention was conceived while working under a government contract with the New York State Energy Research and Development Agency under reference 4466L-IABR-IA99.

FIELD OF THE INVENTION

The present invention relates to the field of mechanical polishing. More particularly, the present invention relates to a system for mechanical polishing of long lengths of translating metal substrate tape used in the manufacture of high-temperature superconductor (HTS) tape.

BACKGROUND OF THE INVENTION

Wire forms the basic building block of the world's electric power system, including transformers, transmission and distribution systems, and motors. The discovery of revolutionary HTS compounds in 1986 led to the development of a radically new type of wire for the power industry; this discovery is the most fundamental advance in wire technology in more than a century. However, to date only short samples of the HTS-coated tape used in the manufacture of next-generation HTS wires have been fabricated at high performance levels. In order for HTS technology to become commercially viable for use in the power generation and distribution industry, it will be necessary to develop techniques for continuous, high-throughput production of HTS-coated tape.

A typical HTS tape is a 3-layer laminate of a support layer, a buffer layer and a HTS film. The support layer is typically composed of stainless steel or nickel and provides structural integrity and flexibility to the tape. The buffer layer buffer layer is disposed between the metal substrate and the HTS film to prevent reaction between the substrate and the HTS film and, importantly, acts as a template for epitaxial growth of the HTS film. Typical buffers are yttrium-stabilized zirconia (YSZ) or cerium oxide (CeO_2). The HTS film is formed of, for example, yttrium-barium-copper-oxide (YBCO).

Presently, substrates are polished by well-known mechanical, chemical, or electrical means to achieve a high degree of planarity or surface smoothness. Planarity is important in the manufacture of integrated circuits and numerous processes have been developed to meet the requirement of achieving a high degree of surface smoothness in the silicon wafer substrates used in manufacturing such electronic components.

One type of polishing process, mechanical polishing, holds a stationary substrate on a rotating pad and presses it against a conformable rotating polishing pad. Mechanical polishing may be performed in conjunction with a chemically active abrasive solvent slurry, a process commonly referred to a chemical mechanical polishing, which provides a higher material removal rate.

The abrasive slurry is typically comprised of small very hard particles such as diamond or boron oxide. The size of the particles used and other parameters, such as rotation speed, duration and contact force determine the removal rate and eventual roughness of the substrate.

In order to achieve high current densities in the HTS film, one of the main requirements is that the substrate be very smooth, with minimal surface imperfections. When the coatings are in form of thin films (up to 10 microns), the surface quality of the substrate becomes critical. Defects in the surface of the metal substrate can lead to voids, delamination, undesired texture, and roughness in the coatings. Furthermore, these imperfections or roughness on the substrate surface can be transmitted through the intermediate buffer layer and lead to a defect in the HTS film, which in an HTS-coated tape application must have a high degree of planarity, with minimal surface imperfections over long lengths.

A number of surface polishing techniques are known to the art. One such polishing technique is described in Kubo, U.S. Pat. No. 5,938,502, dated Aug. 17, 1999 and entitled "Polishing Method Of Substrate And Polishing Device Therefor". Kubo describes a method employing a polishing pad and a slurry. The polishing device includes a bed formed with a polishing pad on the surface and driven for rotation, a rotatable carrier for holding the substrate to be polished, and a slurry supply means for supplying a slurry as an abrasive to the surface of the polishing pad. The substrate is polished by the abrasive slurry and the polishing pad, while pressing the substrate held by the carrier onto the polishing pad. Kubo's polishing technique may require several passes to achieve the smoothness required for an HTS-coated tape application.

Kubo's technique however, is applicable only to stationary substrates and is not suitable for the polishing of long lengths of continuously translating substrate tape. Furthermore, in the manufacturing of HTS-coated tape it is preferable to complete the surface preparation of the substrate in one pass so as to increase throughput and reduce cost. Thus, another drawback of Kubo's polishing technique is that it requires several passes and is therefore not suitable to a process for polishing long lengths of continuously translating substrate tape.

Shendon, U.S. Pat. No. 6,336,851, dated Jan. 8, 2002 and entitled "Substrate Belt Polisher," describes a flexible membrane-polishing belt against which a substrate for a semiconductor wafer is polished using chemical mechanical polishing principles. A fluidized layer is provided on a surface of a polishing member backing assembly, which urges the moving polishing membrane toward the substrate held in a polishing head. The linear motion of the belt provides uniform polishing across the full width of the belt and provides the opportunity for a chemical mechanical polishing to take place. Several configurations are disclosed. They include belts which are wider than the substrate being polished, belts which cross the substrate being polished, but which provide relative motion between the substrate and the polishing belt, and polishing belt carriers having localized polishing areas which are smaller than the total area of the substrate to be polished. Only a small area on the surface of the substrate is in contact with polishing membrane but the motion of the carrier with respect to the substrate is programmed to provide uniform polishing of the full substrate surface, as is each configuration described.

Jackson et al., U.S. Pat. No. 6,241,591, dated Jun. 5, 2001, and entitled "Apparatus And Method For Polishing A Substrate," describes a polishing apparatus. Uniform pressure distribution allows a semiconductor substrate polished

with the polishing apparatus to have reduced edge exclusion, and thus increased die yield.

Nagahara et al., U.S. Pat. No. 6,179,690, dated Jan. 30, 2001, entitled "Substrate Polishing Apparatus," describes a chemical mechanical polishing apparatus that includes a rotating plate on which a substrate is received, and a polishing pad, which moves across the substrate as it rotates on the plate to polish the substrate. The load of the pad against the substrate, and the rotary speed of the plate, may be varied to control the rate of material removed by the pad.

Sarfaty et al., U.S. Pat. No. 5,741,171, dated Apr. 21, 1998 and entitled "Precision Polishing System," describes a polishing system able to polish samples to accuracy within the sub micron range. The polishing system has applications in the semiconductor field for use in polishing silicon wafers during testing and quality control inspections.

However, none of these prior art polishing systems are capable of solving the problem existing during the manufacture of HTS tape, viz. how to polish a continuously moving length of material in a single pass.

It is an object of this invention to provide a polishing system amendable to continuous production of HTS tape in a one-pass operation.

It is therefore an object of the invention to provide a system and method for surface preparation of long lengths of metal substrates in a continuous manner.

It is another object of the invention to provide a polishing system and method for producing a surface roughness of the substrate that is of very high quality, suitable to achieve high current densities in long lengths of superconducting tapes, in a single polishing pass.

SUMMARY

The polishing system of the present invention is a reel-to-reel single-pass continuous mechanical polishing system suitable for polishing long lengths of metal substrate tape used in the manufacture of HTS-coated tape. The polishing system of the present invention includes multiple instantiations of a surface treatment unit, each comprising a polishing station in combination with a subsequent rinsing station arranged along the axis of a metal substrate tape that is continuously translating between a payout spool and a take-up spool. By translating through the multiple instantiations of a polishing station in combination with a subsequent rinsing station, the metal substrate tape experiences a series of polishing and cleaning events to progressively diminish its surface roughness and achieve a surface smoothness that is acceptable for depositing a buffer layer for use in the manufacture of HTS-coated tape.

More specifically, disposed within each polishing station are multiple polishing wheels upon which is dispensed a polishing medium, such as a slurry formed by mixing an abrasive material and water. Within each polishing station one surface of the translating metal substrate tape is in contact under pressure with the polishing wheels and polishing medium. As the HTS tape translates through the polishing operation, the surface imperfections are gradually removed by varying the parameters of the process, such as size and hardness of the abrasive.

The hardness of the polishing wheels disposed within the successive polishing stations typically varies from very hard to hard to soft as the relative position of the polishing stations progress along the line from the front end of the polishing system (the payout spool) to the back end of the polishing system (the take-up spool). The particle size of the polishing medium used in the successive polishing stations ranges, for example, from 1.0 to 0.3 to 0.05 microns as the relative position of the polishing stations progress along the line from the front end of the polishing system to the back end of the system. In this way, the metal substrate tape experiences, via progressive stages, rougher to finer polishing events, each in combination with a respective rinsing event, as it translates through the polishing system, thereby achieving in a single pass through the polishing system a surface smoothness that is suitable for the subsequent deposition of a buffer layer.

The translation of the metal substrate tape through the polishing system is accomplished via a tape feeder assembly that is driven by a stepper motor for providing a controlled rate of translation to allow the proper exposure time of the metal substrate tape to the polishing and cleaning events. The tape feeder assembly operates in combination with the payout spool and the take-up spool that are each driven by a torque motor for controlling the tension of the metal substrate tape as it translates through the polishing system of the present invention.

Lastly, the polishing system of the present invention includes an optical surface roughness measurement gage at the back end of the polishing system for monitoring the finished surface quality of the metal substrate tape.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a high-level diagram of a polishing system of the present invention suitable for polishing long lengths of metal substrate tape used in the manufacture of HTS-coated tape.

FIGS. **2**A and **2**B illustrate a side view and a front view, respectively, of a spool suitable for use as the payout and take-up spool within the polishing system of the present invention.

FIGS. **3**A, **3**B, and **3**C illustrate a side view, a top view, and an end view, respectively, of a substrate tape drive mechanism suitable for use as the tape feeder apparatus within the polishing system of the present invention.

FIGS. **4**A, **4**B and **4**C illustrate a side view, a top view, and an end view, respectively, of a mechanical polisher suitable for use as a polishing station within the polishing system of the present invention.

FIG. **5** illustrates a side view of a pressure device suitable for use within the polishing station illustrated in FIGS. **4**A, **4**B and **4**C.

FIGS. **6**A and **6**B illustrate a side view and an end view, respectively, of a substrate tape cleaning mechanism suitable for use as a rinsing station within the polishing system of the present invention.

FIG. **7** illustrates a top view of a mechanical polisher suitable for use as the final polishing station within the polishing system of the present invention.

FIGS. **8**A and **8**B illustrate a side view and a top view, respectively, of a substrate tape cleaning mechanism suitable for use as the final rinsing station within the polishing system of the present invention.

FIG. **9** is a flow diagram illustrating a method of operation of the polishing system of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** illustrates a polishing system **100** in accordance with the invention. The polishing system **100** of the present

invention is a mechanical polishing system suitable for polishing long lengths of metal substrate tape used in the manufacture of HTS-coated tape.

The polishing system **100** includes multiple instantiations of a spool **110** (i.e., a spool **110***a* and a spool **110***b*). The spool **110***a* serves as a payout spool located at the entry point of the polishing system **100**. Upon the spool **110***a* is wound a length of substrate tape **124** that is formed of metals, such as stainless steel or a nickel alloy such as Inconel. The substrate tape **124** has a non-polished surface **126** and a polished surface **128**. The substrate tape **124** is capable of withstanding high temperatures and vacuum conditions, and is typically between 3 mm and 1 cm in width and upwards of several hundred meters in length. The substrate tape **124** typically has several meters of "leader" at both ends to aid in handling. The substrate tape **124** is laced through the polishing system **100** from the spool **110***a* and wound onto the spool **110***b* that serves as a take-up spool at the exit point of the polishing system **100**. Each spool **110** is driven by a torque motor and is described in detail in FIGS. **2**A and **2**B.

The polishing system **100** further includes a tape feeder **112** that is a set of motor-driven belts that serve as the driving mechanism for translating the substrate tape **124** through the polishing system **100**. The tape feeder **112** also guides the substrate tape **124** from the spool **110***a* into a first instantiation of a polishing station **114**. The tape feeder **112** is described in detail in FIGS. **3**A and **3**B.

The polishing system **100** further includes multiple instantiations of a polishing station **114**, for example, a polishing station **114***a*, a polishing station **114***b*, and a polishing station **114***a*; where each polishing station **114** includes a stainless steel tank containing a set of polishing wheels that contact the substrate tape **124** in combination with a polishing medium, such as aluminum oxide. Furthermore, each polishing wheel within the polishing station **114** has an associated pressure device for applying pressure upon the substrate tape **124** against the respective polishing wheel. The polishing station **114** is described in detail in FIGS. **4**A, **4**B, and **4**C. The pressure device is described in detail in FIG. **5**.

The polishing system **100** further includes multiple instantiations of a rinsing station **116**, for example, a rinsing station **116***a*, a rinsing station **116***b*, and a rinsing station **116***c*; where each rinsing station **116** includes a stainless steel tank containing a sprayer assembly for applying de-ionized water or standard tap water to the substrate tape **124** for rinsing the polishing medium from the substrate tape **124**. The rinsing station **116** is described in detail in FIGS. **6**A and **6**B.

The polishing system **100** further includes a polishing station **118** that serves as a final polishing station; where the polishing station **118** includes a stainless steel tank containing multiple sets of polishing wheels that contact the substrate tape **124** in combination with a polishing medium, such as aluminum oxide. Furthermore, each polishing wheel within the polishing station **118** has an associated pressure device for applying pressure upon the substrate tape **124** against the respective polishing wheel. The polishing station **118** is described in detail in FIG. **7**.

The polishing system **100** further includes a rinsing station **120** that serves as a final rinsing station; where the rinsing station **120** includes a stainless steel tank containing multiple sprayer assemblies for applying de-ionized water or standard tap water to the substrate tape **124** for rinsing the polishing medium from the substrate tape **124**. Furthermore, the rinsing station **120** includes a set of soft polishing wheels for removing the last remaining residue of the polishing medium. The rinsing station **120** is described in detail in FIGS. **8**A and **8**B.

With continuing reference to FIG. **1**, all elements of the polishing system **100** are arranged in a line along the axis of the substrate tape **124** formed between the spool **110***a* and the spool **110***b*. More specifically, the substrate tape **124** is unwound from the spool **110***a* and is laced through the tape feeder **112**, then subsequently through the first polishing station **114** (i.e., polishing station **114***a*), then subsequently through the first rinsing station **116** (i.e., rinsing station **116***a*), then subsequently through the second polishing station **114** (i.e., polishing station **114***b*), then subsequently through the second rinsing station **116** (i.e., rinsing station **116***b*), then subsequently through the third polishing station **114** (i.e., polishing station **114***c*), then subsequently through the third rinsing station **116** (i.e., rinsing station **116***c*), then subsequently through the polishing station **118**, then lastly through the rinsing station **120** and onto the spool **110***b*.

Disposed between the spool **110***a* and the tape feeder **112** is a guide wheel **130**. Likewise, disposed between the rinsing station **120** and the spool **110***b* is a guide wheel **132**. The guide wheels **130** and **132** are in contact with the polished surface **128** of the substrate tape **124** and assist in supporting and guiding the substrate tape **124** as it translates along the polishing system **100**. The guide wheels **130** and **132** are formed of a material that is not damaging to the polished surface **128** of the substrate tape **124**, such materials include Teflon or soft rubber.

Lastly, and optionally, the polishing system **100** includes a roughness monitor **122** disposed between the guide wheel **132** and the spool **110***b* and directed at the polished surface **128** of the substrate tape **124**. The roughness monitor **122** is mounted on a 3-axis adjustable stage (not shown), such that its position relative to the polished surface **128** of the substrate tape **124** may be adjusted. The distance between the substrate tape **124** and the roughness monitor **122** is set appropriately for measuring roughness to the required accuracy. The roughness monitor **122** provides a quality check mechanism at the exit point of the polishing system **100**. The roughness monitor **122** is an optical surface roughness measurement gage, such a LASER^{CHECK} device manufactured by Optical Dimensions LLC, which is designed to measure the surface roughness over which it passes. In the case of the polishing system **100** of the present invention, the roughness monitor **122** provides an average surface roughness of the polished surface **128** of the substrate tape **124**.

FIGS. **2**A and **2**B illustrate a side view and a front view, respectively, of the spool **110** that is suitable for use as the payout spool (i.e., the spool **110***a*) and take-up spool (i.e., the spool **110***b*) of the polishing system **100** of the present invention. The spool **110** includes a reel **210** mechanically connected to a motor **212** via a rotatable shaft **214**. The reel **210** is a reel upon which the substrate tape **124** is wound. The diameter and width of the reel **210** may vary depending on the dimensions of the substrate tape **124**. The motor **212** is a conventional torque motor, such as an Oriental Motor 5TK20GN. When installed the torque exerted by the spool **110***a* is opposite the torque exerted by the spool **110***b* to provide the proper tension on the substrate tape **124** as it unwinds from the spool **110***a* and translates through the polishing system **100** and subsequently winds onto the spool **110***b*.

FIGS. **3**A, **3**B, and **3**C illustrate a side view, a top view, and an end view, respectively, of the tape feeder **112**. The tape feeder **112** is a substrate tape drive mechanism suitable

for use as the tape feeder apparatus within the polishing system **100** of the present invention. The tape feeder **112** provides a controlled rate of translation to allow the proper exposure time of the substrate tape **124** to the polishing and cleaning events that take place within the polishing system **100**.

With reference to FIG. **3**A, the tape feeder **112** includes a belt assembly **310** that further includes a belt **312** forming a loop around a conventional pulley **314** and a conventional pulley **316**. Additionally, the tape feeder **112** includes a belt assembly **318** that further includes a belt **320** forming a loop around a conventional pulley **322** and a conventional pulley **324**. Such that the belt assembly **310** and the belt assembly **318** are arranged in parallel with one another in a stacked fashion such that the outer surface of the belt **312** is facing the outer surface of the belt **320**, as shown in FIGS. **3**A and **3**C.

With reference to FIGS. **3**A, **3**B, and **3**C, the belt assembly **310** and the belt assembly **318** are mechanically coupled via a mechanical drive assembly **326** and rotatably driven by a motor **328** that is a conventional stepper motor, such as an Oriental M540-401-115 motor. The drive assembly **326** is designed using various belts, pulleys and gears (not shown) in a conventional manner such that in operation the belt assembly **310** rotates in a direction opposite the belt assembly **318**. For example, if the pulleys **314** and **316** of the belt assembly **310** are rotating counter-clockwise, then the pulleys **322** and **324** of the belt assembly **318** are rotating clockwise.

In operation, as the substrate tape **124** is fed through the tape feeder **112**, the outer surface of the belt **312** of the belt assembly **310** is in contact with the non-polished surface **126** of the substrate tape **124** and the outer surface of the belt **320** of the belt assembly **318** is in contact with the polished surface **128** of the substrate tape **124**, as shown in FIGS. **3**A and **3**C. As a result, the spacing between the belt assembly **310** and the belt assembly **318** is dependent upon the thickness of the substrate tape **124**. The pressure exerted on the substrate tape **124** by the belt **312** and the belt **320** creates sufficient friction to cause the substrate tape **124** to translate through the tape feeder **112** due to the rotation of the belt **312** and the belt **320**.

FIGS. **4**A, **4**B and **4**C illustrate a side view, a top view, and an end view, respectively, of the polishing station **114** that is a mechanical polisher suitable for use within the polishing system **100** of the present invention.

The polishing station **114** includes a polisher assembly **410** and a slurry dispenser **412** disposed within a tank **414** formed of stainless steel. The tank **414** has an entry slot **416** and an exit slot **418** through which the substrate tape **124** may translate. Inserted in the entry slot **416** and the exit slot **418** is a squeegee (not shown) formed, e.g. of silicon rubber and felt for removing excess slurry from the substrate tape **124** as it passes therethrough.

The polisher assembly **410** includes a polishing wheel **420** mounted on a rotatable shaft **422** whose ends pass through opposing walls of the tank **414** leaving the polishing wheel **420** suspended within the tank **414**. Similarly, the polisher assembly **410** includes a polishing wheel **424** mounted on a rotatable shaft **426** whose ends pass through opposing walls of the tank **414** leaving the polishing wheel **424** suspended within the tank **414**. When installed, the polishing wheel **420** and the polishing wheel **424** of the polisher assembly **410** are aligned along the axis of the substrate tape **124** passing through the tank **414**. Additionally, the polishing wheel **420** and the polishing wheel **424** of the polisher assembly **410** are aligned on a horizontal plane such that they make contact with the polished surface **128** of the substrate tape **124**.

The polishing wheel **420** and the polishing wheel **424** are, for example, four inches in diameter. The polishing wheel **420** and the polishing wheel **424** are diamond hard felt polishing wheels, such as manufactured by Boston Felt, with a "Shore A hardness" above 85 or a functionally equivalent material. Alternatively, the polishing wheel **420** and the polishing wheel **424** are hard felt polishing wheels formed by pure felt, such as manufactured by Boston Felt, with a "Shore A hardness" in the range of 30 to 85 depending on which polishing station they are operating within, i.e., the polishing station **114***a*, **114***b*, **114***c*, or **118**. Shore hardness is a well-known measure of the resistance of a material to indentation by a spring-loaded indenter. The Shore hardness scale is a raw number between 0 and 100 with no units, the higher the number, the greater the resistance, i.e. the harder the material. Materials with appropriate Shore hardness may be substituted.

A conventional motor **428** rotatably drives the shaft **422** and subsequently the polishing wheel **420**. The motor **428** additionally drives the shaft **426** and subsequently the polishing wheel **424** via a belt **430** that couples the rotational motion of the shaft **422** to the shaft **426** via pulleys (not shown). The motor **428** is, for example, a conventional 0.5 hp motor, such as a Dayton 5K984D motor, that is capable of a rotational speed of up to 1600 rpm. FIG. **4**B illustrates but one example driving mechanism, those skilled in the art will appreciate that the shaft **422** and the shaft **426** may be rotatably driven by other conventional means.

The polisher assembly **410** further includes multiple instantiations of a pressure assembly **432**, for example a pressure assembly **432***a* associated with the polishing wheel **420** and a pressure assembly **432***b* associated with the polishing wheel **424**. In operation, the substrate tape **124** is sandwiched between the pressure assembly **432***a* and the polishing wheel **420**, and between the pressure assembly **432***b* and the polishing wheel **424**. As a result, the pressure assembly **432***a* and the pressure assembly **432***b* apply pressure onto the non-polished surface **126** of the substrate tape **124** that in turn transfers pressure to the polished surface **128** of the substrate tape **124** against the polishing wheel **420** and the polishing wheel **424**, respectively. The pressure assembly **432** is described in detail in FIG. **5**.

The slurry dispenser **412** further includes an inlet **434** feeding a first outlet **436** and a second outlet **438**. The inlet **434** enters through the wall of the tank **414** and feeds the outlet **436** that is directed toward the polishing wheel **420** and the outlet **438** that is directed toward the polishing wheel **424**. In operation, a polishing medium, in the form of a slurry, is pumped (pump not shown) into the tank **414** with a controlled flow rate of, for example, 60 ml per minute via the slurry dispenser **412**. The pump is typically capable of providing a flow rate of between 17 ml to 17 liters per minute. The polishing medium is subsequently dispensed onto the polishing wheel **420** and the polishing wheel **424** via the outlet **436** and the outlet **438**, respectively. The polishing medium is, for example, a slurry formed of one part aluminum oxide powder mixed with fifteen parts water. The particle size of the aluminum oxide powder is in the range of 1.0 to 0.05 microns depending on the polishing station location, i.e., the polishing station **114***a*, **114***b*, or **114***c*. Finally, an outlet **440** disposed in the bottom of the tank **414** provides an outlet for recirculating the polishing medium.

FIG. **5** illustrates a side view of the pressure assembly **432** that is a pressure device suitable for use within the polishing

station **114** illustrated in FIGS. **4**A, **4**B and **4**C. The pressure assembly **432** includes a stainless steel plate **510** whose ends, when installed, is connected to opposing walls of, for example, the tank **414** of the polishing station **114**. The thickness of the plate **510** is such that negligible deflection of the plate **510** occurs when the pressure assembly **432** is under load. The plate **510** has a first clearance hole **512** and a second clearance hole **514** through which passes a first screw **516** and a second screw **518**, respectively. The diameter of the clearance hole **512** and the clearance hole **514** is sufficiently large to allow the screw **516** and the screw **518** to freely float as they pass through the plate **510**. The screw **516** and the screw **518** are conventional screws, such as a 2 inch 10–32 screw, that provide mechanical coupling to a block **520** by threading through a first block surface **522** of the block **520**, which is the surface of the block **520** that is oriented toward the plate **510**. A second block surface **524** of the block **520** is oriented toward the substrate tape **124** upon which it contacts when installed. The block **520** is formed of a low friction material, such as Teflon, that is not damaging to the non-polished surface **126** of the substrate tape **124**. The dimensions of the block **520** are, for example, 2 inches wide by 2.75 inches long by 1 inch thick. Fitting flush against the head of the screw **516** is a standard washer **526**. Furthermore, a spring **528** is arranged between the washer **526** and the plate **510**. Similarly, fitting flush against the head of the screw **518** is a standard washer **530** and a spring **532** is arranged between the washer **530** and the plate **510**. The spring **528** and the spring **532** are conventional springs having a maximum spring force of, for example, 2205 lbs and that have a large enough inside diameter to allow the screw **516** and the screw **518** to pass. Lastly, a control screw **534** is disposed between the screw **516** and the screw **518** and threaded entirely through the plate **510**. Having passed through the plate **510** the threaded end of the control screw **534** subsequently passes through a spring **536** disposed between the plate **510** and the block surface **522** of the block **520** and then comes into contact with the block surface **522** of the block **520**, as shown in FIG. **5**. The control screw **534** is conventional machine screw, such as a ⅜ inch 6–32 screw that is 1.5 inches long. The spring **536** is a conventional spring having a maximum spring force of, for example, 2205 lbs and has a large enough inside diameter to allow the control screw **534** to pass.

With continuing reference to FIG. **5**, the block **520** is essentially suspended from the plate **510** via the screw **516** and the screw **518** that are allowed to freely float as they pass through the plate **510**. The spring **528** and the spring **532** provide upward force against the washer **526** and the washer **530**, respectively, thereby creating a pulling action to draw the block **520** toward the plate **510**, where the plate **510** provides a stationary mechanical reference within the tank **414** of the polishing station **114**. In its relaxed state (i.e., the control screw **534** in a retracted position) the spring **536** prevents the block surface **522** of the block **520** from coming into contact with the plate **510**. However, when the control screw **534** is adjusted such that its threaded end is in contact with the block surface **522** of the block **520** it provides an opposing force to the spring **528** and the spring **532**, thereby forcing the block **520** to be pushed away from the plate **510** and into contact with the non-polished surface **126** of the substrate tape **124**. The pressure assembly **432** is capable of a maximum pressure of 1000 lbs per square inch but is typically set within a range of 0 to 300 lbs per square inch. A load sensor (not shown) is disposed within the center of the block **520** and is connected through a cable (not shown) to an external readout display so that the pressure exerted by the pressure assembly **432** upon the substrate tape **124** may be monitored. The load sensor is, for example, a simple button sensor, such as Sensotec Model 53 AL131.

FIGS. **6**A and **6**B illustrate a side view and an end view, respectively, of the rinsing station **116** that is a substrate tape cleaning mechanism suitable for use within the polishing system **100** of the present invention.

The rinsing station **116** includes multiple instantiations of a sprayer assembly **610**, for example a sprayer assembly **610***a* and a sprayer assembly **610***b*, disposed within a tank **612** formed of stainless steel. The tank **612** has an entry slot **614** and an exit slot **616** through which the substrate tape **124** may translate. Inserted in the entry slot **614** and the exit slot **616** is a squeegee (not shown) formed of felt for removing excess water from the substrate tape **124** as it passes therethrough.

Each sprayer assembly **610** includes an inlet **618** feeding a conventional spray nozzle **620**. More specifically, the sprayer assembly **610***a* includes an inlet **618***a* feeding a spray nozzle **620***a* and the sprayer assembly **610***b* includes an inlet **618***b* feeding a spray nozzle **620***b*. The inlet **618***a* and the inlet **618***b* pass through the wall of the tank **612** and are connected to a source of rinsing water, such as tap water or de-ionized water, having a pressure that is typically less than 75 psi. The sprayer assembly **610***a* and the sprayer assembly **610***b* are oriented 180 degrees to one another within the tank **612** such that the spray nozzle **620***a* and the spray nozzle **620***b* are facing one another and are sufficiently spaced to allow the substrate tape **124** to pass between, as shown in FIG. **6**B. In operation, the rinsing water is released into the tank **612** via the sprayer assembly **610***a* and the sprayer assembly **610***b* and directed onto the substrate tape **124** for the purpose of rinsing the polishing medium residue from the surfaces of the substrate tape **124**. Finally, an outlet **622** disposed in the bottom of the tank **612** provides a drain for expelling the rinsing water.

FIG. **7** illustrates a top view of the polishing station **118** that is a mechanical polisher suitable for use within the polishing system **100** of the present invention.

The polishing station **118** includes multiple instantiations of the polisher assembly **410** as described in FIG. **4**. For example, the polishing station **118** includes a polisher assembly **410***a* having a polishing wheel **420***a* and a polishing wheel **424***a* driven by a motor **428***a*, a polisher assembly **410***b* having a polishing wheel **420***b* and a polishing wheel **424***b* driven by a motor **428***b*, and a polisher assembly **410***c* having a polishing wheel **420***c* and a polishing wheel **424***c* driven by a motor **428***c*. For simplicity of illustration, the pressure assembly **432** associated with each polishing wheel is not shown in FIG. **7**.

FIG. **7** illustrates but one example driving mechanism, those skilled in the art will appreciate that the multiple polishing wheels may be rotatably driven by other conventional means, for example, by a single motor **428** with multiple belts.

The polisher assembly **410***a*, the polisher assembly **410***b*, and the polisher assembly **410***c* are disposed within a tank **710** formed of stainless steel. The tank **710** has an entry slot **712** and an exit slot **714** through which the substrate tape **124** may translate. Inserted in the entry slot **712** and the exit slot **714** is a squeegee (not shown) formed of silicon rubber and felt for removing excess slurry from the substrate tape **124** as it passes therethrough.

When installed, the polishing wheel **420***a* and the polishing wheel **424***a* of the polisher assembly **410***a*, the polishing wheel **420***b* and the polishing wheel **424***b* of the polisher

assembly **410***b*, the polishing wheel **420***c* and the polishing wheel **424***c* of the polisher assembly **410***c*, are all aligned along the axis of the substrate tape **124** passing through the tank **710**. Additionally, all polishing wheels are aligned on a horizontal plane such that they make contact with the polished surface **128** of the substrate tape **124**.

The polishing station **118** further includes multiple instantiations of the slurry dispenser **412** for directing the polishing medium onto the polishing wheels as described in FIG. **4**. However, for simplicity of illustration, the multiple instantiations of the slurry dispenser **412** are not shown in FIG. **7**. Likewise, it can be assumed that the tank **710** has on or more outlets for recirculating the polishing medium as described in FIG. **4**. Again, for simplicity of illustration, the outlets are not shown in FIG. **7**.

FIGS. **8**A and **8**B illustrate a side view and a top view, respectively, of the rinsing station **120** that is a substrate tape cleaning mechanism suitable for use within the polishing system **100** of the present invention.

The rinsing station **120** includes a tank **810** formed of stainless steel and having an entry slot **812** and an exit slot **814** through which the substrate tape **124** may translate. Inserted in the entry slot **812** and the exit slot **814** is a squeegee (not shown) formed of silicon rubber and felt for removing excess water from the substrate tape **124** as it passes therethrough. Disposed within tank **810** is a polisher assembly **816** in combination with multiple instantiations of a sprayer assembly **830** that is identical to the sprayer assembly **610** having an inlet and a spray nozzle as described in FIGS. **6**A and **6**B. For example, the rinsing station **120** includes a sprayer assembly **830***a*, a sprayer assembly **830***b*, a sprayer assembly **830***c*, and a sprayer assembly **830***d*.

The polisher assembly **816** includes a polishing wheel **818** mounted on a rotatable shaft **820** whose ends pass through opposing walls of the tank **810** leaving the polishing wheel **818** suspended within the tank **810**. Similarly, the polisher assembly **816** includes a polishing wheel **822** mounted on a rotatable shaft **824** whose ends pass through opposing walls of the tank **810** leaving the polishing wheel **824** suspended within the tank **810**. When installed, the polishing wheel **818** and the polishing wheel **822** of the polisher assembly **816** are aligned along the axis of the substrate tape **124** passing through the tank **810**. However, the polishing wheel **818** and the polishing wheel **822** of the polisher assembly **816** are not arranged on the same horizontal plane within the tank **810**. Instead, the polishing wheel **818** and the polishing wheel **822** are arranged on opposing sides of the substrate tape **124**. More specifically, the polishing wheel **818** makes contact when installed with the non-polished surface **126** of the substrate tape **124** and the polishing wheel **822** makes contact when installed with the polished surface **128** of the substrate tape **124**, as shown in FIG. **8**A.

The polishing wheel **818** and the polishing wheel **822** are soft polishing wheels, such as a Boston Felt soft wheel with a "Shore A hardness" in the range of 30 to 40. A conventional motor **826** rotatably drives the shaft **820** and subsequently the polishing wheel **818**. The motor **826** additionally drives the shaft **824** and subsequently the polishing wheel **822** via a belt **828** that couples the rotational motion of the shaft **820** to the shaft **824** via pulleys (not shown). The motor **826** is, for example, a conventional 0.5 hp motor, such as Dayton 5K984D motor, that is capable of a rotational speed of up to 1600 rpm. FIG. **8**B illustrates but one example driving mechanism, those skilled in the art will appreciate that the shaft **820** to the shaft **824** may be rotatably driven by other conventional means.

Unlike the polisher assembly **410** described in FIGS. **4**A, **4**B and **4**C, the polisher assembly **816** does not include any instantiations of the pressure assembly **432** that is described in FIG. **5**.

The inlet of each sprayer assembly **830** passes through the wall of the tank **810** and feeds its associated spray nozzle, where each inlet is connected to a source of rinsing water, such as tap water or de-ionized water, having a pressure that is typically less than 75 psi. The sprayer assembly **830***a* and the sprayer assembly **830***b* are oriented 180 degrees to one another within the tank **810** such that their spray nozzles are facing one another and are sufficiently spaced to allow the substrate tape **124** to pass between, as shown in FIG. **8**A. The sprayer assembly **830***c* is oriented at an angle directing its spray nozzle toward the contact point of the polishing wheel **818** and the non-polished surface **126** of the substrate tape **124**. Likewise, the sprayer assembly **830***d* is oriented at an angle directing its spray nozzle toward the contact point of the polishing wheel **822** and the polished surface **128** of the substrate tape **124**, as shown in FIG. **8**A.

In operation, the rinsing water is released into the tank **810** via the sprayer assembly **830***a*, the sprayer assembly **830***b*, the sprayer assembly **830***c*, and the sprayer assembly **830***d* and directed onto the substrate tape **124** for the purpose of rinsing the polishing medium residue from the surfaces of the substrate tape **124**. Finally, an outlet **832** and an outlet **834** disposed in the bottom of the tank **810** provide a drain for expelling the rinsing water.

In operation, and with reference to FIG. **1**, the polishing wheels in the polishing station **114***a*, the polishing station **114***b*, the polishing station **114***c*, the polishing station **118**, and the rinsing station **120**, are selected having a hardness according to Table 1 below and installed. Additionally, the particle size of the polishing medium within the slurry feeding the polishing station **114***a*, the polishing station **114***b*, the polishing station **114***c*, and the polishing station **118** is selected according to Table 1 below.

TABLE 1

Polishing wheel hardness and polishing medium particle size as required for the polishing system 100

	Polishing wheel Shore A hardness		Polishing medium particle size	
	Acceptable range	Specific example	Acceptable range	Specific example
Polishing station 114a	Above 85	Diamond Hard	0.3 to 1.0 microns	1.0 microns
Polishing station 114b	55 to 65	Hard	0.05 to 0.3 microns	0.3 microns
Polishing station 114c	55 to 65	Hard	0.05 to 0.3 microns	0.3 microns
Polishing station 118	55 to 65	Hard	≦0.05 microns	0.05 microns
Rinsing station 120	30 to 40	Soft	n/a	n/a

With continuing reference to FIGS. **1** through **8**B, the operation of the polishing system **100** is described as follows. The reel **210** of the spool **110***a* that has a length of substrate tape **124** wound upon it is mounted at the front end of the polishing system **100**. The leader of the substrate tape **124** is laced through the tape feeder **112** between the belt **312** and the belt **320** (FIGS. **3**A, **3**B and **3**C), all the while the substrate tape **124** is riding on the guide wheel **130**. The leader of the substrate tape **124** is then laced through the polishing station **114***a* via its entry slot **416** and subsequently

through its polisher assembly **410** and finally through its exit slot **418**. The leader of the substrate tape **124** is then laced through the rinsing station **116***a* via its entry slot **614** and subsequently passing in close proximity to multiple instantiations of the of the sprayer assembly **610** and finally through its exit slot **616**. The leader of the substrate tape **124** is then laced through the polishing station **114***b* via its entry slot **416** and subsequently through its polisher assembly **410** and finally through its exit slot **418**. The leader of the substrate tape **124** is then laced through the rinsing station **116***b* via its entry slot **614** and subsequently passing in close proximity to multiple instantiations of the of the sprayer assembly **610** and finally through its exit slot **616**. The leader of the substrate tape **124** is then laced through the polishing station **114***c* via its entry slot **416** and subsequently through its polisher assembly **410** and finally through its exit slot **418**. The leader of the substrate tape **124** is then laced through the rinsing station **116***c* via its entry slot **614** and subsequently passing in close proximity to multiple instantiations of the of the sprayer assembly **610** and finally through its exit slot **616**. The leader of the substrate tape **124** is then laced through the polishing station **118** via its entry slot **712** and subsequently through its multiple instantiations of the polisher assembly **410** and finally through its exit slot **714**. The leader of the substrate tape **124** is then laced through the rinsing station **120** via its entry slot **812** and subsequently passing in close proximity to multiple instantiations of the of the sprayer assembly **830** and through its polisher assembly **816** and finally through its exit slot **814**. Lastly, the leader of the substrate tape **124** is laced onto the spool **110***b*, all the while the substrate tape **124** is riding on the guide wheel **132** and the tension of the substrate tape **124** is set by adjusting the torque on the motor **212** of the spool **110***a* and on the motor **212** of the spool **110***b*. The tension is set to a level sufficient to maintain the flatness of the substrate tape **124** for polishing, yet without stressing the substrate tape **124** to its breaking point.

Having laced the substrate tape **124** through all the elements of the polishing station **100**, the water source feeding the rinsing station **116***a*, the rinsing station **116***b*, the rinsing station **116***c*, and the rinsing station **120** is activated. Additionally, the slurry pumps (not shown) feeding the slurry dispenser **412** of the polishing station **114***a*, the slurry dispenser **412** of the polishing station **114***b*, and the slurry dispenser **412** of the polishing station **114***c* are activated and all flow rates are adjusted via the pump controls. Likewise, the slurry pump feeding the multiple instantiations of the slurry dispenser **412** of the polishing station **118** is activated and the flow rate is adjusted via the pump control. In all cases, the flow rate is set such that an optimal supply of polishing medium is present at the polishing wheels to achieve the desired result.

Having begun the flow of rinsing water and polishing medium, all motors within the polishing system **100** are activated. More specifically, the motor **428** of the polishing station **114***a* is activated, the motor **428** of the polishing station **114***b* is activated, the motor **428** of the polishing station **114***c* is activated, and the multiple instantiations of the motor **428** of the polishing station **118** are activated. Additionally, the motor **212** of the spool **110***a* and the motor **212** of the spool **110***b* are activated. Lastly, the motor **328** of the tape feeder **112** is activated. The pressure exerted on the substrate tape **124** by the belt **312** and the belt **320** of the tape feeder **112** creates sufficient friction to cause the substrate tape **124** to translate through the polishing system **100** due to the rotation of the belts **312** and **320** of the tape feeder **112**. The translation speed of the substrate tape **124** is set by adjusting the speed of the tape feeder **112** to provide a controlled rate of translation to allow the proper exposure time of the substrate tape **124** to the various polishing and cleaning events. The translation rate can vary in a range of from about 0.1 to about 1.5 cm/min; preferably form about 0.15 to about 0.5 cm/min. A typical translation rate is, for example, 0.2 to about 0.4 cm/min.

Subsequently, the pressure of the substrate tape **124** against the polishing wheels disposed throughout the polishing system **100** is set by adjusting the control screw **534** of each instantiation of the pressure assembly **432** within the polishing station **114***a*, by adjusting the control screw **534** of each instantiation of the pressure assembly **432** within the polishing station **114***b*, by adjusting the control screw **534** of each instantiation of the pressure assembly **432** within the polishing station **114***c*, and by adjusting the control screw **534** of each instantiation of the pressure assembly **432** within the polishing station **118**. In all cases, the pressure is set within a range of 0 to 300 lbs per square inch by monitored the pressure via the load sensor that is built into each block **520**.

Subsequently, the roughness monitor **122** is activated and its position is manually adjusted via the 3-axis adjustable stage such that the distance between the substrate tape **124** and the roughness monitor **122** is appropriate for measuring roughness to the required accuracy. Having begun the flow of rinsing water and polishing medium, and having activated all motors, the substrate tape **124** is now translating through the polishing system **100** and experiencing multiple polishing and rinsing events in succession. More specifically, the substrate tape **124** experiences the first polishing and rinsing event via the polishing station **114***a* and the rinsing station **116***a*. The polishing wheel hardness and polishing medium particle size is as shown in Table 1, and thus this first polishing event is considered the most aggressive polishing event within the polishing system **100**.

Next, the substrate tape **124** experiences a series or more moderate polishing events and subsequent rinsing events by passing through the polishing station **114***b* and the rinsing station **116***b*, then through the polishing station **114***c* and the rinsing station **116***c*, and then through the polishing station **118**. The polishing wheel hardness and polishing medium particle size for the polishing station **114***b*, the polishing station **114***c*, and the polishing station **118** is as shown in Table 1, and thus these polishing events are considered less aggressive than that of the polishing station **114***a*.

Lastly, the substrate tape **124** experiences a final polishing and rinsing event via the rinsing station **120** that provides the function of both rinsing and polishing, but without the presence of a polishing medium. The polishing wheel hardness is as shown in Table 1, and thus this polishing event is considered the least aggressive polishing event within the polishing system **100** and applies the most fine and smooth surface quality to the polished surface **128** of the substrate tape **124**.

In this way, the substrate tape **124** experiences, via progressive stages, first a rough, then a medium, then a fine polishing event in combination with a respective rinsing event as it translates through the polishing system **100**, thereby achieving in a single pass through the polishing system **100** a surface smoothness that is suitable for the subsequent deposition of a buffer layer.

It is noted that the polishing wheel hardness and polishing medium particle size is not limited to that as shown in Table 1, other combinations are possible depending on the product application.

FIG. **9** illustrates a method **900** in accordance with the invention of operating the polishing system **100** that is a mechanical polishing system suitable for polishing long lengths of metal substrate tape used in the manufacture of HTS-coated tape. The method **900** includes the steps of:

Step 910: Mounting Payout Spool

In this step, the user mounts the reel **210** of the spool **110***a* within the polishing system **100**. The reel **210** has a length of substrate tape **124** wound upon it. Method **900** proceeds to step 912.

Step 912: Lacing Substrate Tape through Tape Feeder

In this step, the user laces the leader of the substrate tape **124** through the tape feeder **112** between the belt **312** and the belt **320** of the tape feeder **112** (FIGS. **3**A, **3**B and **3**C), all the while the substrate tape **124** is riding on the guide wheel **130**. Method **900** proceeds to step **914**.

Step 914: Lacing Substrate Tape Through Polishing and Rinsing Stations

In this step, the user laces the leader of the substrate tape **124** through the polishing station **114***a* via its entry slot **416** and subsequently through its polisher assembly **410** and finally through its exit slot **418**. The user then laces the leader of the substrate tape **124** through the rinsing station **116***a* via its entry slot **614** and subsequently passing in close proximity to multiple instantiations of the of the sprayer assembly **610** and finally through its exit slot **616**. The user then laces the leader of the substrate tape **124** through the polishing station **114***b* via its entry slot **416** and subsequently through its polisher assembly **410** and finally through its exit slot **418**. The user then laces the leader of the substrate tape **124** through the rinsing station **116***b* via its entry slot **614** and subsequently passing in close proximity to multiple instantiations of the of the sprayer assembly **610** and finally through its exit slot **616**. The user then laces the leader of the substrate tape **124** through the polishing station **114***c* via its entry slot **416** and subsequently through its polisher assembly **410** and finally through its exit slot **418**. The user then laces the leader of the substrate tape **124** through the rinsing station **116***c* via its entry slot **614** and subsequently passing in close proximity to multiple instantiations of the of the sprayer assembly **610** and finally through its exit slot **616**. The user then laces the leader of the substrate tape **124** through the polishing station **118** via its entry slot **712** and subsequently through its multiple instantiations of the polisher assembly **410** and finally through its exit slot **714**. The user then laces the leader of the substrate tape **124** through the rinsing station **120** via its entry slot **812** and subsequently passing in close proximity to multiple instantiations of the of the sprayer assembly **830** and through its polisher assembly **816** and finally through its exit slot **814**. Method **900** proceeds to step **916**.

Step 916: Lacing Substrate Tape Onto Take-Up Spool

In this step, the user laces the leader of the substrate tape **124** onto the spool **110***b*, all the while the substrate tape **124** is riding on the guide wheel **132**. Method **900** proceeds to step 918.

Step 918: Setting Substrate Tape Tension

In this step, the user sets the tension of the substrate tape **124** by adjusting the torque on the payout spool and take-up spool motors. More specifically, by adjusting the torque on the motor **212** of the spool **110***a* and on the motor **212** of the spool **110***b*. The tension is set to a level sufficient to maintain the flatness of the substrate tape **124** for polishing, yet without stressing the substrate tape **124** to its breaking point. Method **900** proceeds to step **920**.

Step 920: Pumping Water into Rinsing Stations

In this step, the user activates the water source feeding the rinsing station **116***a*, the rinsing station **116***b*, the rinsing station **116***c*, and the rinsing station **120**. Method **900** proceeds to step 922.

Step 922: Activating Slurry Pumps and Adjusting Flow Rate

In this step, the user activates the slurry pump feeding the slurry dispenser **412** of the polishing station **114***a* and adjusts the flow rate via the pump controls. Subsequently, the user activates the slurry pump feeding the slurry dispenser **412** of the polishing station **114***b* and adjusts the flow rate via the pump controls. Subsequently, the user activates the slurry pump feeding the slurry dispenser **412** of the polishing station **114***c* and adjusts the flow rate via the pump controls. Subsequently, the user activates the slurry pump feeding the multiple instantiations of the slurry dispenser **412** of the polishing station **118** and adjusts the flow rate via the pump controls. In all cases, the flow rate is set such that an optimal supply of polishing medium is present at the polishing wheels to achieve the desired result. Method **900** proceeds to step 924.

Step 924: Activating Polishing System

In this step, the user activates the motor **428** of the polishing station **114***a*, the motor **428** of the polishing station **114***b*, the motor **428** of the polishing station **114***c*, and the multiple instantiations of the motor **428** of the polishing station **118**. Additionally, the user activates the motor **212** of the spool **110***a* and the motor **212** of the spool **110***b*. Lastly, the user activates the motor **328** of the tape feeder **112**. Method **900** proceeds to step 926.

Step 926: Setting Substrate Tape Translation Speed

In this step, the user sets the translation speed of the substrate tape **124** by adjusting the speed of the tape feeder **112** to provide a controlled rate of translation to allow the proper exposure time of the substrate tape **124** to the polishing and cleaning events. A typical translation rate is, for example, 1.0 inch per 7 minutes. Method **900** proceeds to step 928.

Step 928: Adjusting Substrate Tape Pressure Devices

In this step, the user adjusts the pressure of the substrate tape **124** against the polishing wheels by adjusting the control screw **534** of each instantiation of the pressure assembly **432** within the polishing station **114***a*, by adjusting the control screw **534** of each instantiation of the pressure assembly **432** within the polishing station **114***b*, by adjusting the control screw **534** of each instantiation of the pressure assembly **432** within the polishing station **114***c*, and by adjusting the control screw **534** of each instantiation of the pressure assembly **432** within the polishing station **118**. In all cases, the pressure is set within a range of 0 to 300 lbs per square inch by monitoring the pressure via the load sensor that is built into the block **520**. A cable connected to the sensor provides readout to an external display to allow monitoring by the user. Method **900** proceeds to step **930**.

Step 930: Activating Roughness Monitor

In this step, the user activates the roughness monitor **122**. Method **900** proceeds to step **932**.

Step 932: Adjusting Roughness Monitor

In this step, the user manually adjusts the position of the roughness monitor **122** via the 3-axis adjustable stage. More specifically, the roughness monitor **122** is adjusted such that the distance between the substrate tape **124** and the roughness monitor **122** is, for example, 1 inch. Method **900** proceeds to step 934.

Step 934: Deactivating Polishing System Upon Completion

In this step, when the entire length of the substrate tape **124** has been exposed to the polishing system **100**, the user deactivates all motors, pumps, and water supplies within the polishing system **100** and removes the take-up spool. More specifically, the user removes the reel **210** of the spool **110***b* that has the full length of the substrate tape **124** wound upon it. Method **900** ends.

What is claimed is:

1. A process for the continuous single pass multistage surface polishing of a metal tape comprising

a] providing an unpolished metal tape

b] providing a polishing chamber comprising a multiplicity of surface treatment units, each unit comprising a polishing station and a rinsing station

c] continuously feeding the unpolished metal tape into the polishing chamber

d] sequentially passing the metal tape through a series of surface treatment units where each successive surface treatment unit further polishes a surface of the tape with the aid of a slurry polishing medium comprising an abrasive material and water; and

e] retrieving polished metal tape from the chamber.

2. The process of claim **1** where the tape is provided to the chamber from a feed reel and is retrieved from the chamber by a take-up reel and where the reels are synchronized to maintain a selected tension in the tape as it moves through the polishing chamber

3. The process of claim **1** where the tape is selected from the group consisting of stainless steel, nickel, and nickel alloy tapes.

4. The process of claim **1** where the tape moves through the polishing chamber at a rate in the range of from about 0.2 to about 0.4 cm/min.

5. The process of claim **1** where the tape is moves through the polishing chamber at a rate in the range of from about 0.15 to about 0.5 em/mm.

6. The process of claim **1** where the tape moves through the polishing chamber at a rate in the range of from about 0.1 to about 1.5 em/mm.

7. The process of claim **1** where the slurry polishing medium used to surface treat the tape is a water slurry of aluminum oxide.

8. The process of claim **1** where the ratio of abrasive material to water in the slurry polishing medium is in the range of from about 1:10 to about 1:20.

9. The process of claim **1** where the ratio of abrasive material to water in the slurry polishing medium is in the range of from about 1:14 to about 1:16.

10. The process of claim **1** where the flow rate of slurry polishing medium in the polishing steps is from about 0.017 l/mm to about 17 l/min.

11. The process of claim **1** where the flow rate of slurry polishing medium in the polishing steps is from about 0.05 l/min to about 5 l/min.

12. The process of claim **1** where the flow rate of slurry polishing medium in the polishing steps is from about 0.1 l/mm to about 1 l/min.

13. The process of claim **1** where the abrasive material in the slurry polishing medium in the initial polishing step has a Shore A hardness of above 85 and a particle size in the range of from about 0.3 microns to about 1.0 micron.

14. The process of claim **1** where the abrasive material in the slurry polishing medium in the second polishing step has a Shore A hardness of from about 55 to about 65 and a particle size in the range of from about 0.05 microns to about 0.3 microns.

15. The process of claim **1** where the abrasive material in the slurry polishing medium in the final polishing step has a Shore A hardness of from about 55 to about 65 and a particle size of no more than about 0.05 microns.

16. A reel-to-reel single-pass continuous mechanical polishing system suitable for polishing long lengths of metal substrate tape used in the manufacture of HTS-coated tape comprising multiple instantiations of a polishing station in combination with a subsequent rinsing station arranged along the axis of the metal substrate tape that is continuously translating between a payout spool and a take-up spool whereby the metal substrate tape experiences a series of polishing events utilizing a slurry polishing medium comprising an abrasive material and water and cleaning events to progressively diminish its surface roughness and achieve a surface smoothness that is acceptable for depositing a buffer layer in the manufacture of HTS-coated tape.

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