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DRAWINGS ATTACHED.

Inventors: BRUCE GUY SARGENT and ROBERT LEONARD DRESSLER

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COMPLETE SPECIFICATION.

Improvements in or relating to the Building of Spoked Wheels.

We, T. I. (GROUP SERVICES) LIMITED, a British Company of Rocky Lane, Aston, Birmingham 6, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to the building of spoked wheels such as cycle wheels. There are three main stages in the building of spoked wheels by hand:—

1. Lacing:— in which the spokes are threaded in a certain order through the holes in the hub and inserted in the correct holes in the rim where they are lightly held by nipples which are just started on the spoke thread.
2. Tensioning:— in which the nipples are screwed on to the spoke threads by substantially the same amount to tighten the spokes to the required tension.
3. Truing:— in which the wheel is spun upon its spindle and individual spokes are tightened or slackened to make the rim flat (that is without lateral irregularities), circular and concentric with the spindle.

The present invention provides a machine for tensioning and truing of previously laced wheels.

A machine according to the present invention comprises means for gripping and locating the hub of a laced wheel, means for rotating the spoke nipples, means for rotating the wheel spindle with respect to the hub, means for detecting errors in the rim with respect to the rotating spindle, means responsive to the errors detected for controlling the nipple rotating means in the sense to correct the error and means for stopping the nipple rotating means upon reaching a predetermined tension in at least some of the spokes.

The invention further consists in a method of truing and tensioning a laced spoked wheel, having a hub rotatably mounted on a spindle, which compirses supporting the wheel by means of the hub, rotating the spindle to move around the rim detecting means which is clamped to the spindle and controls the tightening of the spokes to make the "flat" and "radial" spacings of the detector means from the rim constant.

The rim is not clamped and is restrained merely by the spokes wrich are preferably substantially relieved of loading by the nipple rotating means in order that the wheel may be tensioned and trued in the machine under conditions which are very similar to those which will obtain when the wheel is removed from the machine.

When a spoked wheel mounted on conventional cup and cone hub bearings rotates on its spindle, owing to normal running clearances and manufacturing tolerances the axis about which the wheel rotates does not coincide with the geometrical axis of the spindle. It is for this reason that the wheel is clamped in the machine by its hub and is trued with reference to the rotating spindle. In this way normal running conditions are closely simulated.

The means for detecting errors are preferably electrical pick-ups mounted for rotation in fixed relation to the spindle and close to the rim, but not making actual physical contact with it.

The pick-ups may be inductive, or capacitative, their inductance or capacitance increasing as the width of air gap between the pick-up head and the adjacent portion

[*Price* 3*s*. 6*d*.]

Price 4s 6d.

of the rim decreases. The inductance or capacitance can then be compared with a reference inductance or capacitance, to provide a difference signal which is used as a convenient measure of error.

Although in the remainder of this Specification only an inductive pick-up system is referred to, it is clear that this may readily be modified to a capacitative pick-up system as an alternative. Two pick-ups are preferably employed one directed radially towards the curved surface of the rim to indicate radial error of the wheel and the other directed axially opposite the annular face of the rim to indicate axial or "flat" error.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings in which:—

Figure 1 is an elevation partly in section of a cycle-wheel building machine according to the invention the operation of which is automatic apart from the insertion of a laced wheel to be trued and tensioned and removal of a finished wheel.

Figure 2 is a sectional elevation on an enlarged scale of the part of the machine shown in the lower part of Figure 1.

Figure 3 is a sectional elevation on an enlarged scale of the part of the machine shown in the upper part of Figure 1.

Figure 3A is a fragmentary section on line A–A of Figure 3.

Figure 4 is an elevation of one of the nipple rotating units of the machine.

Figure 5 is a fragmentary elevation of part of the nipple rotating unit looking in the direction of the arrow 5 in Figure 4.

Figure 6 is a fragmentary sectional elevation on line 6–6 of Figure 5.

Figures 7 to 11 are diagrams of the electrical circuits for controlling the machine.

A wheel W previously laced and fitted with spindle and bearings is supported horizontally in the machine and gripped at the then lower end *a* of its hub *b* (see Figure 2) by a hub collet 20 actuated by a collet-operating mechanism 21. A head 22 above the wheel (see Figure 3) and guided for vertical movement can be lowered to engage a spindle collet 23 with the upwardly projecting end of the wheel spindle *c*. The spindle collet 23 is rotatable through a universal drive 24 by an electric motor 25 and clamps to the spindle *c* for rotation with it a radial arm 26 carrying pick-ups 27 and 28 for indicating axial or "flat" and radial errors respectively.

A separate nipple-rotating unit 29 (Figures 4, 5 and 6) is provided at each spoke.

All the movements of the machine necessary before the truing and tensioning operation can begin are initiated by the pressing of a start button by the operator and are derived from a timing camshaft 30 (see Figure 2) by mechanical linkages or performed by solenoids timed directly or indirectly by the camshaft. The camshaft makes half a revolution to perform the starting cycle and after completion of the tensioning and truing operation a further half revolution to open the machine to allow the finished wheel to be removed.

The nipple-rotating units 29 after they have been engaged with the nipples under the control of the timing camshaft 30 are controlled by the electrical circuit shown in Figures 7 to 11 of the accompanying drawings, in carrying out the tensioning and truing operation.

At the end of the starting cycle the timing camshaft initiates the tensioning and truing operation by starting the motor 25 which rotates the radial arm 26 carrying the pick-ups.

The radial arm 26 of the slidable head is balanced by a counterweight 110 and while rotating is guided solely by the spindle *c*. While the head is being lowered, the radial arm and collet are maintained in the correct central and horizontal position for engagement with the spindle end by means of the spigot 102 located by an inner tubular portion 111 of the body of the head assembly and a spring loaded steady 112 slidable axially in an outer tubular portion 113 of the body of the head assembly. Relative movement between these members and the fixed portion of the head leaves the arm unrestrained by the time the collet has closed on the spindle.

The nipple rotating units 29, of which there are forty in the machine described which is for building forty-spoke wheels, are divided for control purposes into stations each comprising several units, four in the present instance, on adjacent spokes running to a section of the rim. By a distributor 35 rotating with the radial arm 26 the units of a station are connected to the output of the error detecting circuits when the pick-ups are opposite the rim section associated with that station. The units of the station are set by this output signal so as to tend to correct the error, and continue as set until the pick-ups return to the section of the rim as the arm 26 is rotated. The units are then re-set to tend to correct the error detected in the same fashion.

Adjacent spokes run alternately to the upper and lower spoke flanges of the hub *b*. In each station two of the nipple rotating units are on upper and two on lower spokes. The preferred mode of operation is that the nipple rotating units have only two conditions namely running to screw up the nipples or stopped. Normally all the units are run together. If on an inspection the "flat" error pick-up indicates that the rim section is low the two lower-spoke units are stopped but if the rim section is high the two upper-spoke units are stopped. If the radial pick-up indicates that the wheel radius is small the radial pick-up over-rides the "flat" pick-up and stops all the units of the section.

The nipple rotating units are driven preferably, as illustrated, by an individual electric motor 32 through torque-responsive switches 33 (see Figures 6 and 11) which are adjustable for predetermining the torque at which the switch contacts are actuated. When a prescribed number of units have reached the pre-determined torque the nipple-rotating units of all the stations are stopped. The number of units to be prescribed may be determined by experiment and experience. For a forty spoke wheel with every unit driven through a torque responsive unit six or eight units reaching the predetermined torque is probably an adequate indication that the wheel has been sufficiently tensioned. It will be understood that the continuous inspection and correction of the rim position as the wheel is being tensioned reduces the errors progressively until the wheel is flat and true. This condition is not necessarily consistent with equal tension of the spokes which is a consideration less important than the truth and flatness of the wheel. Nor is nipple-rotating torque an accurate indication of spoke tension since it also includes friction between the nipple and the spoke thread and the rim, nevertheless when taken on several spokes it is a fairly close indication of the general tension level of the spokes of the wheel.

In the present example the nipple-rotating means includes as the nipple-engaging member a pinion 36 with a radial slot 37 which is in mesh with a gear or gear train 31 continuously rotatable by the unit drive. The number of turns which can be applied to tighten a nipple is thus unlimited. The radial slot 37 allows the pinion 36 to straddle the spoke co-axially. After embracing the spoke the pinion can be moved axially of the spoke to engage the flats of the nipple by means of a complementary socket 38 in the end face of the pinion. A spoke can only be entered in the pinion slot when this slot is aligned with an entrance slot 39 in the body of the nipple-rotating unit. When the wheel is horizontally mounted as in the present machine these entrance slots are directed upwards.

When the prescribed number of units have reached the predetermined torque, the minimum tension circuit Figure 11 initiates the second half revolution of the timing camshaft 30 which first moves the nipple-rotating units 29 to withdraw the sockets 38 from the nipple *n*.

When all the units 29 stop, upon the wheel becoming sufficiently tensioned, the pinion slots 37 might come to rest in any angular position. Means are provided for aligning the pinion slot 37 and entrance slot 39 of each unit. A rotary switch 40 driven synchronously with the pinion 36 has a wiper contact 41 and two arcuate contacts 42, 43 which form a continuous fixed contact path for the wiper contact except for a gap 44 between one pair of adjacent ends of the arcuate contacts. The arrangement is such that when the wiper arm is at the gap the slot 37 of the pinion 36 is aligned with the entrance slot 39; when it is in contact with the fixed contact 42 the drive rotates to move the pinion slot 37 in the shorter direction towards the entrance slot 39 and when it is in contact with the other fixed contact it rotates in the opposite direction. The rotary switch is only connected into the unit drive control circuit by the timing camshaft 30 when all the drive units have been stopped and the pinions have been moved axially to disengage the nipples. The pinion is then driven in one direction or the other until the wiper arm is at the gap and the pinion slot aligned with the entrance slot. Means may be provided for arresting the attempted ejection of a finished wheel from the machine if any of the slots are not aligned. Alternatively the arrangement may be that the ejection procedure occurs only after all the slots have been aligned.

Having now described the general construction of the machine and the principles on which it operates, further details of the more important components will now be given.

Hub collet operating mechanism (Figure 2).

The hub collet 20 is controlled from the timing camshaft 30 both for bodily movement and for opening and closing the collet.

In an annular guide 50 rigidly supported by the framework of the machine, a tubular hub collet holder 51 is slidably mounted. A coupling tube 52 connects the holder 51 to a cam follower 53 engaging a cam 54 on the timing camshaft to raise and lower the hub collet 20 bodily.

The collet 20 has conventional radial slits 55 to enable its mouth to be contracted. A sleeve 56 axially slidable in the holder 51 has a flared or tapering entrance 57 to its bore which engages a complementary tapering surface 58 on the outside of the collet 20. Below the lower end of the collet 20 the bore of the sleeve 56 is enlarged forming an annular shoulder which a disc 59 engages. A compression spring 60 abuts at one end against the disc 59 and at the other against a flat head 61 formed on a rod 62 extending through a guide bush 63 closing the lower end of the sleeve 56 and into the bore of the coupling tube 52. The rod 62 is slidable in both the guide bush 63 and the coupling tube 52.

Upward movement of the rod 62 applies

upward force to the sleeve 56 through the spring 60 and by the co-operation of the taper surfaces 57 and 58 closes the collet 20 under the resilient pressure. The spring 60 enables manufacturing tolerances in the diameter of the hub to be accommodated. Downward movement of the rod 62 withdraws the sleeve 56 to open the collet 20.

Through the rod 62 and coupling tube 52 cross-pins 65 and 66 extend. The upper cross-pin 65 is fitted into a transverse bore in the rod 62 and passes through axial slots 67 in the coupling tube 52. The lower cross-pin 66 passes through an axial slot 68 in the rod 62 and is fitted into bores in the coupling tube 52. The externally projecting ends of the cross-pins 65, 66 are connected by toggle links 64 to a shuttle 69. Movement of the shuttle 69 to the left as viewed in Figure 2 "breaks" the toggle and moves the rod 62 downwards with respect to the coupling tube 52 to open the collet 20. Movement of the shuttle to the right locks the toggle as shown in Figure 2 and closes the collet 20.

The shuttle is moved by a collet-closing tappet 70 and a collet-opening tappet 71 and is kept horizontal for engagement with them by a collar 72 clamped to the coupling tube 52. The tappets 70 and 71 are mounted on plungers 73 slidably supported in the machine frame.

The hub of a loosely laced wheel can be rotated through a small angle (about 5 degrees in each direction) relative to the rim and might not be in the central position when gripped by the hub collet. The hub collet assembly must therefore be free to rotate to enable the hub to take up its correct position during tensioning. The follower 53 is kept in correct alignment by side plates of a forked member 45 which straddle the cam 54. A thrust race 46 between the stem of the forked member 45 and the coupling tube 52 permits relative rotation but this is restricted to about 15 degrees by a transverse pin 47 which is anchored to the forked member 45 and works in arcuate slots in the coupling tube 52. The end faces of the shuttle 69 are part-cylindrical so that the tappets 70 and 71 can strike and operate the shuttle in any angular position.

The plungers 73 and tappets 70 and 71 are moved inwards by arms 75 pivoted to the frame at 76 and linked together for equal and opposite angular movement upon operation by cam follower 77 and cam 78 on the timing crankshaft 30.

Upper head assembly (Figures 1 and 3).

The whole upper head assembly of the machine is guided for vertical movement by suitable means (not shown) and is supported by links 80 (Figure 3) from one end of a lever 81 (Figure 1) having a fulcrum on the machine frame at 82. The other end of the lever 81 is coupled by a rod 83 to a rocker arm 84 pivoted to the frame at 85 and having a cam follower roller 86 to engage a cam 87 on the timing camshaft 30 for bodily raising and lowering the head assembly.

The drive from the motor 25 is taken through reductive gearing 88 to a vertical shaft 89 which passes through and drives the rotary element of the distributor 35. The lower end of the shaft 89 is connected by an axially-slidable square drive coupling 90 (Figure 3) and two universal joints 91 of the universal drive 24 to a collet holder 92, to the lower end of which the radial arm 26 is firmly secured. The drive of the motor 25 is thus transmitted to the radial arm without imposing restraint on angular movement in a vertical plane containing the arm or bodily vertical movement of the radial arm 26.

Spindle collet actuating mechanism (Figures 1, 3 and 3A).

The spindle collet 23 is mounted in the holder 92 and is closable to grip the spindle in a similar manner to the hub collet 20 by axial movement of a sleeve 93 slidable in the holder 92. The collet actuating mechanism comprises solenoids 94 and 95 for opening and closing the collet respectively. The armatures of the solenoids are connected to outer arms of a three-arm crank 96 pivoted to the frame of the head assembly at 97. A central arm 98 of the three-arm crank forms one element of a toggle linkage completed by a link 99 which is connected at the lower end to a collar 100. An arm 104 (Figure 1) angularly movable with the three-arm crank actuates limit switches 105, 106 in the electrical circuits of the solenoids 94 and 95 to de-energize the solenoids when the toggle linkage reaches the "fully-open" and "fully-closed" positions respectively. A light leaf spring 107 bears on the arm 104 to keep the linkage in the "fully-closed" or "fully-open" positions while the solenoids are de-energized. Pegs 101 project radially inwards from the collar 100 to engage a circumferential groove 103 in a spigot member 102 axially slidable on the holder 92.

The spigot 102 has an internal part-conical surface 108 which engages the end of upward arms of bell cranks 109 (Figure 3A), the other arms of which enter a slot or recess 115 in the sleeve 93. The bell cranks 109 can rock about fulcra 116. When the spigot 102 is moved down by the toggle linkage the part-conical surface 108 rocks the bell cranks 109 about their fulcra to move the sleeve 93 downwards and close the spindle collet 23.

The radial arm 26 of the slidable head is balanced by a counterweight 110 and while rotating is guided solely by the spindle *c* owing to the grip of the collet upon it. While the head is being lowered, the radial arm and collet are maintained in the correct central and horizontal position for engagement with the spindle end by means of the spigot 102 located by an inner tubular portion 111 of the body of the head assembly and a spring-loaded steady 112 slidable axially in an outer tubular portion 113 of the body of the head assembly.

As the spigot 102 moves downwards to close the collet its outer diameter leaves contact with the inner tubular portion 111 so removing central restraint on the arm. Stops (not shown) are provided to limit downward movement of the steady 112, so that when the spindle is fully entered in the collet, the arm is also free to move angularly in a vertical plane. Closing of the collet clamps the arm to the spindle which thereafter controls its movement.

The positions of the detector pick-ups may be adjustable to suit different types of rim. Tolerances in the manufacture of a given type of rim may require the accommodation of an appreciable range of dimensions notably of mean wheel diameter. Accordingly it is preferred that the rim position signals obtained from the pick-ups should not be compared to an absolute standard dimension but to a relative standard assessed by a preliminary survey of the rim of each laced wheel on first insertion of the wheel into the machine. The survey may be performed by the pick-ups during the first few revolutions of the spindle the mean value of each of the inductances being matched by a reference inductance variable by movement of an iron core set by a heavily damped servo-system which in endeavouring to balance a bridge circuit by which the fluctuating pick-up inductance and the reference inductances are compared, achieves a mean value setting. In the subsequent tensioning and truing operation the reference inductance so set becomes the standard with respect to which the pick-up inductances are compared to apply an error signal to the nipple rotating units 29.

The counterweight 110 is slidable along the radial arm 26 and can be clamped in its adjusted position. The pick-ups 27 and 28 are mounted on a slider 114 by which the suit different sizes and types of rim. Provision is also made for adjustment of the vertical position of the pick-ups with respect to the slider 114.

Nipple rotating units (Figures 2, 4, 5 and 6).

The gear train 31 of each nipple rotating unit 29 comprises reduction gearing which is enclosed in a casing 120 and has an output shaft 121 which is connected by a torsion bar 122 to the outer end of a co-axial tubular shaft 123 rotabaly mounted in bearings in the body of the nipple-rotating unit. Rigid with the tubular shaft 123 is a pinion 124 in mesh with an intermediate pinion 125 which meshes with the slotted pinion 36.

The torque responsive switch 33 comprises a segment 126 which is mounted for rotation with, but is insulated from, the output shaft 121. Electrical contact with the rotating segment is made by a brush 127. An earthed segment 128 is clamped on the inner end of the tubular shaft 123. A contact pin 129 projects from the earthed segment 128 into an opening or gap in the insulated segment 126. The insulated segment 126 is mounted on the output shaft 121 by a clamp 130 which may be slackened for angular adjustment of the insulated segment 126 with respect to the contact pin 129. The adjustment is so made that when no drive is being transmitted the contact pin 129 does not touch the insulated segment 126 but when a predetermined resistance to rotation of the slotted pinion 36 is met the torsion bar has twisted sufficiently to bring them into contact.

The intermediate pinion 125 has a hub 131 which projects through the body of the unit to drive the wiper contact 41 of the rotary switch 40. The wiper contact 41 is mounted in a carrier 132 clamped to the end of the hub 131 and is earthed. The arcuate contacts 42, 43 (Figure 5) are supported by, but insulated from, the body of the unit. There is a narrow gap sufficient to prevent bridging of the gap by the wiper contact between one pair of adjacent ends of the arcuate contacts 42, 43. The carrier 132 is so adjusted angularly on the hub 131 that the wiper contact 41 is opposite the gap when the pinion slot 37 and entrance slot 39 are radially aligned.

Each unit is mounted on a bracket 140 adapted to allow appreciable freedom of movement so that the slotted pinion imposes very little loading upon the spoke to which it is applied.

Each bracket 140 is a bell-crank or its equivalent connected by a universal joint 141 to a head 142 of a supporting plunger 143. The universal joint 141 allows the bracket to rock freely in any direction with respect to the head 142 but the extent of such rocking movement is limited by contact between the surfaces of the bracket 140 and head 142 surrounding the universal joint 141. Only very limited movement of the bracket out of its vertical radial plane is permitted; more movement in that plane is allowed. One arm 144 extends upwards to support the motor and unit. The other arm 145 extends radially inwardly to engage the underside of a plate 146 (Figure 2) vertically movable to rock all the bell-crank brackets simultaneously about their universal joints to move the slotted pinions axially of the spokes for engaging them with and disengaging them from the nipples.

The plate 146 is rigid with a collar 147 slidable on the outside of the annular guide 50 and moved through links 148, rocker levers 149 and further linkage (not shown) by a cam on the timing camshaft 30.

The plungers 143 are supported by compression springs 150. The springs 150 are low-rate and adjustable by screw-threaded collars 151 and permit sufficient bodily vertical movement of the nipple-rotating units for a very small change in spring force. The weight of the units is borne by the springs 150 and very little loading is applied to the spokes. When in engagement with the nipple the sockets 38 (Figure 5) of the slotted pinions are substantially intersected by the axis of their respective supporting plungers 143 which are free to turn about their axes to allow the sockets 38 to align themselves with the spokes which are inclined at a small angle to the radial.

Near the lower end of each supporting plunger 143 is a stop 154 pivotally mounted on a pivot pin 152 supported by an annulus 153 attached to the machine frame.

The stops 154 can all be moved simultaneously by a solenoid (not shown) and suitable connecting linkage (not shown) either so that a cut-away portion 155 on each stop is aligned with the end of the plunger which is then free to slide vertically or so that downward movement of the plunger is obstructed and the nipple-rotating units are firmly supported to hold the wheel in a fixed position during the preliminary survey.

For quick stopping and starting of the timing camshaft 30 it is driven through a magnetic clutch-brake (not shown) by a continuously rotating motor (not shown). Upon completion of the first half-turn of the camshaft the magnetic clutch is held disengaged while the wheel is trued and tensioned under the control of the pick-ups. As soon as the prescribed number of nipple-rotating units have reached the predetermined torque the magnetic clutch re-engages the camshaft drive to make the second half-revolution and start the machine-opening motions. Meanwhile the slotted pinions' slots are being aligned with the entrance slots and unless all the slots have been aligned by the time the final camshaft-controlled opening movement, that of raising the hub-gripping collet to eject the spokes from the nipple-rotating units, is about to occur this movement is automatically arrested by disengaging the magnetic clutch until all the slots are aligned.

ELECTRICAL CIRCUITS.

The diagram of the main signal handling and motor switching electrical circuits which begins at Figure 7, continues through Figure 8 to Figures 9, 10 and 11.

Error Pick-up and Servo-amplifier circuits (Figures 7, 8 and 10).

Referring first to Figure 10, the "flat" pick-up 27 and radial pick-up 28 are shown in relation to a section of the rim of the wheel W. The "flat" pick-up 27 is connected with a "flat" reference inductor 170 in a bridge circuit supplied with high frequency A.C. power. The resulting A.C. "flat" error signal is fed by a lead 172 to the input of a two-stage amplifier 173 (Figure 7).

The "radial" pick-up 28 is similarly connected with a "radial" reference inductor 171 and the resulting "radial" error signal is fed by a lead 174 to a two-stage amplifier 175 (Figure 7).

The output of the two-stage amplifiers 173 and 175 is converted to D.C. by phase-sensitive rectifiers 176, 177. The phase-sensitive rectifier 176 is double and splits the amplified "flat" error signal into two parts and compares its phase with a reference supply in phase with the high frequency supply to the bridge circuit by transformers 178, 179 the primary windings of which are oppositely connected to the reference supply. The two parts of the split signals are rectified and produce D.C. outputs at leads 180 and 181 which are equal and of opposite sign.

The phase-sensitive rectifier 177 gives only a single D.C. output at a lead 182.

During the preliminary survey of the rim the D.C. signals on leads 181 and 182 are each supplied to two servomechanism circuits shown in Figure 8 to set iron cores 191, 192 of the reference inductors 170, 171. The two servomechanism, circuits are similar. Lead 181 is connected through contacts 205 to lead 181. The D.C. signal on lead 181 or 182 passes through a smoothing circuit 183 to a modulator 184 which reconverts it into alternating current but at a frequency of 50 c.p.s. A servo amplifier 185 amplifies the A.C. signal and its power output is supplied to one stator winding 186 of a servomotor 187 of which a second stator winding 188 is connected to an A.C. supply at 50 c.p.s. The phase-relationship between the supplies to the windings 186 and 188, determined by whether the D.C. signal input on lead 181^1 or 182 is negative or positive, decides the direction in which the rotor 189 of the corresponding servomotor turns. The rotors 189 are coupled by the mechanical connection indicated by the broken lines 190 to move the iron cores 191, 192 of the reference inductors 170, 171.

Each servomotor 187 is provided with a tacho-generator having an energizing winding 194 connected to the same 50 cycle supply as the stator winding 188. An output winding 195 supplies a negative feed-back by means of a lead 196 to the input of the servoamplifier. This servosystem, being heavily damped, in attempting to match the fluctuating inductance of the associated pick-up as it moves around the rim of the wheel during the preliminary survey achieves an "average" value and stops.

From the servomechanism circuit for the "flat" error signal alone the output of the servoamplifier and the output of tachogenerator are supplied by leads 197, 198 to windings 199, 200 (Figure 7) respectively of an "average" relay 201. A third winding 202 is energized by the supply. The relay 201 controls switch contact pairs 203, 204, 205, 206. While the servomotor is bringing the reference inductance to its "average" value the windings 199 and 200 are energized and the switch contact pairs remain in the positions indicated, namely 205 closed and 203, 204 and 206 open. When the iron core is in the "average" position the signal on the winding 199 falls to zero and when the servomotor is stationary the signal on the winding 200 is also zero. When both signals are zero simultaneously, indicating that the iron core is stationary in the "average" position, the relay operates and reverses the switch contacts 203, 204, 205, 206.

The opening of the contacts 205 removes the error signal from the servo-mechanism circuit for the "flat" error signals. Since the circumference of the wheel is fixed the average radius is fixed and after the preliminary survey the average signal to the "radial" servomechanism circuit (after smoothing) should remain at zero so that the reference inductance does not move. The servomechanism circuit may therefore remain connected so that contacts corresponding to contacts 205 are unnecessary.

The D.C. output of the phase-sensitive rectifier 177 on lead 182 in addition to being passed through the "radial" servoamplifier in the lower part of Figure 8 is amplified in a step-amplifier adapted to provide a sudden increase of output to a large negative value when radial error reaches a predetermined value. On the closing of contacts 206 the radial error signal is superimposed in a mixer 214 on the "flat" error signals on lines 180 and 181, for joint operation of the nipple rotating units as is described later.

Motor switching circuits (Figures 9, 10 and 11).

The closing of contacts 203, 204 applies the combined signals on leads 180, 181 through leads 207, 208 to the distributor 35 (Figure 9). The distributor is in two parts 209, 210 for the motors of the nipple-rotating units on the upper and lower spokes respectively. Each part is arranged to connect the lead 207 or 208 respectively to the switching circuit of the pair of upper or lower motors of the station to which the pick-ups are then opposite. For simplicity the connections to the switching circuits of the four motors of only one station are shown in Figure 9. From the distributor part 209 a connection is made to control grids of thermionic relays V2 and V4 controlling relays F2/2 and F4/2 for the two upper-spoke motors Nos. 2 and 4 (Figure 10) of the station. From the distributor part 210 similar connections are made to thermionic relays V1 and V3 controlling relays F1/2 and F3/2 for the two lower-spoke motors Nos. 1 and 3. Between the grid of each of the thermionic relays V1, V2, V3, V4 and earth, are connected capacitators 211, which are charged to maintain the grid voltages at the set value while the signals supplied to the distributor are connected to the motor switching circuits of the other stations.

Normally the thermionic relays V1, V2, V3, V4 conduct and all four motors of the station run. If the "flat" error signal on leads 207, 208 to the upper or lower motors becomes negative, thermionic relays V2 and V4 or V1 and V3 operate to stop their respective motors. If however the "radial" error signal, as a result of the operation of the step amplifier, suddenly increases to a large negative value, the signal applied to control grids of all the thermionic relays V1, V2, V3, V4 becomes negative whether the "flat" error signal on 180, 181 is positive or negative and all the motors of the station are stopped.

The motor switching circuit is shown in a simplified form in Figure 10. A more detailed circuit diagram is shown in Figure 11 which shows in some detail the motor control circuits of one station, called No. 1, and represents part of the corresponding circuits of stations Nos. 2 and 3 to assist in understanding the operation of certain parts of the circuits.

In the middle of Figure 11 is shown the nipple screwing motor 32, the armature 220 of which is mechanically coupled, as indicated by the broken line, to rotate the wiper contact 41 of the rotary switch 40 and the torque-responsive switch 33. The upper part of Figure 11 shows details of a slot aligning circuit 221 and the lower part the minimum tension circuit 222.

Minimum Tension Circuit (Figure 11).

The insulated segment 126 of each torque responsive switch 33 is connected through the brush 127 and a resistor 223 to a line 224 and the earthed segment 128 of each switch, being earthed, is in effect as though connected to a line 225.

The line 224 is connected to the positive side of an isolated D.C. supply and the line 225 through a resistor 226 to the negative side of the supply. Across the supply resistors 227 and 228 in series are also connected and a tapping 229 on resistor 227 is connected to the control grid of a relay valve V5 whose anode circuit controls a relay TN/1 included in the circuit of the magnetic clutch-brake for the timing camshaft 30. As each torque-responsive switch 33 closes the potential difference across the resistor 226 increases so changing the potential with respect to earth of the tapping 229.

When the prescribed number of torque responsive switches have closed the potential of the tapping 229 becomes such that the relay valve V5 operates through the relay TN/1 controlling the magnetic clutch-brake, by means not shown to restart the timing camshaft to perform the second part of its cycle. The relay TN/1 also indirectly switches off the power supply to all the nipple rotating motors, by further means not shown.

Slot aligning circuit (Figure 11).

The thermionic relay VI is actually a double-triode one anode 243 of which is connected to a relay F1/2 and the other 244 to a relay B1/2. The two control grids 240, 241 of the thermionic relay are connected to the arcuate contacts 42, 43 respectively of the rotary switch 40. The grids 240, 241 are connected through resistors 242 to a lead 248 to which a negative bias is applied. When the wiper arm 41 is in contact with, say, the contact 42 the grid 240 is directly earthed and the left-hand side of valve V1 conducts and the relay F1/2 operates. At the same time the grid 241 is negatively biased so that anode current on the right-hand side of valve V1 is suppressed. On the other hand when the wiper 41 is in contact with the contact 43 the condition of the two sides of valve V1 is reversed and the relay B1/2 is operated. When the wiper 41 is in the gap 44, anode current on both sides of valve V1 is suppressed and neither of the relays F1/2 and B1/2 is operated.

The motor 32 has a field winding 245 which is separately excited and the armature 220 has brushes 246 and 247. The brush 247 is permanently earthed.

The contacts of relays F1/2 and B1/2 are shown near the armature 220. Relay F1/2 has one pair of contacts F1.1 closed when the relay is operated to connect brush 246 to a positive D.C. supply and so to run the motor in the forward direction. Relay B1/2 similarly has a pair of contacts B1.1 which when the relay is operated connect brush 246 to a negative D.C. supply and so reverse the direction of running of the motor.

Both relays F1/2 and B1/2 have contacts F1.2 and B1.2 which are closed when the relays are not operating. These contacts F1.2 and B1.2 are connected in series between brush 246 and earth and so, when both are closed, short-cricuit the armature to stop the motor as quickly as possible.

The slot aligning circuit does not come into operation until completion of the tensioning and truing operation. During tensioning and truing the grid 240 of the left-hand half of each of the double triode valves V1, V2, V3, V4, etc., is disconnected from the arcuate contact 42 and resistor 242 and connected to the appropriate contacts of the distributor as represented in Figure 9. The H.T. supply is also disconnected from the right-hand half of all the double triodes.

All slots lined up circuit (Figure 11).

The negative bias 254 is applied through a resistor 250 at point 265 to the lead 248. The lead 248 is common to the corresponding slot-aligning circuit of all the nipple-screwing motors.

The resistor 250 forms part of a cricuit 251 for denoting that all the slots have been lined up. The circuit 251 is a " long-tailed pair " circuit which comprises a double-triode valve V6 one anode of which is connected to an anode resistor 252 and the other anode to a relay L/1. The common cathode of valve V6 is connected through cathode resistor 253 to the negative bias supply 254. Between earth and negative bias supply 254 resistors 255, 256, 257 in series are connected, between adjacent pairs of which are tappings 258 and 259. The tapping 259 is connected to the grid 260 of valve V6 controlling anode current through relay L/1. Between tapping 258 and point 265 a diode clamp V7 is connected and point 265 is also connected to the grid 261 of valve V6 controlling current flow through anode resistor 252.

Until all the slots are lined up there is current flow through one or more of the resistors 242 and consequently through resistor 250 across which there is therefore a potential difference making point 265 approach earth potential, but the diode clamp V7 prevents the potential at point 265 becoming positive with respect to tapping 258. Under these conditions heavy current flows through anode resistor 252 and through cathode resistor 253. The common cathode of valve V6 is consequently held positive with respect to grid 260 which is at the potential of tapping 259 so that no current flows through relay L/1.

When the final slot becomes lined up the current flow through resistor 250 ceases and point 265 reaches the full negative potential of bias supply 254 and so does the grid 261 which cuts off anode current through anode resistor 252 and consequently current immediately flows through relay L/1 which, as already mentioned, is included in the magnetic clutch-brake circuit of the timing camshaft 30. If the camshaft 30 reaches the stage at which the wheel is to be ejected before the relay L/1 operates, the camshaft 30 is stopped until the relay has operated.

At the end of the cycle H.T. to V6 is switched off so that the All Slots Lined Up circuit is restored to its initial condition. The H.T. supply is switched on again soon after the beginning of the next cycle.

Summary of operation.

The sequence of operations of the complete machine is as follows.

The operator places a laced wheel in the machine with its spokes lying on the entrance slots 39 of the nipple-rotating units and the lower end *a* of the hub *b* in the open hub-collet 20. The operator then starts the machine by pressing a start button which engages the clutch brake of the timing camshaft 30. Rotation of the timing camshaft first closes the hub-collet 20 and then moves it down to pull the spokes into engagement with the slotted pinions.

As soon as the spokes are engaged laterally with the slotted pinions, the nipple-rotating units are rocked about the pivots of their supporting bell cranks to move the sockets 38 radially into engagement with their respective nipples. The head 22 is brought down with the spindle collet 23 open and with the radial arm 26 held horizontal by the spring-loaded steady to engage the end of the spindle *c*. The spindle collet 23 is then closed and grips the spindle, after which the camshaft stops and rotation of the radial arm begins for the preliminary survey to be made, the nipple-rotating units being supported by the stops 154. When the "average" relay 201 has operated the stops 154 are withdrawn by a solenoid so that the nipple-rotating units may "float" on their springs 150.

The timing camshaft remains stationary while the truing and tensioning operation is performed under the control of the electrical circuits as already described. On completion of the truing and tensioning operation indicated by the operation of the relay TN/1 of the Minimum Tension Unit the timing camshaft is restarted. Under its control the nipple-rotating units are retracted radially, and the spindle collet is opened and the head raised, the hub collet opened and, finally, raised to eject the wheel from the nipple rotating units for removal by the operator. Meanwhile the slotted pinions are being aligned by the slot-aligning circuits and unless all the slots have been aligned by the time the timing camshaft is about to cause ejection of the wheel the timing camshaft is stopped temporarily. The final movement of the timing camshaft completes the hub collet rise to the starting position and then stops the machine.

In addition to the simplified electrical circuits including relays and limit switches on various parts of the machine described there is a sequence control circuit to control the sequence of operation of the various solenoids and motors of the machine. This circuit performs some of the functions to which reference has already been made. It also includes safety interlocks to alter the normal sequence of the machine to eject a laced wheel without attempting to true and tension it upon the detection of faults such as incorrect loading resulting in failure of the spindle to enter the spindle collet as the head is lowered, oversize or undersize of the spindle or a faulty rim.

Details of the machine described may obviously be varied particularly in the electrical circuits in which known alternative circuits to those described may be employed.

WHAT WE CLAIM IS:—

1. A machine for tensioning and truing previously laced spoked wheels comprising means for gripping and locating the hub of a laced wheel, means for rotating the spoke nipples, means for rotating the wheel spindle with respect to the hub, means for detecting errors in the rim with respect to the rotating spindle, means responsive to the errors detected for controlling the nipple-rotating means in the sense to correct the error and means for stopping the nipple-rotating means upon reaching a pre-determined tension in at least some of the spokes.

2. A machine according to Claim 1 wherein the spokes are substantially relieved of transverse loading by the nipple-rotating means.

3. A machine according to Claim 1 or 2 wherein the means for detecting errors includes an inductive or capacitative electrical pick-up mounted for rotation in fixed relation to the spindle and close to the rim.

4. A machine according to Claim 3 wherein the inductance or capacitance of the electrical pick-up is compared with a reference inductance or capacitance to provide a difference signal as a measure of error.

5. A machine according to Claim 4 wherein the reference inductance or capacitance is variable by a servosystem connected to the electrical pick-up during a preliminary survey of the rim, the arrangement being such that the reference inductance is set to match the mean value of the fluctuating inductance of the pick-up.

6. A machine according to any preceding claim wherein the means for detecting errors comprises two pick-ups, one directed radially towards the curved surface of the rim to indicate radial error of the wheel and the other directed axially opposite the annular face of the rim to indicate axial or "flat" error.

7. A machine according to Claim 6 as dependent upon Claim 4 or Claim 5 wherein each pick-up has an associated reference inductance or capacitance.

8. A machine according to any preceding claim wherein "radial" and "flat" errors of the rim are detected independently and are applied to control the nipple-rotating unit or units at the part of the rim instantaneously opposite the detecting means, the "flat" error causing the nipple-rotating unit or units

of spokes on one face of the wheel to run and on the other face to stop in the sense to correct the error and the radial error overriding the flat error signals to stop the nipple-rotating unit or units where the radial error indicates that the wheel radius at the associated rim part is small.

9. A machine according to Claim 8 wherein the nipple-rotating units are divided for control purposes into stations of several units on adjacent spokes running to a section of the rim.

10. A machine according to Claim 9 wherein a distributor rotated with "flat" and "radial" pick-ups forming the means for detecting errors connects electrical signals derived from the pick-ups to the nipple-rotating units of the appropriate station.

11. A machine according to any preceding claim wherein a nipple-rotating member of some or all of the spoke units of the nipple-rotating means is driven through a torque-responsive device adapted on reaching a predetermined torque to affect means for stopping all the nipple-rotating units when a prescribed number of units have reached the predetermined torque.

12. A machine according to Claim 11 wherein the torque-responsive device is a torque-responsive electric switch which is connected in an electric circuit so as to affect the potential of a point in the circuit as each switch is actuated, an electrical relay responsive to the potential of the point being actuated when a potential is reached which corresponds to the prescribed number of nipple-rotating units having reached the predetermined torque.

13. A machine according to any preceding claim wherein each spoke unit of the nipple-rotating means has a nipple-engaging socket rotatable in a bearing having an entrance slot with which a radial slot in the socket can be aligned for lateral engagement and disengagement of the socket with the spoke, and also has a slot-aligning device, operative upon stopping of the nipple-rotating units on reaching the predetermined spoke tension.

14. A machine according to Claim 13 wherein each slot-aligning device comprises a rotary switch having a wiper contact driven synchronously with the nipple-engaging socket and two arcuate contacts which form a continuous fixed contact path for the wiper contact except for a gap between one pair of adjacent ends of the arcuate contacts and so located that when the wiper contact is at the gap the radial slot is aligned with the entrance slot, the rotary switch being connected in an electrical circuit controlling the direction of rotation of the nipple-engaging socket to move the radial slot in the shorter direction towards the entrance slot.

15. A machine according to Claim 14 wherein all the rotary switches of the nipple-rotating means are connected in a further electrical circuit adapted to operate a relay when in each rotary switch the wiper contact is at the gap.

16. A machine according to Claim 4 wherein the A.C. difference signal is amplified and converted to D.C. by phase-sensitive rectifiers which compare the phase of the difference signal with a reference supply in phase with the A.C. supply to the electrical pick-up, the resulting D.C. signals being applied to thermionic relays controlling units of the nipple-rotating means.

17. A machine according to Claim 16 wherein there are electrical pick-ups for "radial" and "flat" errors of the rim each pick-up having an associated reference inductance or capacitance and phase-sensitive rectifier, the phase-sensitive rectifier for the "flat" signal being double giving two D.C. output signals which are equal and of opposite sign and are applied respectively to thermionic relays controlling nipple-rotating units on spokes on opposite faces of the wheel.

18. A machine according to Claim 16 wherein the phase-sensitive rectifier for the "radial" signal has a single D.C. output which is passed through a step-amplifier adapted to give the signal a large and sudden increase when a predetermined value is reached, so that it is so much larger than the "flat" D.C. signals upon which it is superimposed that the relays of the nipple-rotating units are operated by the combined signals to stop the nipple-rotating units.

19. A machine according to any of Claims 16 to 18 wherein the or each reference inductance or capacitance is variable and is set during a preliminary survey of the rim by a servosystem to which the D.C. error signal is fed, and by which it is re-converted to A.C. and amplified to control a servomotor adapted to set the variable reference inductance, the servosystem being heavily damped in order to set the reference inductance to the average value of a fluctuating error signal.

20. A machine according to Claim 19 wherein the servomotor has a tacho-generator or an equivalent winding to supply a negative feed-back to the input of the servoamplifier when the servomotor is in motion, and wherein corrections are made from the tacho-generator output and the servomotor input to coils of an "average" relay which operates when both signals fall to zero indicating that the reference inductance or capacitance is in the "average" position and is at rest, the "average" relay initiating the succeeding operation of the machine.

21. A machine according to any preceding claim wherein the means for detecting errors in the rim comprises a radial arm adapted to be clamped to an end of the wheel spindle and carrying the detector ele-

ment or elements on its outer end, the arm, and thereby the spindle, being rotated by drive means imposing no significant restraint on other movements of the arm.

22. A machine according to Claim 21 wherein the arm is carried by a part of the machine which is movable towards the wheel position during loading of the machine and away from the wheel position during unloading, the head including means for locating the arm suitably for engagement with the wheel spindle during loading.

23. A machine according to any preceding claim wherein the means for gripping and locating the hub of a laced wheel comprises a collet for gripping one end of the hub and the nipple-rotating means comprising nipple-engaging sockets having radial slots for lateral engagement with the wheel spokes, the collet being axially movable to move a wheel loaded into the machine with its hub in the hub collet and its spokes in the entrances of the slots into full engagement of the spokes with the nipple-rotating socket and to eject the wheel after completion of the tensioning and truing operation.

24. A machine according to any preceding claim dependent upon Claim 2 wherein the nipple-rotating means comprises individual spoke units each mounted for floating movement in a direction at right angles to the plane of the wheel.

25. A machine according to Claim 24 wherein the spoke units are mounted on arms movable in a substantially radial plane of the wheel during engagement and disengagement of nipple-rotating sockets and the spoke nipples.

26. A method of truing and tensioning a laced spoked wheel having a hub rotatably mounted on a spindle which comprises supporting the wheel by means of the hub, rotating the spindle to move around the rim detecting means which is clamped to the spindle and controls the tightening of the spokes to make the flat and radial spacings of the detector means from the rim constant.

27. A method according to Claim 26 wherein the tensioning and truing operation is arrested when a prescribed number of spokes reach a predetermined tension.

28. A method of truing and tensioning a laced spoked wheel in which the wheel is supported by the hub alone and the rim during tensioning and truing is laterally and radially substantially unrestrained except by the spokes.

29. A method according to any of Claims 26 to 28 wherein the nipples are rotated during tensioning and truing in such a way that no significant lateral loading is imposed on the spokes.

30. A machine for tensioning and truing previously laced spoked wheels according to any of the preceding claims which is constructed and adapted to operate in respect of any of its component elements substantially as described with reference to any of the accompanying drawings.

31. A machine for tensioning and truing previously laced spoked wheels substantially as described herein with reference to and as illustrated by the accompanying drawings.

32. A spoked wheel tensioned and trued by the machine, or according to the method, claimed in any preceding claim.

BARKER, BRETTELL & DUNCAN,
Chartered Patent Agents,
75 & 77 Colmore Road, Birmingham 3.

PROVISIONAL SPECIFICATION.

Improvements in or relating to the Building of Spoked Wheels.

We, T. I. (Group Services) Limited, a British Company of Rocky Lane, Aston, Birmingham 6, do hereby declare this invention to be described in the following statement: —

This invention relates to the building of spoked wheels such as cycle wheels. There are three main stages in the building of spoked wheels by hand: —

1. Lacing: — in which the spokes are threaded in a certain order through the holes in the hub and inserted in the correct holes in the rim where they are lightly held by nipples which are just started on the spoke thread.

2. Tensioning: — in which the nipples are screwed on to the spoke threads by substantially the same amount to tighten the spokes to the required tension.

3. Truing: — in which the wheel is spun upon its spindle and individual spokes are tightened or slackened to make the rim flat (that is without lateral irregularities), circular and concentric with the spindle.

The present invention provides a machine for tensioning and truing of previously laced wheels.

A machine according to the present invention comprises means for gripping and locating the hub of a laced wheel, means for rotating the spoke nipples, means for rotating the wheel spindle with respect to the hub, means for detecting errors in the rim with respect to the rotating spindle, means responsive to the errors detected for controlling the nipple rotating means in the sense to correct the error and means for stopping the nipple rotating means upon reaching a predetermined tension in at least some of the spokes.

The rim is not clamped and is restrained merely by the spokes which are preferably substantially relieved of loading by the nipple rotating means in order that the wheel may be tensioned and trued in the machine under conditions which are very similar to those which will obtain when the wheel is removed from the machine.

When a spoked wheel mounted on conventional cup and cone hub bearings rotates on its spindle, owing to normal running clearances and manufacturing tolerances the axis about which the wheel rotates does not coincide with the geometrical axis of the spindle. It is for this reason that the wheel is clamped in the machine by its hub and is trued with reference to the rotating spindle. In this way normal running conditions are closed simulated.

The means for detecting errors are preferably electrical pick-ups mounted for rotation in fixed relation to the spindle and close to the rim, but not making actual physical contact with it.

The pick-ups may be inductive, or capacitative, their inductance or capacitance increasing as the width of air gap between the pick-up head and the adjacent portion of the rim decreases. The inductance or capacitance can then be compared with a reference inductance or capacitance, to provide a difference signal which is used as a convenient measure of error.

Although in the remainder of this Specification only an inductive pick-up system is referred to, it is clear that this may readily be modified to a capacitative pick-up system as an alternative. Two pick-ups are preferably employed one directed radially towards the curved surface of the rim to indicate radial error of the wheel and the other directed axially opposite the annular face of the rim to indicate axial or " flat " error.

The positions of the detector pick-up may be adjustable to suit different types of rim. Tolerances in the manufacture of a given type of rim may require the accommodation of an appreciable range of dimensions notably of mean wheel diameter. Accordingly it is preferred that the rim position signals obtained from the pick-ups should not be compared to an absolute standard dimension but to a relative standard assessed by a preliminary survey of the rim of each laced wheel on first insertion of the wheel into the machine. The survey may be performed by the pick-ups during the first few revolutions of the spindle the means values of each of the inductances being matched by a reference inductance variable by movement of an iron core set by a heavily damped servosystem which in endeavouring to balance a bridge circuit by which the fluctuating pick-up inductance and the reference inductance are compared, achieves a mean value setting. In the subsequent tensioning and truing operation the reference inductance so set becomes the standard with respect to which the pick-up inductances are compared to apply an error signal to the means for tensioning the spokes.

A separate nipple rotating unit is provided at each spoke and for convenience may be divided into stations each comprising several units on adjacent spokes running to a section of the rim. By a suitable rotary switching device associated with the spindle the units of a station are connected to the error detecting circuits while the pick-ups are opposite the associated rim section and appropriately set to correct the current error, continuing as set after the pick-ups have left the rim section until re-set on the next or a subequent occasion upon which the pick-ups are facing that rim section.

The wheel is preferably supported horizontally in the machine, that is, for rotation of its spindle about a vertical axis. Adjacent spokes run alternately to the upper and lower spoke flanges of the hub. A station may conveniently comprise the nipple rotating units of four spokes, two being upper and two lower spokes. The preferred mode of operation is that the nipple rotating units have only two conditions namely running to screw up the nipples or stopped. Normally all the units are run together. If on an inspection the " flat " error pick-up indicates that the rim section is low the two lower-spoke units are stopped but if the rim section is high the two upper spoke units are stopped. If the radial pick-up indicates that the wheel radius is large the units of the station are kept in the setting determined by the " flat " pick-up. On the other hand if the indication is that the wheel radius is small the radial pick-up overrides the " flat " pick-up and stops all the units of the section.

At least some but preferably all of the nipple rotating units are driven, preferably each by an individual electric motor, through torque-responsive switches which are adjustable for predetermining the torque at which the switch contacts are actuated, usually closed. When a prescribed number of units have reached the predetermined torque the tensioning units of all the stations are stopped. The number of units to be prescribed may be determined by experiment and experience. For a forty spoke wheel with every unit driven through a torque responsive unit six or eight units reaching the predetermined torque is probably an adequate indication that the wheel has been sufficiently tensioned. It will be understood that the continuous inspection and correction of the rim position as the wheel is being tensioned reduces the errors progressively until the wheel is flat and true. This condition is not necessarily consistent with equal tension of the spokes which is a consideration less important than the truth and flatness of the wheel. Nor is nipple-rotating torque an accurate indication of spoke tension since it also includes friction between the nipple and the spoke thread and the rim, nevertheless when taken on several spokes it is a fairly close indication of the general tension level of the spokes of the wheel.

The nipple-rotating means preferably includes as the nipple-engaging member a radially slotted pinion which is in mesh with a gear or gear train continuously rotatable by the unit drive. The number of turns which can be applied to tighten a nipple is thus unlimited. The radial slot allows the pinion to straddle the spoke co-axially. After embracing the spoke the pinion can be moved axially of the spoke to engage the flats of the nipple with a complementary socket in the end face of the pinion. A spoke can only be entered in the pinion slot when this slot is aligned with an entrance slot in the body of the nipple-rotating unit. When the wheel is horizontally mounted in the machine these entrance slots are preferably directed upwards.

When all the units are stopped upon the wheel becoming sufficiently tensioned the pinion slots may come to rest in any angular position. According to a further feature of the invention means are provided for aligning the pinion and entrance slots of each unit. A rotary switch driven synchronously with the pinion has a wiper contact and two arcuate contacts which form a continuous fixed contact path for the wiper contact except for a gap between one pair of adjacent ends of the arcuate contacts. The arrangement is such that when the wiper arm is at the gap the slot of the pinion is aligned with the entrance slot, when it is in contact with one fixed contact the drive rotates to move the pinion slot in the shorter direction towards the entrance slot and when it is in contact with the other fixed contact it rotates in the opposite direction. The rotary switch is only connected into the unit drive control circuit when all the drive units have been stopped and the pinions have been moved axially to disengage the nipples. The pinion is then driven in one direction or the other until the wiper arm is at the gap and the pinion slot aligned with the entrance slot. Means may be provided for arresting the ejection of a finished wheel from the machine if any of the slots are not aligned. Alternatively the arrangement may be that ejection occurs only after all the slots have been aligned.

In one embodiment of the invention, apart from inserting a laced wheel to be trued and tensioned and removing a finished wheel the operation of the machine is automatic. The wheel is supported horizontally and gripped at the lower end of the hub by a collet below the wheel. A head slidably mounted on vertical guides above the wheel can be lowered to engage a collet with the upwardly projecting end of the wheel spindle. The collet is rotatable by a universal drive and clamps to the spindle for rotation with it a radial arm carrying the pick-ups at its outer end. The head also includes the selector switch driven in synchronism with the arm for connecting the pick-ups to control the nipple rotating units of the station corresponding to the rim section over which the pick-ups are passing.

Each nipple rotating unit is driven through a torque-responsive switch by an individual electric motor. The unit drive and motor are mounted on brackets adapted to allow appreciable freedom of movement so that the slotted pinion imposes very little loading upon the spoke to which it is applied. Each bracket is a bell-crank or its equivalent pivotally mounted at its angle for movement in a vertical plane radial of the wheel and having one arm upwardly extending to support the unit, drive and motor and the other arm extending inwardly to engage the underside of a plate vertically slidable to rock all the bell-crank brackets simultaneously about their pivot to move the slotted pinions axially of the spokes for engaging them with and disengaging them from the nipples. The bell-crank pivots are mounted on the upper end of spring supported plungers. The springs are low-rated and adjustable and permit sufficient bodily vertical movement of the nipple-rotating units for a very small change in spring force. The weight of the units is borne by the springs and very little loading is applied to the spokes. When in engagement with the nipple the slotted pinions are intersected by the axis of their respective supporting plungers which are free to turn to allow the slotted pinions to align themselves with the spokes which are inclined at a small angle to the radial.

The wheel is inserted in the machine by the operator with the spokes lying on the entrance slots of the nipple-rotating units. The hub gripping collet is first advanced open to embrace the hub end, closed and then moved down again to pull the spokes into engagement with the slotted pinions.

The radial arm of the slidable head is counter-balanced and while rotating is suspended by the universal drive to enable it to be guided solely by the spindle. While the head is being lowered, the radial arm and collet are maintained in the correct central and horizontal position for engagement with the spindle end by means of a spigot and a spring loaded steady. Relative movement between these members and the fixed portion of the head leaves the arm unrestrained by the time the collet has closed on the spindle.

Both the hub and the spindle gripping collets are actuated by means including a spring element which accommodates manufacturing tolerances in the diameters of the components being gripped.

All the movements necessary before the truing and tensioning operation can begin are initiated by the pressing of a start button by the operator and are derived from a camshaft by mechanical linkages or performed by solenoids timed directly or indirectly by the camshaft. The camshaft makes half a revolution to perform the starting cycle and a further half revolution to open the machine to allow the finished wheel to be removed. For quick stopping and starting of the camshaft it is driven through a magnetic clutch-brake by a continuously rotating motor. Upon completion of the first half-turn of the camshaft the magnetic clutch is held disengaged while the wheel is trued and tensioned under the control of the pick-ups. As soon as the prescribed number of nipple rotating units have reached the predetermined torque the magnetic clutch re-engages the camshaft drive to make the second half-revolution and start the machine-opening motions. Meanwhile the slotted pinions' slots are being aligned with the entrance slots and unless all the slots have been aligned by the time the final camshaft-controlled opening movement, that of raising the hub-gripping collet to eject the spokes from the nipple-rotating units, is about to occur this movement is automatically arrested by disengaging the magnetic clutch until all the slots are aligned. After the wheel spokes have been ejected the machine comes to rest while the operator removes the finished wheel and replaces it by a laced wheel to repeat the operation.

The pick-ups and reference inductances are compared on a bridge circuit supplied with high frequency A.C. power, and the resulting A.C. error signals are converted to D.C. by phase sensitive rectifiers.

The radial D.C. error signal is again amplified in such a way that it suddenly increases to a large negative value when radial error reaches the predetermined value.

The flat error signal is split into two signals to control the upper and lower rotating unit motors respectively, and the radial error is superimposed on each of these signals, to form two combined signals. These combined signals are applied to the grids of thermionic relays included in the motor switching circuits to stop the appropriate pair of motors in the case of too large a "flat" error and to stop all the motors in the case of too large a radial error as previously described. These D.C. signals are also used to charge capacitors to maintain the grid voltage at the set value while the pick-up circuit is connected to the motor switching relay circuits of the other stations.

For the preliminary survey of the rim to set the reference inductors the D.C. error signal of each circuit is reconverted to 50 cycle A.C. and again amplified and applied to a servo-motor to correct the position of the iron core of the reference inductor. During this action the nipple rotating units are maintained at the correct height by a stop member, temporarily engaged with the lower ends of their supporting plungers.

The circuit for indicating that the prescribed number of nipple rotating units has reached the predetermined torque comprises a resistance network, into which an additional resistance is added by the closing of the torque responsive switch on each nipple rotating unit.

In this way the voltage level of one point in the network varies with the number of switches closed, and by connecting this point to the grid of a thermionic relay, the relay can be made to operate when the required conditions of tension are reached.

The motor-controlling circuits for the slot-aligning means comprise a double-triode therminoic relay the grid of each of which is connected to a fixed arcuate contact of the slot-aligning rotary switch. When the wiper contact engages one fixed contact a voltage is applied to the grid of one of the triodes which conducts and causes the motor to run in say the forward direction. When the wiper contact engages the other fixed contact the signal is applied to the grid of the circuit which runs the motor in the reverse direction.

The slot aligning rotary switches are also used in another circuit to indicate when the slots of all the slotted pinions have been aligned with their respective entrance slots. A resistance from every arcuate contact is connected to a common point whose voltage changes only when none of the wipers is in contact with either of its arcuate contacts. By connecting this point to the grid of a thermionic relay the relay can be made to operate when the required condition is reached.

BARKER, BRETTELL & DUNCAN,
Chartered Patent Agents,
75 & 77 Colmore Row, Birmingham 3.

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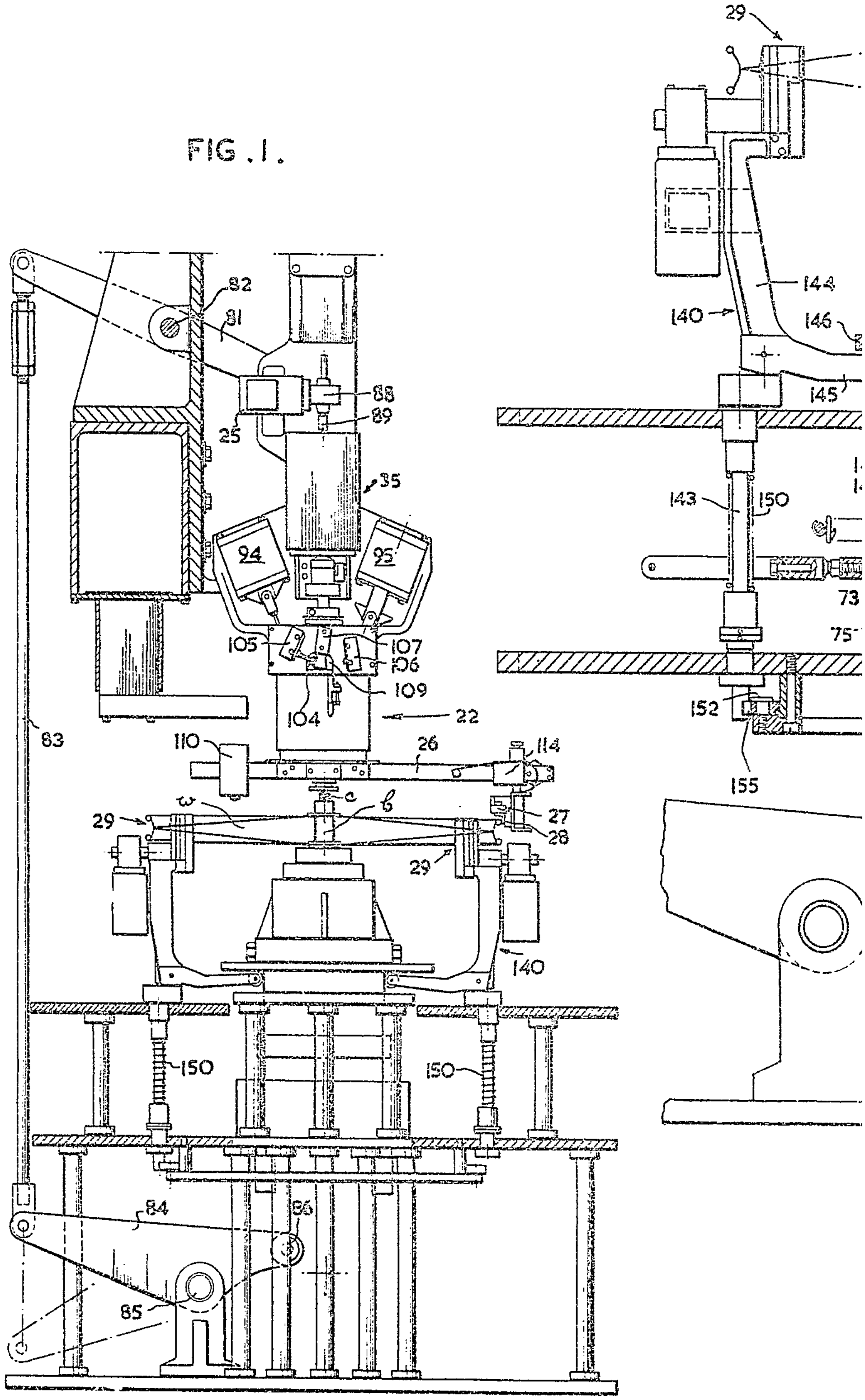
FIG. 1.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856,691 COMPLETE SPECIFICATION
7 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*
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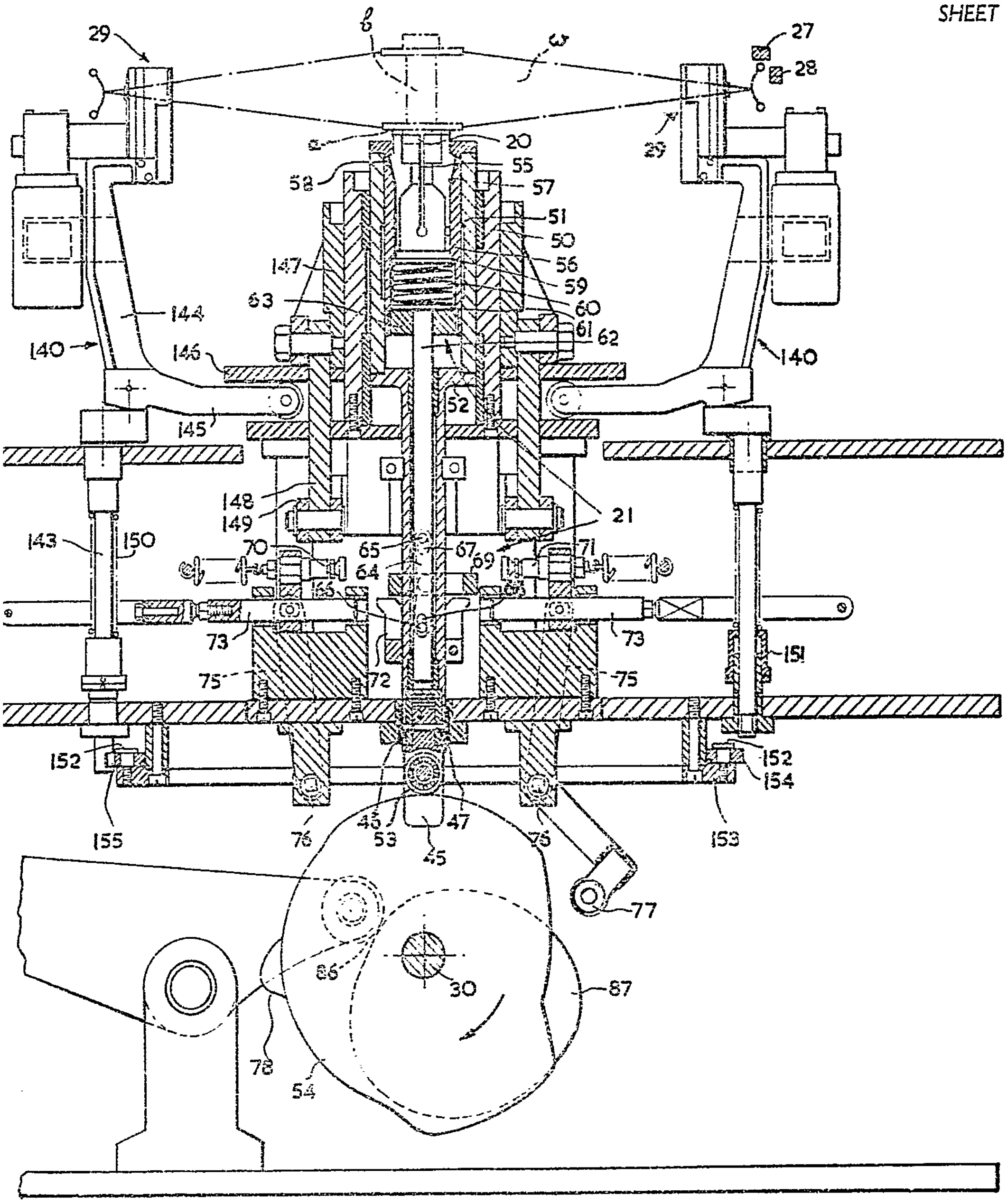
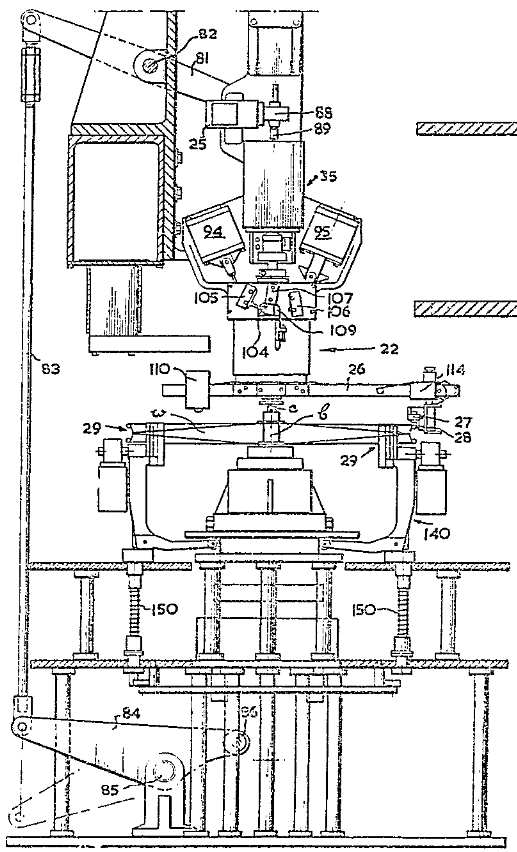


FIG. 2.

FIG. 1.



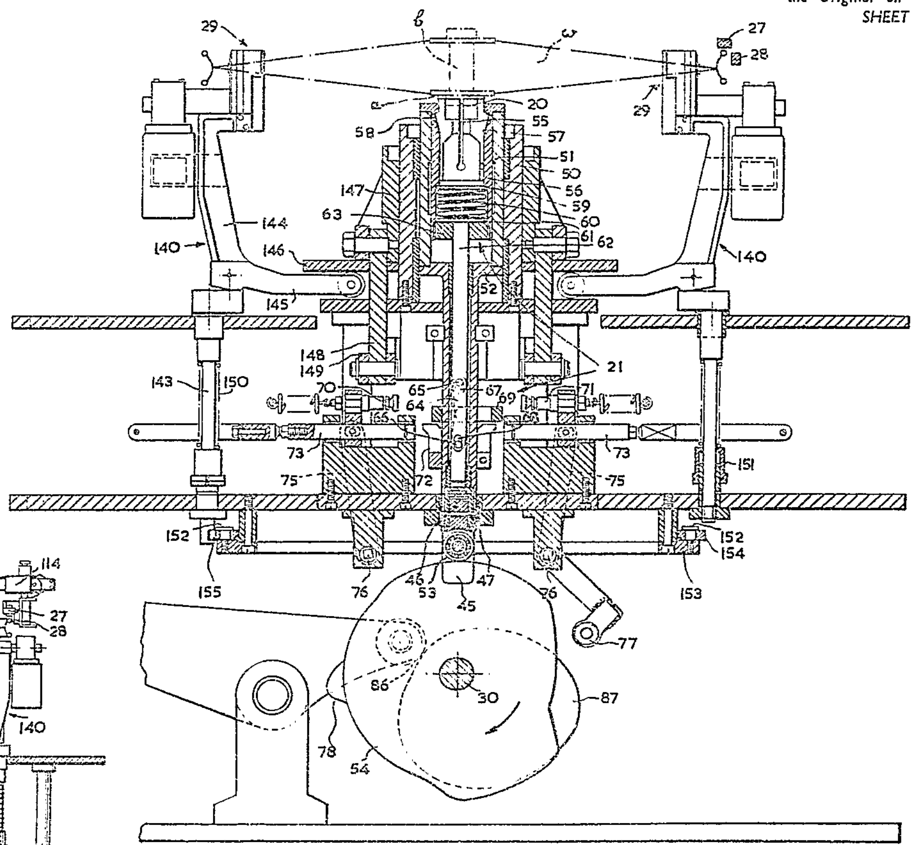


FIG. 2.

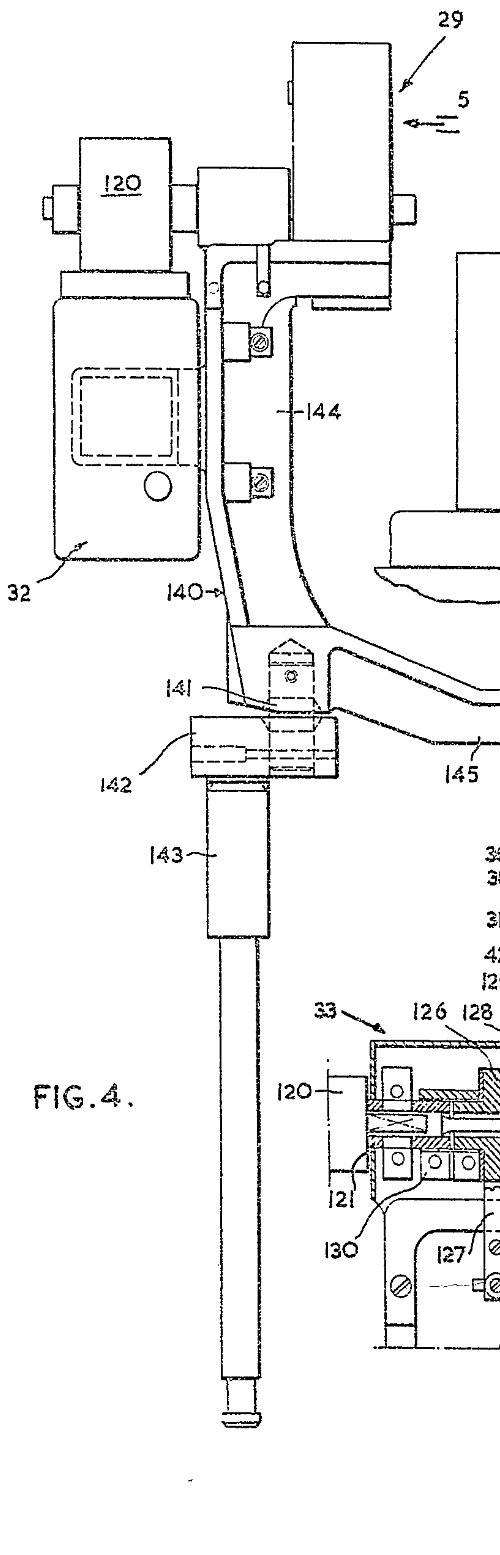


FIG. 4.

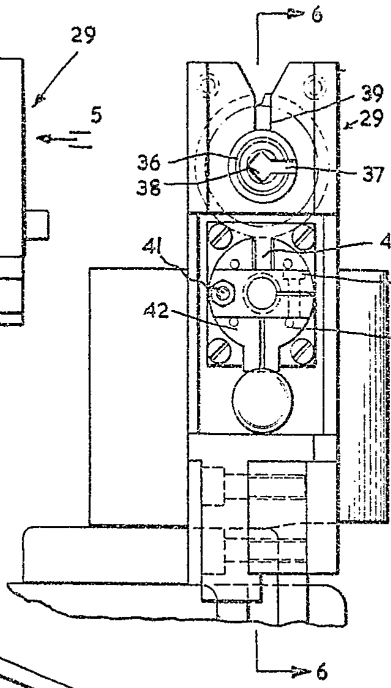


FIG. 5.

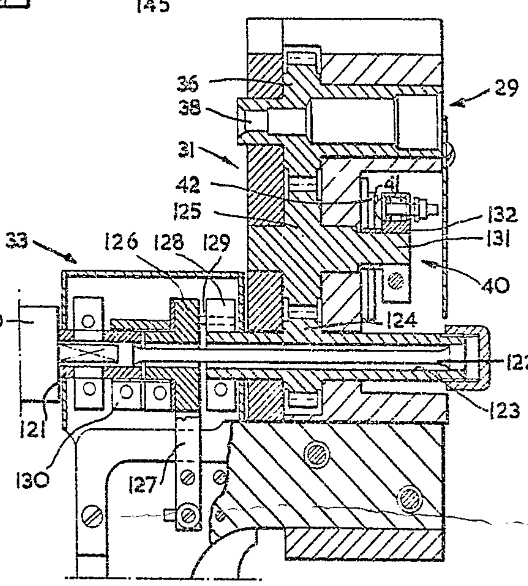


FIG. 6.

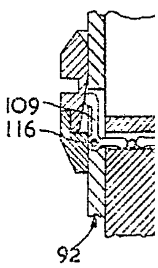


FIG .

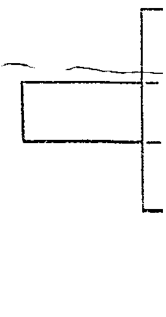


FIG. 5.

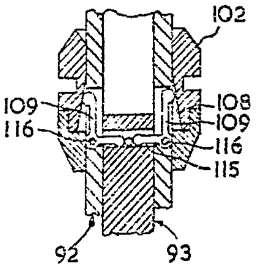


FIG. 3A.

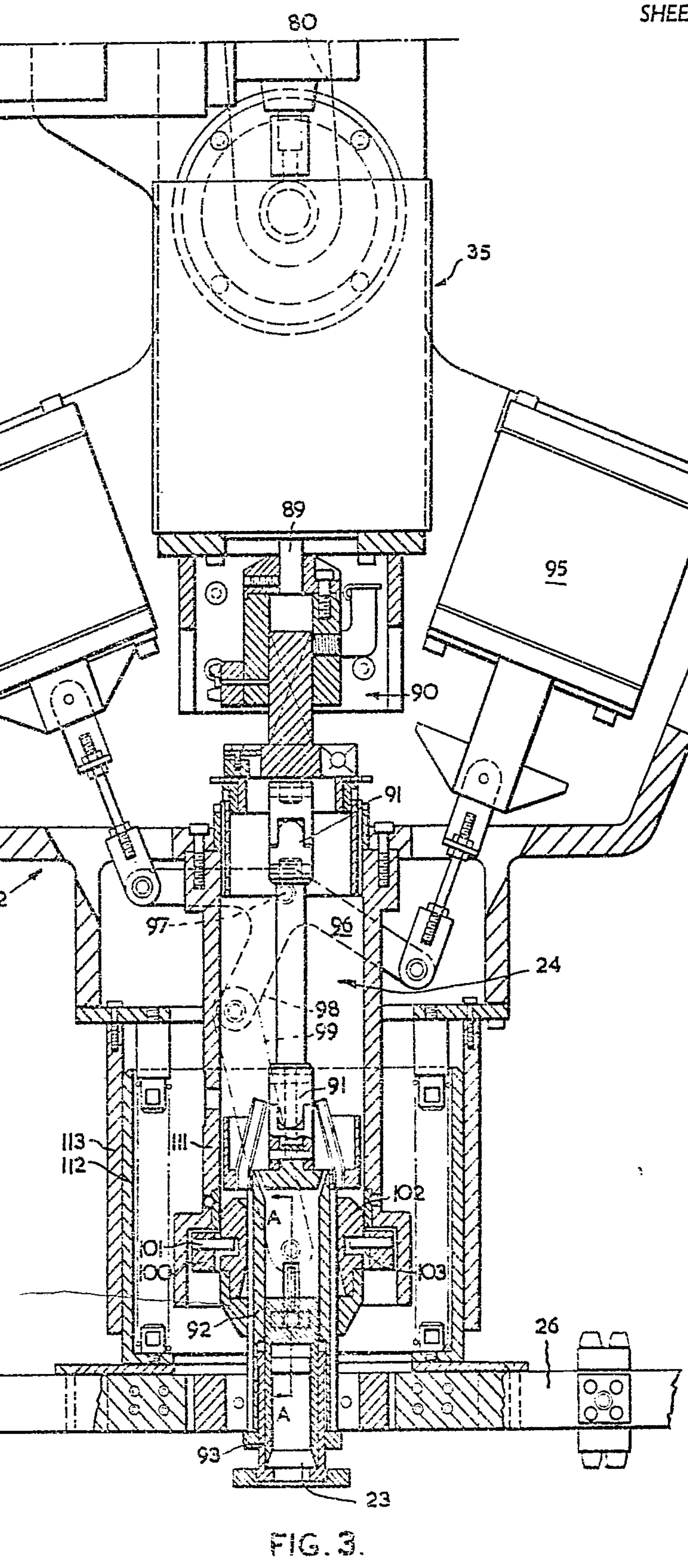


FIG. 3.

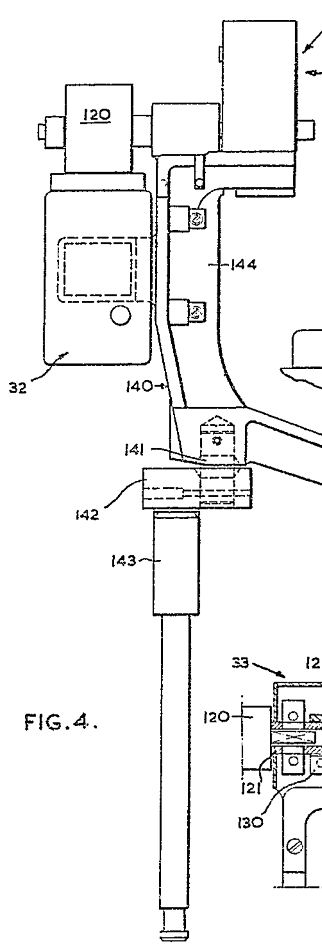


FIG. 4.

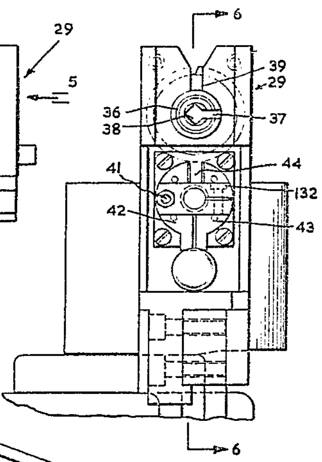


FIG. 5.

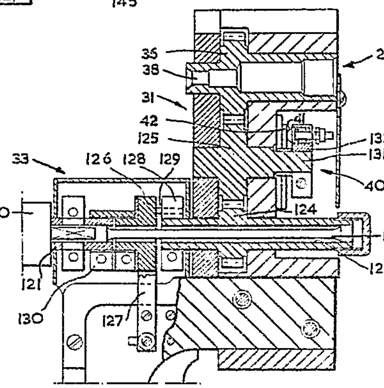


FIG. 6.

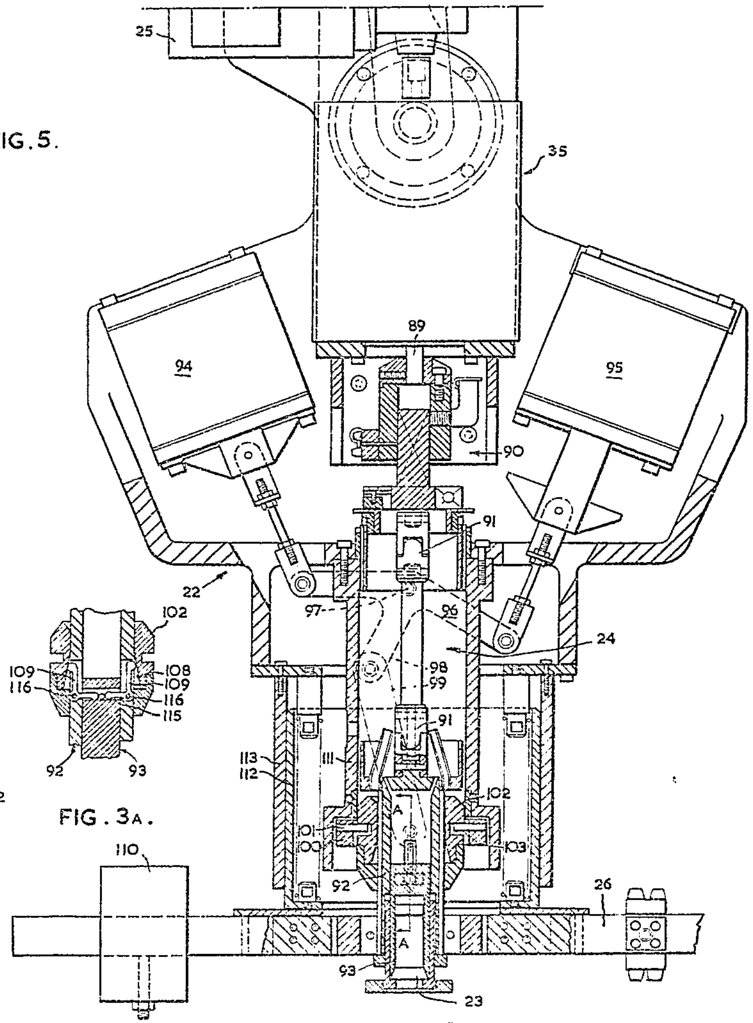


FIG. 3A.

FIG. 3.

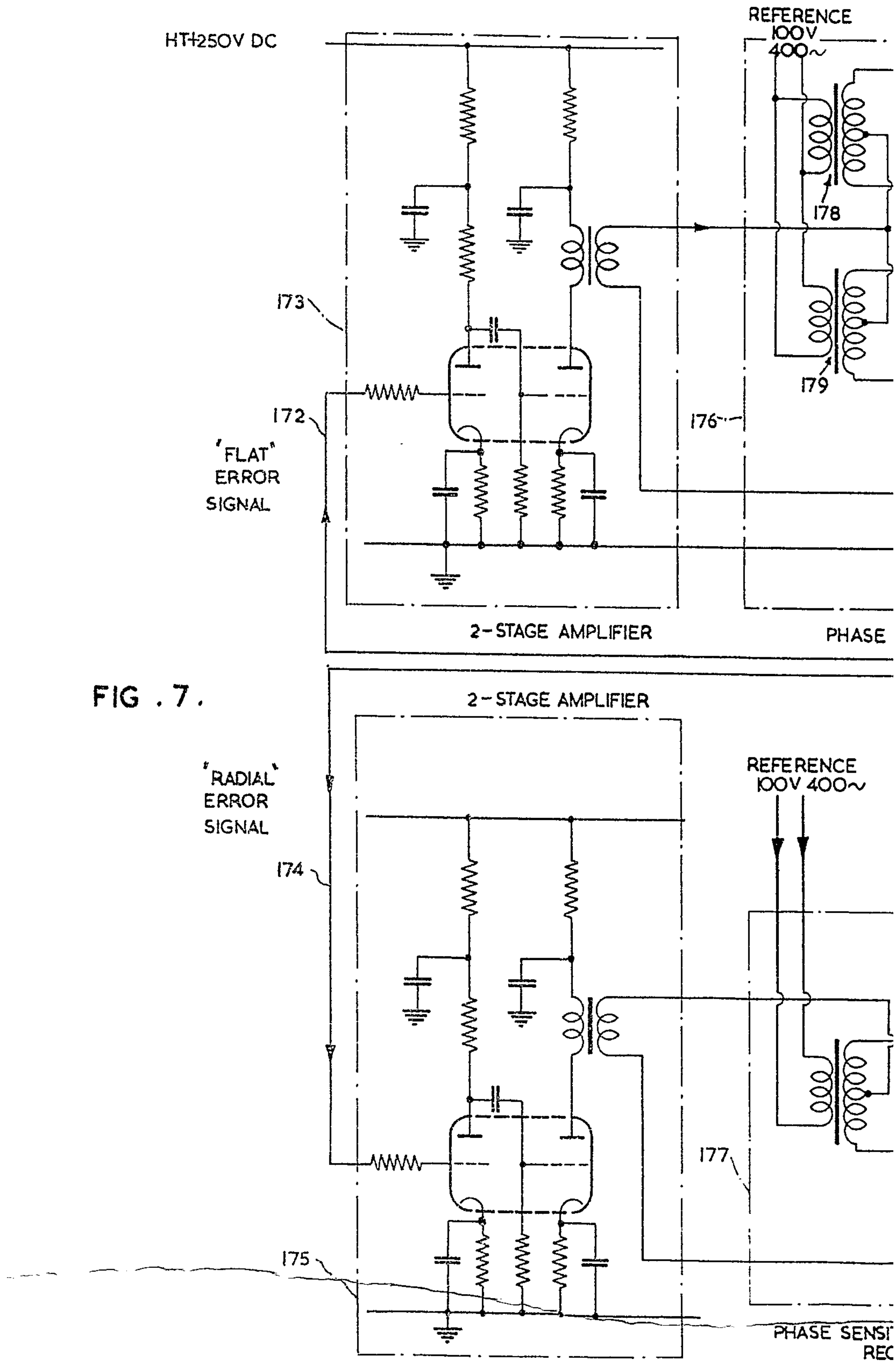
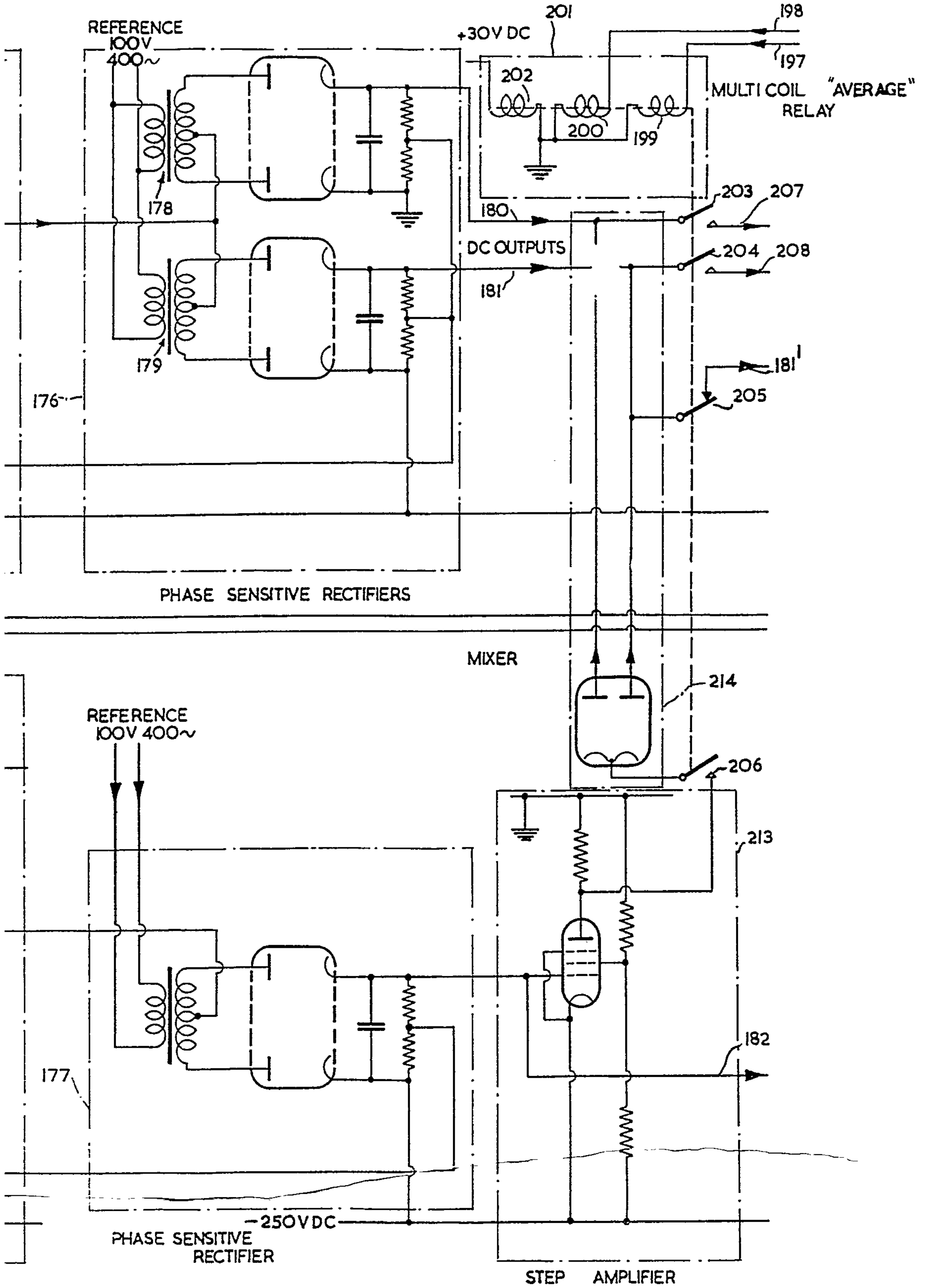

HT+250V DC
REFERENCE
100V
400~
178
179
173
172
176
'FLAT'
ERROR
SIGNAL
2-STAGE AMPLIFIER
PHASE
2-STAGE AMPLIFIER
'RADIAL'
ERROR
SIGNAL
174
REFERENCE
100V 400~
177
175
PHASE SENSI
REC

FIG. 7.

856,691 COMPLETE SPECIFICATION
7 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*
SHEET 3



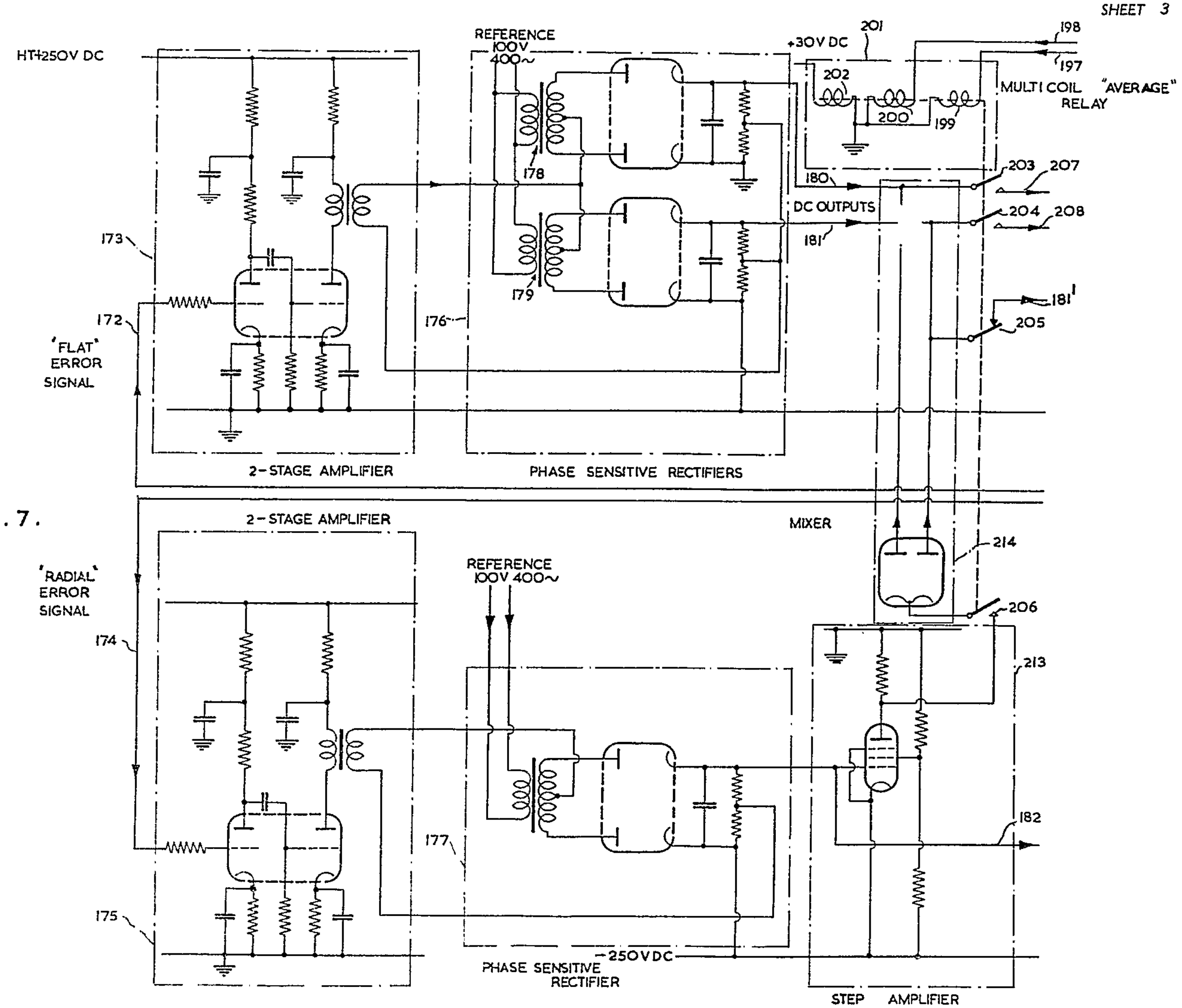

HT+250V DC
REFERENCE 100V 400~
+30V DC
201
198
197
202
200
199
MULTI COIL "AVERAGE" RELAY
178
179
180
181
DC OUTPUTS
203
207
204
208
181'
205
173
172
'FLAT' ERROR SIGNAL
176
2-STAGE AMPLIFIER
PHASE SENSITIVE RECTIFIERS
MIXER
214
2-STAGE AMPLIFIER
REFERENCE 100V 400~
'RADIAL' ERROR SIGNAL
174
206
213
177
182
175
-250VDC
PHASE SENSITIVE RECTIFIER
STEP AMPLIFIER

FIG. 7.

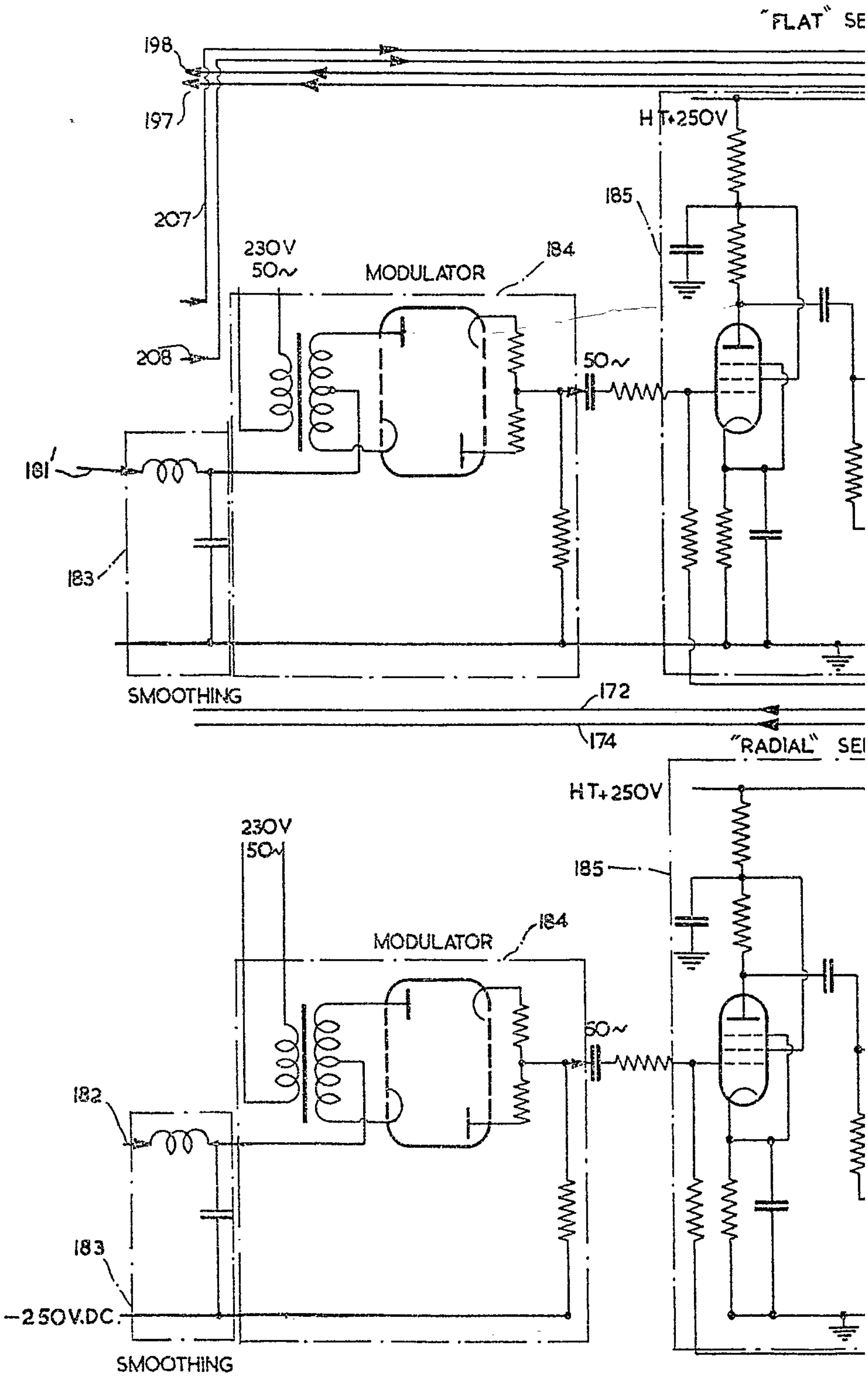

"FLAT" SE
198
197
207
208
230V
50~
MODULATOR
184
185
HT+250V
50~
181
183
SMOOTHING
172
174
"RADIAL" SE
HT+250V
185
230V
50~
MODULATOR
184
50~
182
183
-250V.DC.
SMOOTHING

FIG.

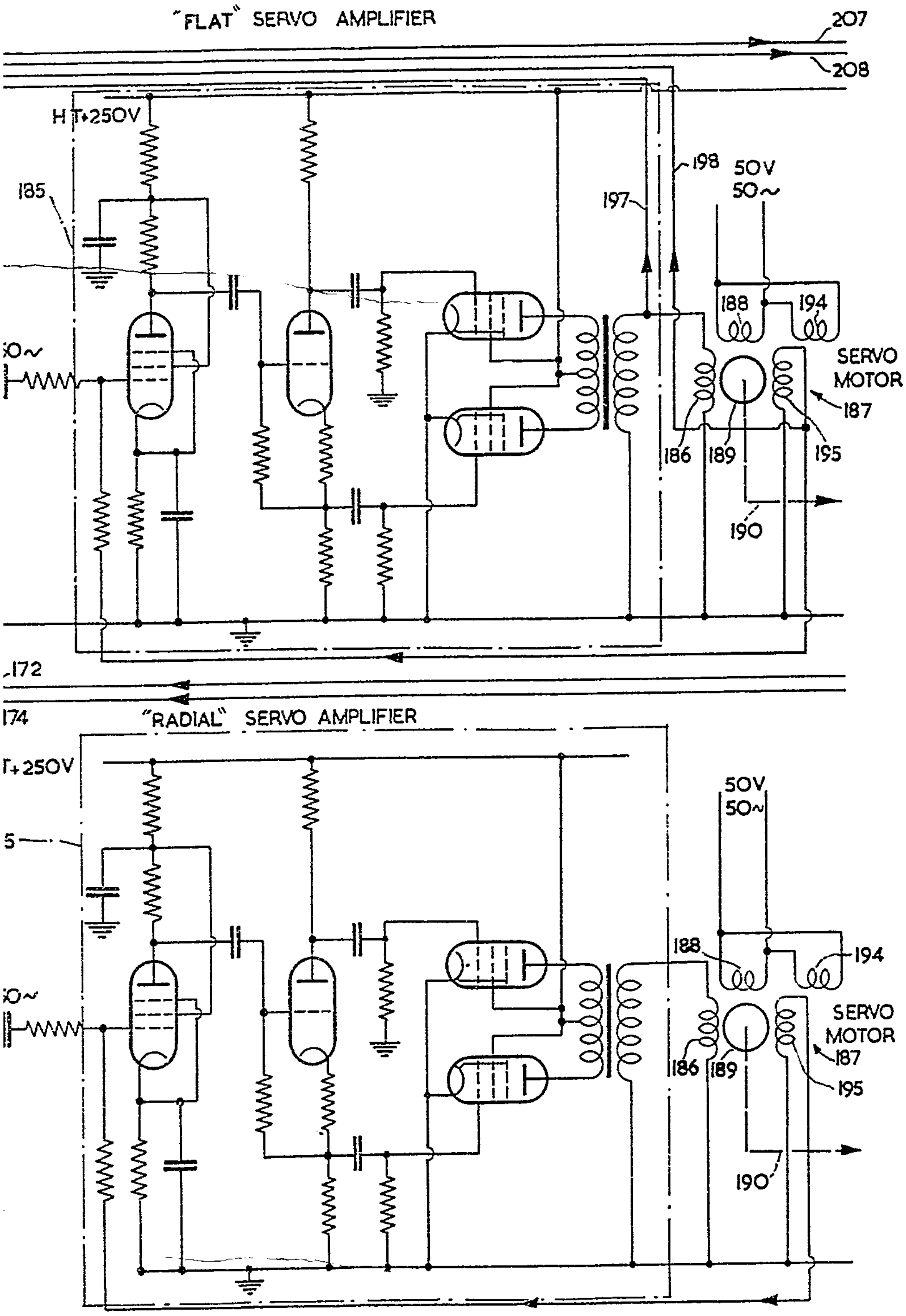

"FLAT" SERVO AMPLIFIER
207
208
H T+250V
185
198
197
50V
50~
188
194
SERVO
MOTOR
187
186
189
195
190
172
174
"RADIAL" SERVO AMPLIFIER
T+250V
5
50V
50~
188
194
SERVO
MOTOR
187
186
189
195
190

FIG. 8.

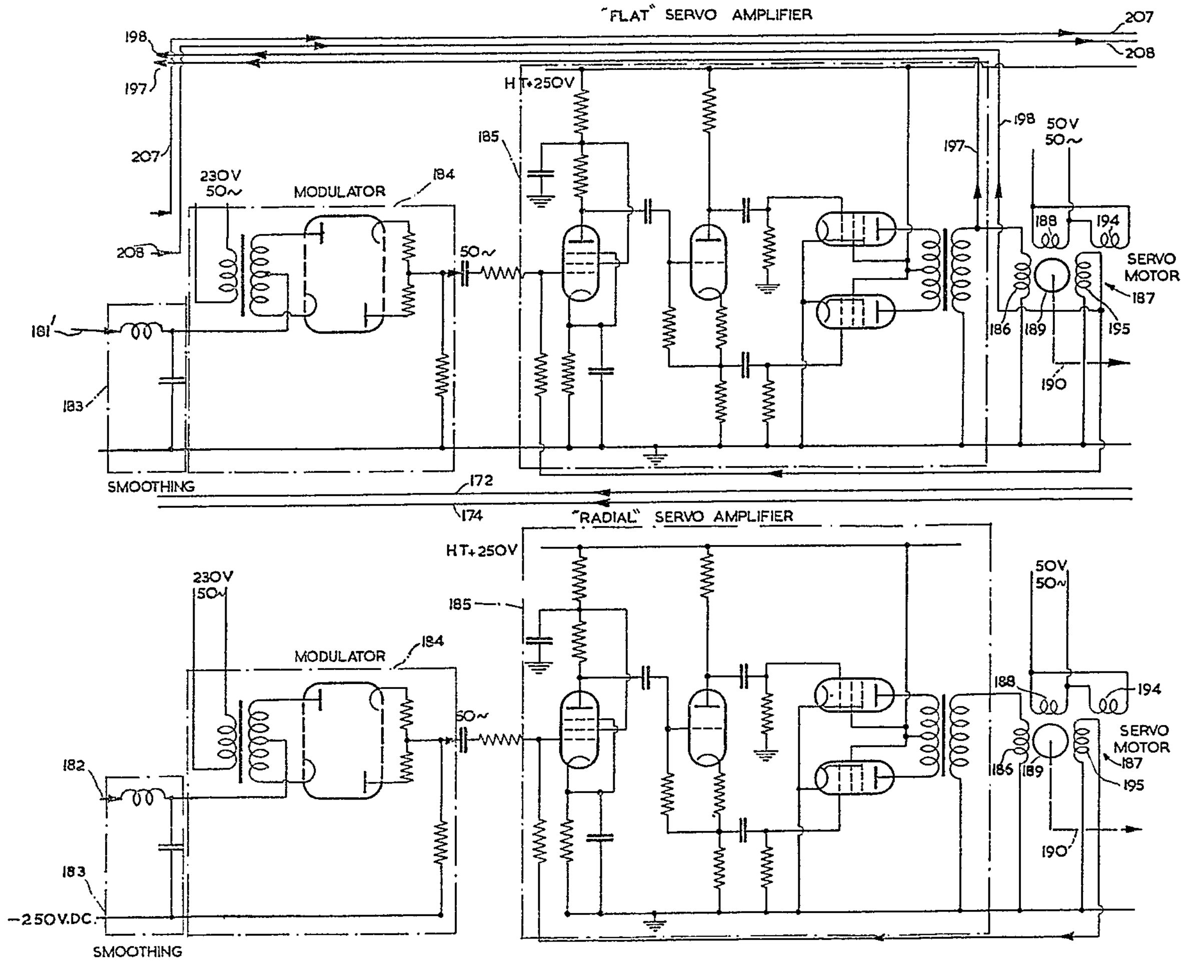

"FLAT" SERVO AMPLIFIER
198
197
207
208
230V
50~
MODULATOR
184
181
183
SMOOTHING
50~
185
HT+250V
197
198
50V
50~
188
194
SERVO
MOTOR
187
186
189
195
190
172
174
"RADIAL" SERVO AMPLIFIER
HT+250V
185
184
182
183
-250V.DC.
188
194
186
189
195
190

FIG. 8.

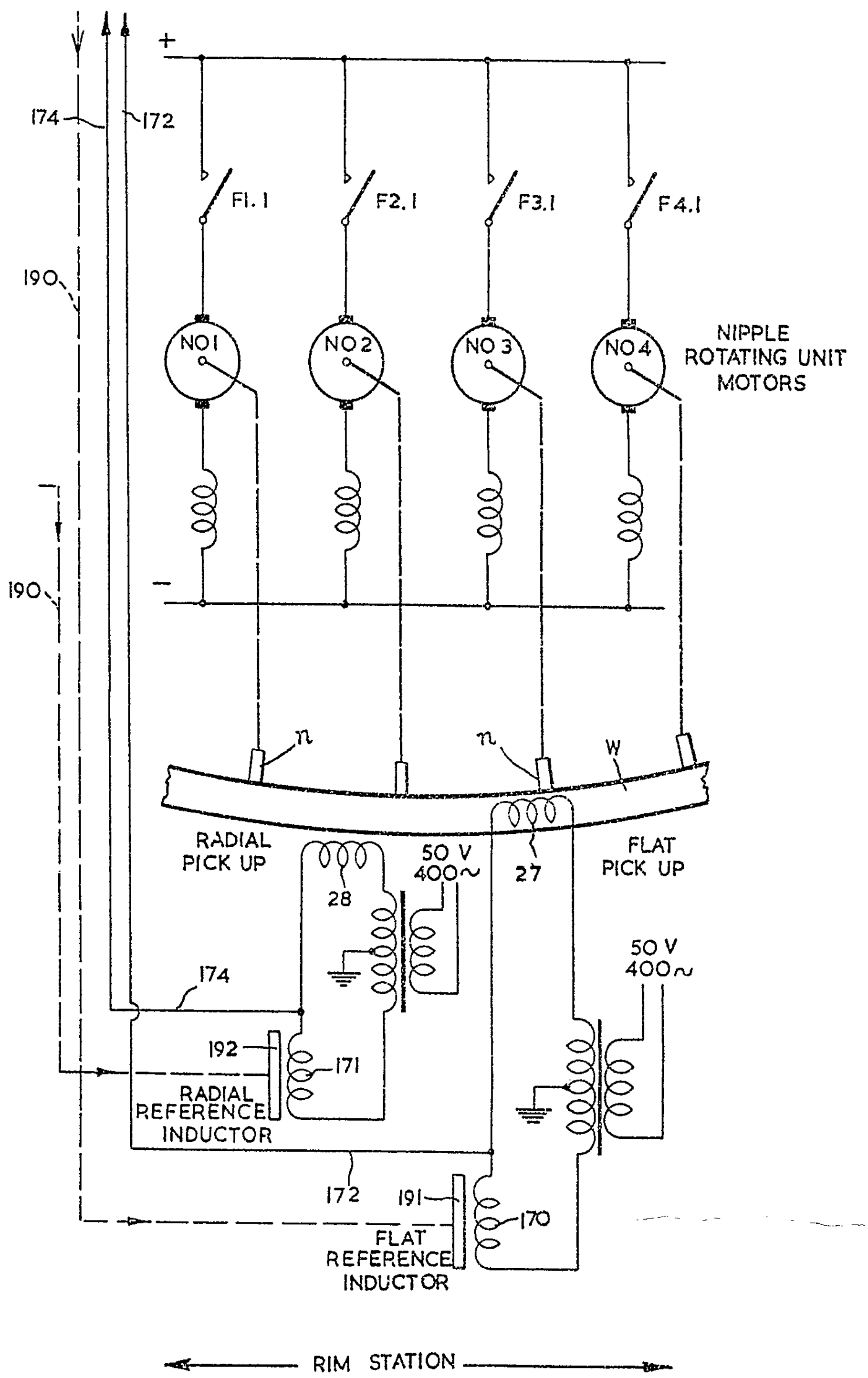

+
174
172
F1.1
F2.1
F3.1
F4.1
190
NO1
NO2
NO3
NO4
NIPPLE
ROTATING UNIT
MOTORS
190
−
n
n
W
RADIAL
PICK UP
28
50 V
400~
27
FLAT
PICK UP
50 V
400~
174
192
171
RADIAL
REFERENCE
INDUCTOR
172
191
170
FLAT
REFERENCE
INDUCTOR
RIM STATION

FIG 10

856,691 COMPLETE SPECIFICATION
7 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*
SHEETS 5 & 6

PPLE
TING UNIT
OTORS

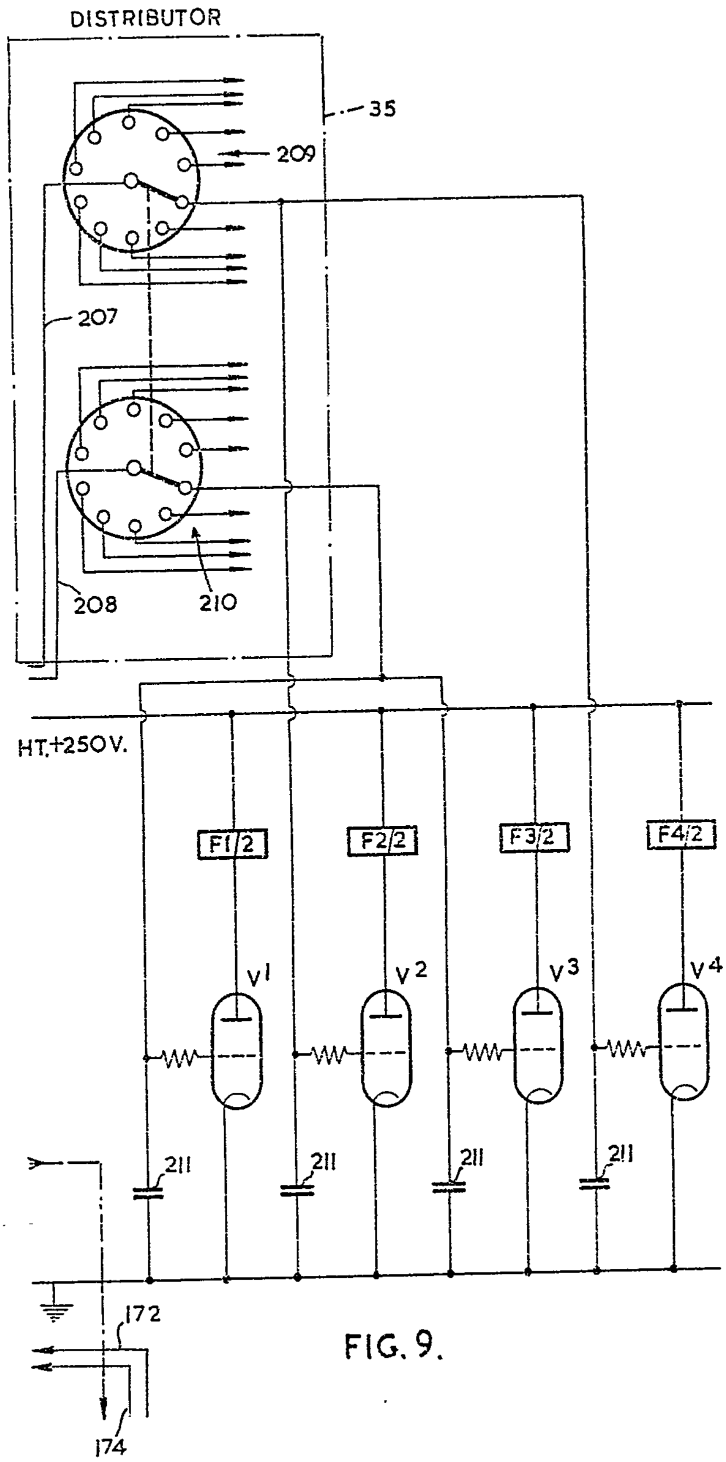


FIG. 9.

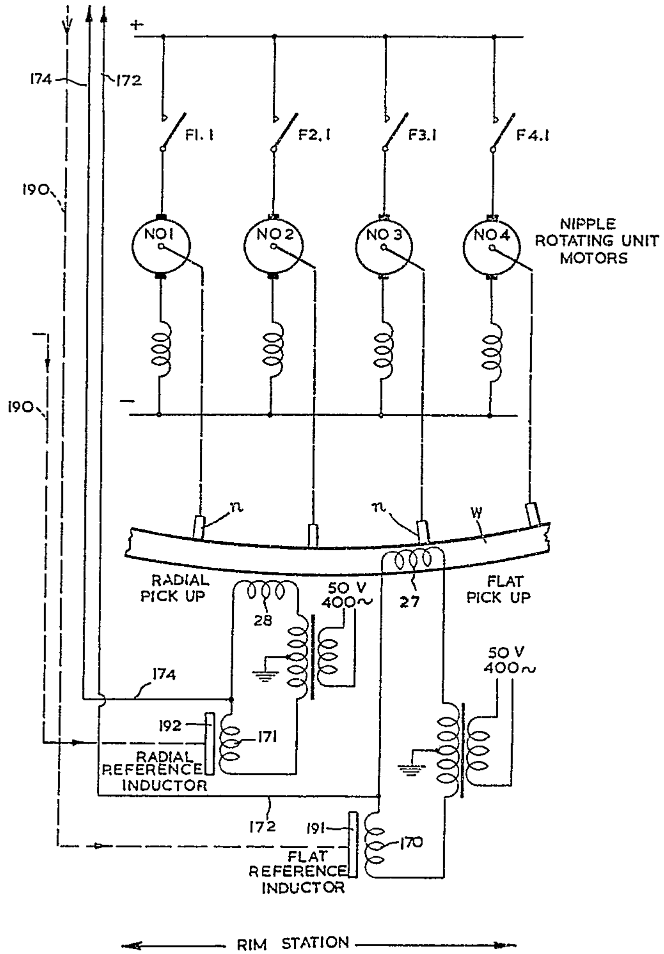

174
172
190
190
+
−
F1.1
F2.1
F3.1
F4.1
NO1
NO2
NO3
NO4
NIPPLE ROTATING UNIT MOTORS
n
n
W
RADIAL PICK UP
28
50 V 400~
27
FLAT PICK UP
50 V 400~
174
192
171
RADIAL REFERENCE INDUCTOR
172
191
170
FLAT REFERENCE INDUCTOR
RIM STATION

FIG 10

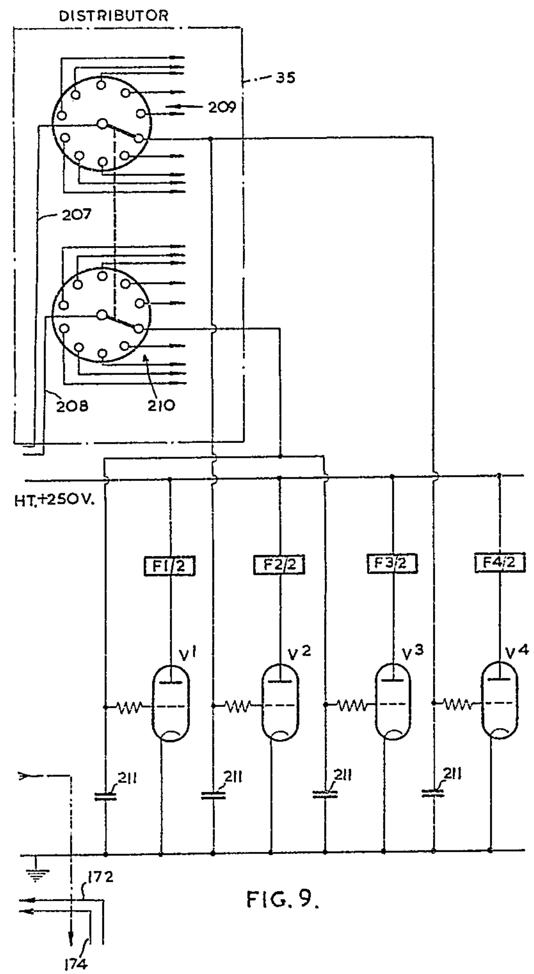

DISTRIBUTOR
35
209
207
208
210
HT.+250V.
F1/2
F2/2
F3/2
F4/2
V1
V2
V3
V4
211
211
211
211
172
174

FIG. 9.

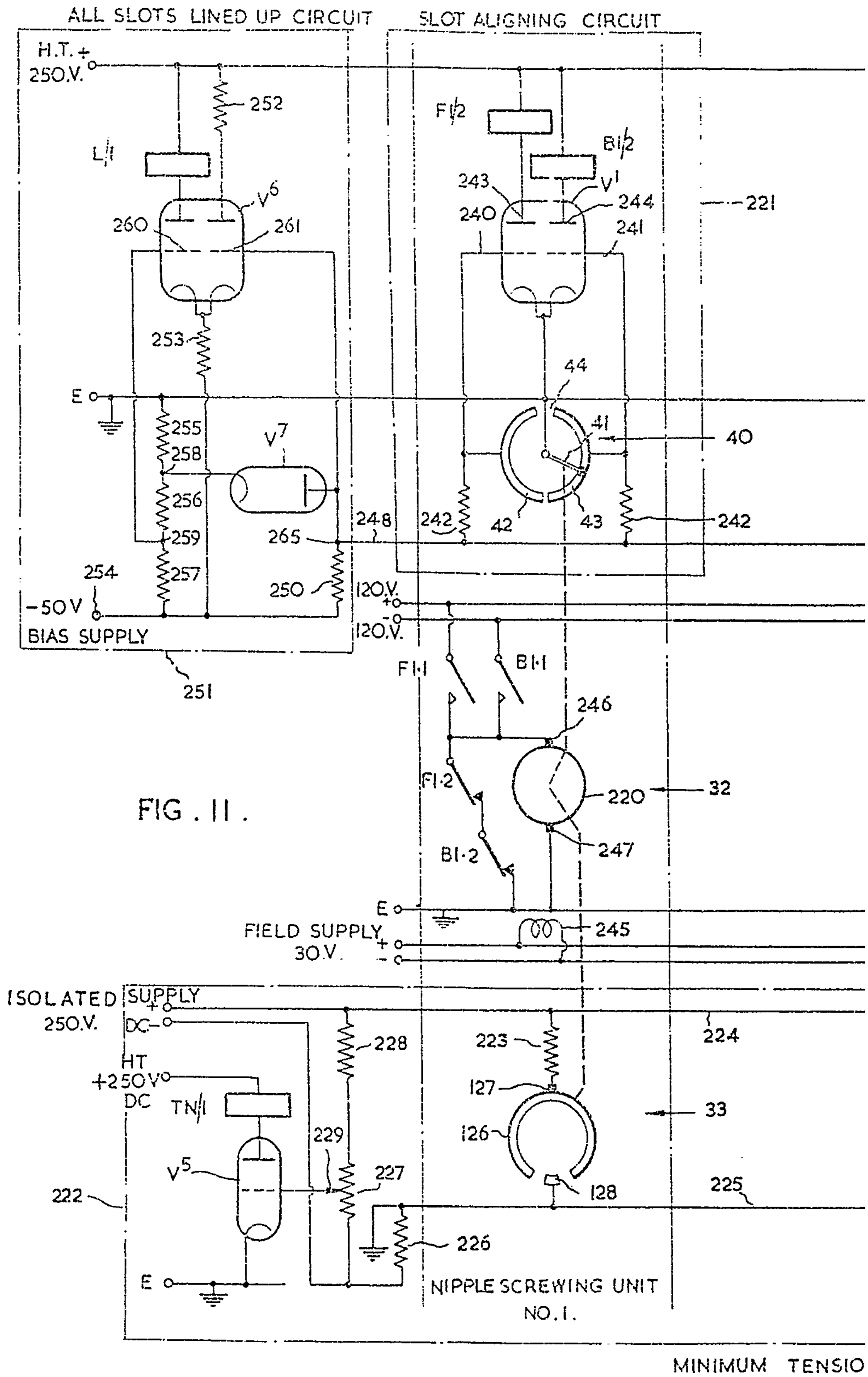
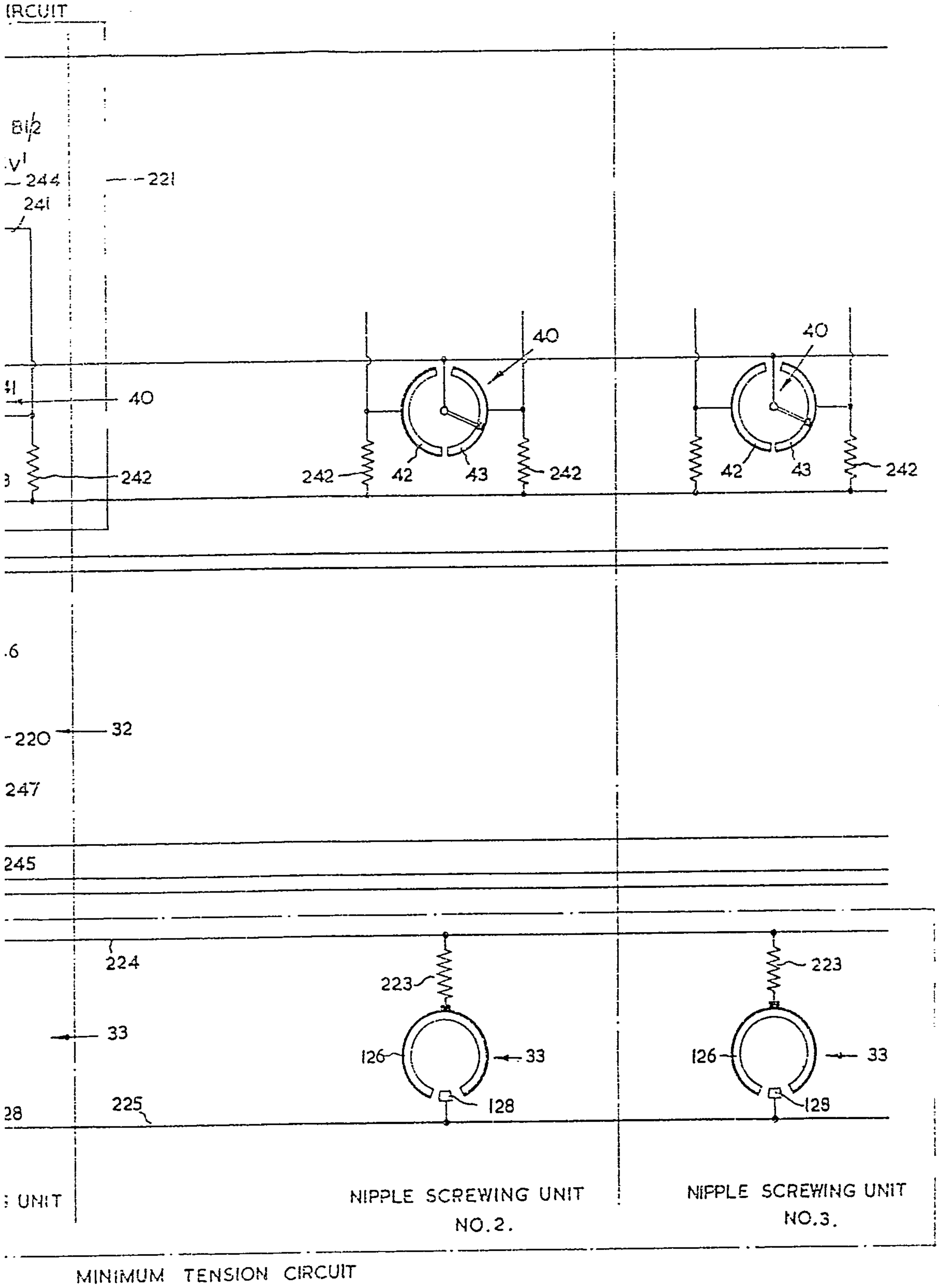

ALL SLOTS LINED UP CIRCUIT
SLOT ALIGNING CIRCUIT
H.T. +
250.V.
252
L/1
V6
260
261
253
E
255
258
256
259
257
V7
254
-50 V
BIAS SUPPLY
250
265
251
248
F1/2
B1/2
243
V1
244
240
241
221
44
41
40
242
42
43
120.V.
F1·1
B1·1
246
F1·2
220
32
B1·2
247
FIELD SUPPLY
30.V.
245
ISOLATED SUPPLY
250.V.
DC-
HT
+250V
DC
TN/1
V5
228
229
227
226
222
223
127
126
128
224
33
225
NIPPLE SCREWING UNIT
NO. 1.
MINIMUM TENSIO

FIG. 11.


IRCUIT
B1/2
V1
244
221
241
40
41
242
40
42
43
242
.6
220
32
247
245
224
223
126
33
128
225
28
UNIT
NIPPLE SCREWING UNIT
NO.2.
NIPPLE SCREWING UNIT
NO.3.
MINIMUM TENSION CIRCUIT

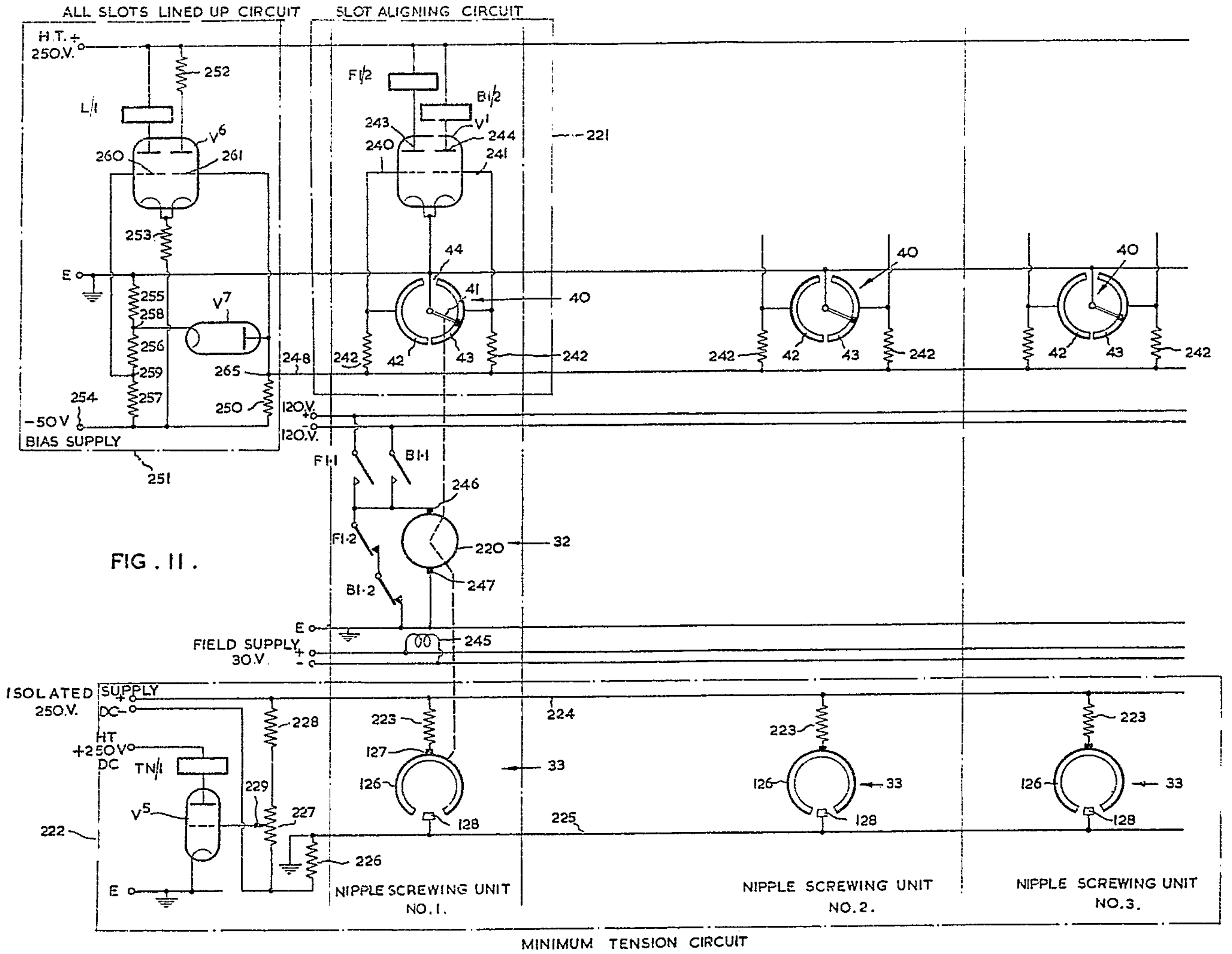

ALL SLOTS LINED UP CIRCUIT
SLOT ALIGNING CIRCUIT
H.T.+ 250.V.
252
L/I
V6
260
261
253
E
255
258
256
259
257
V7
254
-50V
BIAS SUPPLY
251
265
250
248
F1/2
B1/2
V1
243
244
240
241
221
44
41
40
42
43
242
120V. +
120V. -
F1·1
B1·1
246
220
32
F1·2
B1·2
247
E
FIELD SUPPLY 30.V. + -
245
ISOLATED SUPPLY 250.V. DC+ DC-
HT +250V DC
TN/I
V5
222
228
229
227
226
223
127
126
128
33
224
225
NIPPLE SCREWING UNIT NO.1.
NIPPLE SCREWING UNIT NO.2.
NIPPLE SCREWING UNIT NO.3.
MINIMUM TENSION CIRCUIT

FIG. 11.