

Aug. 27, 1929.

E. C. COPE

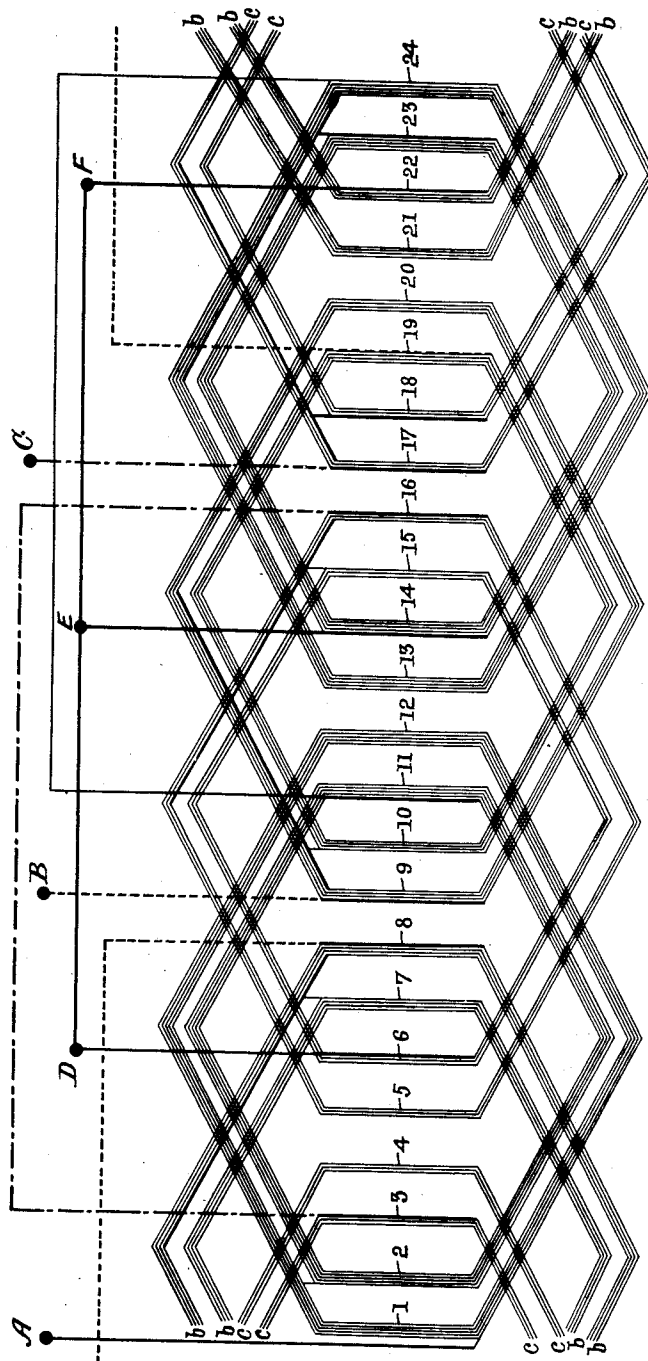
1,725,849

APPARATUS FOR USE IN TEXTILE PROCESSES

Filed Sept. 27, 1926

4 Sheets-Sheet 1

FIG. 1.



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Aug. 27, 1929.

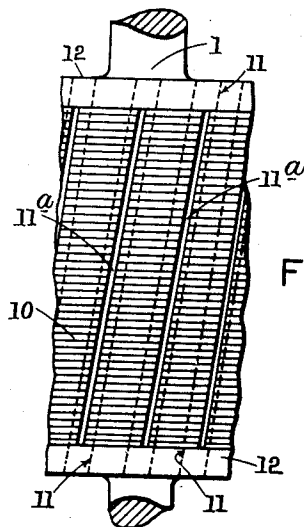
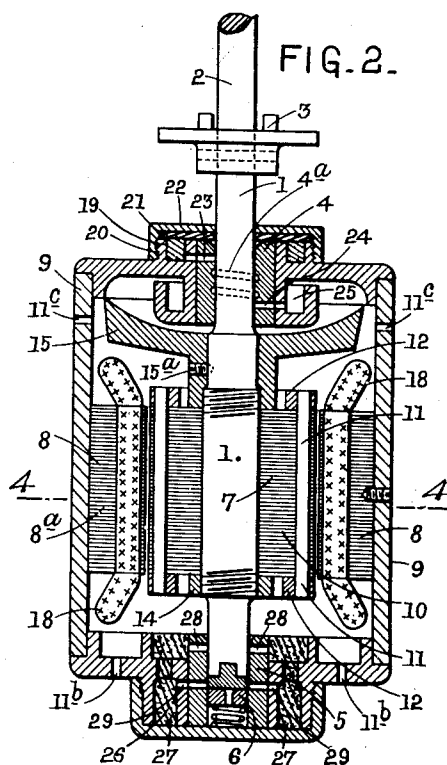
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APPARATUS FOR USE IN TEXTILE PROCESSSES

Filed Sept. 27, 1926

4 Sheets-Sheet 2



INVENTOR:

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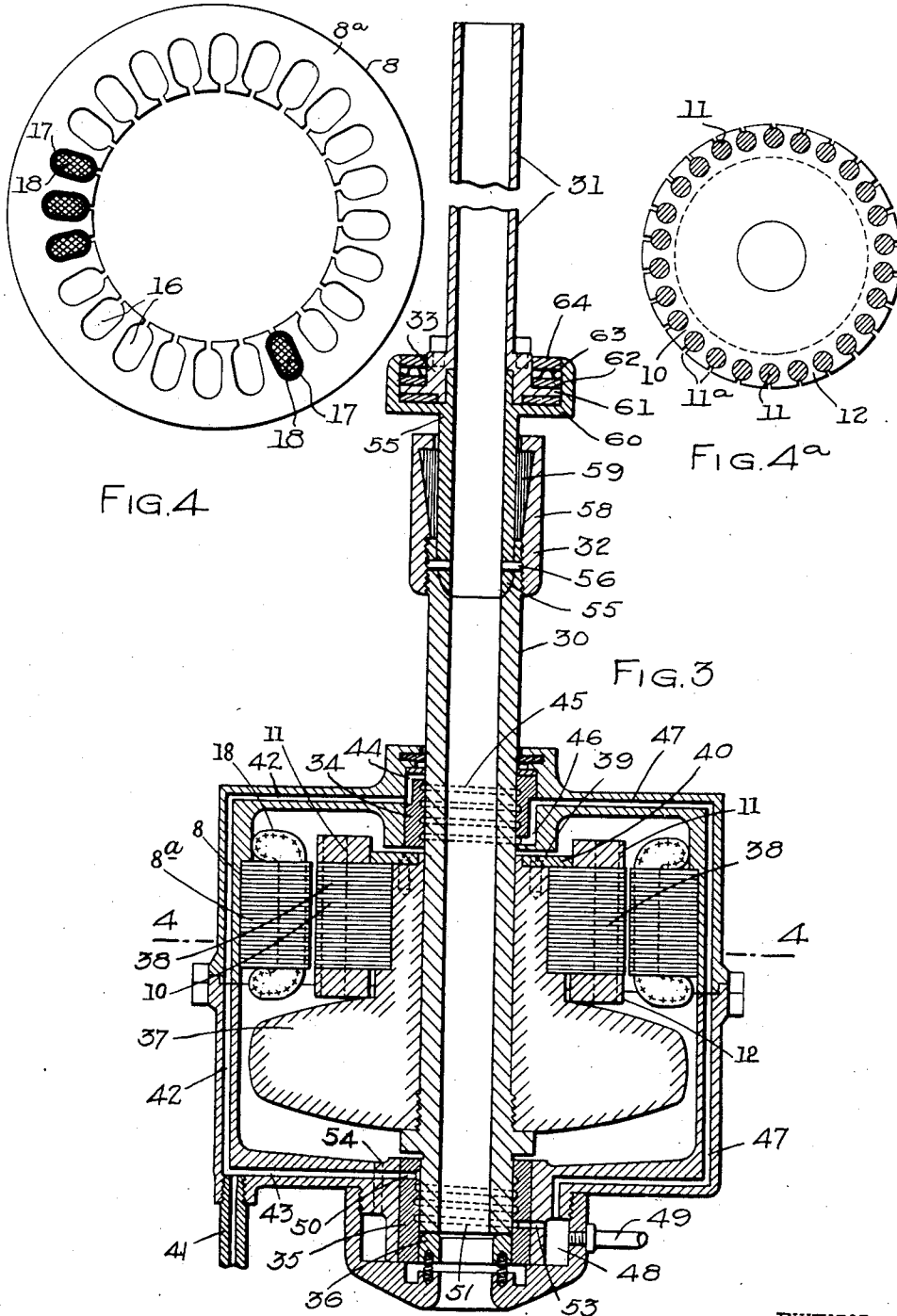
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APPARATUS FOR USE IN TEXTILE PROCESSES

Filed Sept. 27, 1926

4 Sheets-Sheet 3



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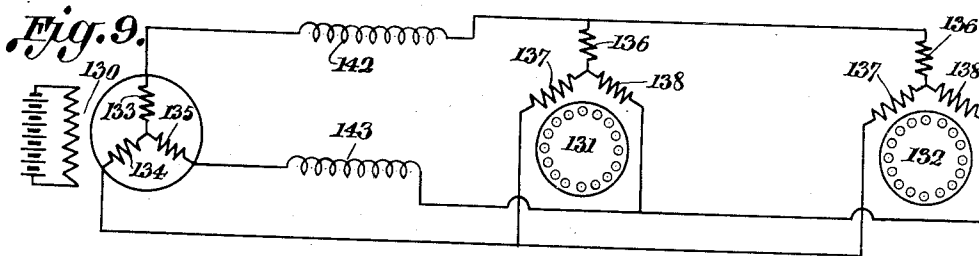
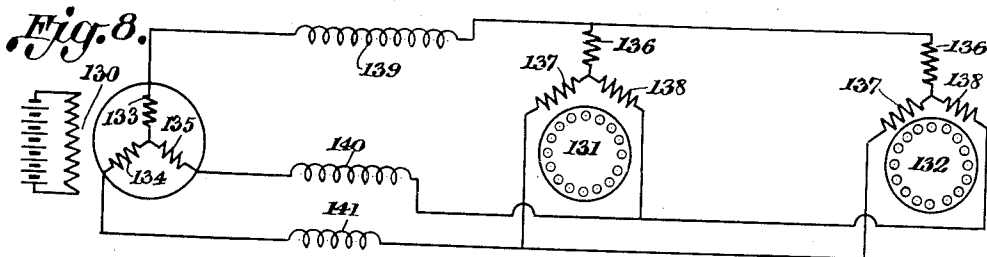
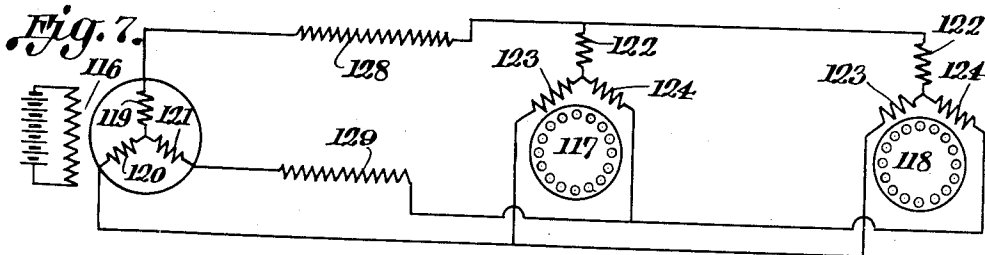
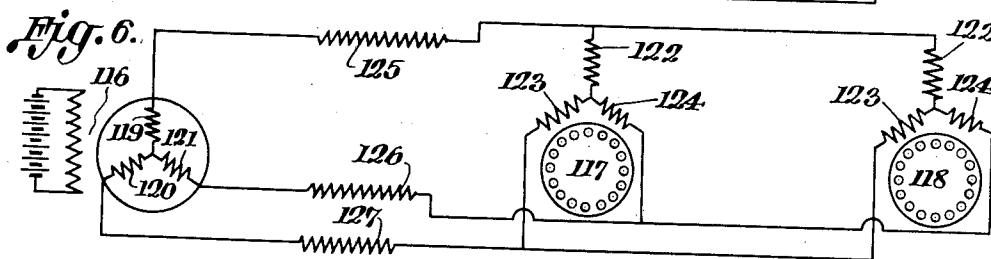
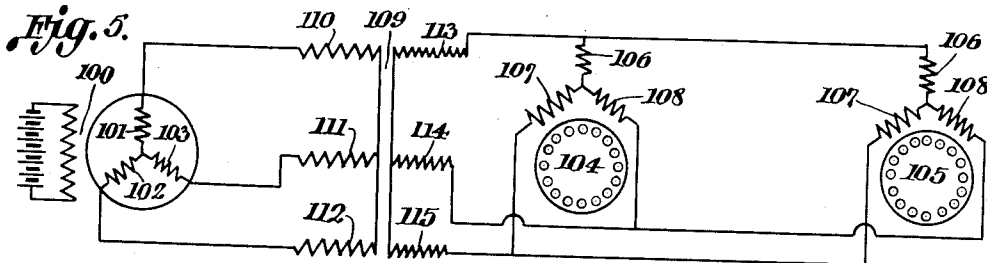
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APPARATUS FOR USE IN TEXTILE PROCESSES

Filed Sept. 27, 1926

4 Sheets-Sheet 4



Inventor
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UNITED STATES PATENT OFFICE.

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APPARATUS FOR USE IN TEXTILE PROCESSES.

Application filed September 27, 1926, Serial No. 138,062, and in Great Britain August 25, 1926.

This invention relates to electrical textile spindles and means for driving the same, for use in spinning, twisting, doubling, winding and analogous textile operations on natural or artificial fibres, filaments, threads or yarns more especially at high or very high speeds.

In many textile operations it is necessary or desirable to employ spindles rotating at high and sometimes very high speeds, for instance 8,000 to 16,000 or even up to 20,000 or 35,000 or more revolutions per minute. As instances of textile operations in which such high or very high speeds are necessary or desirable may be mentioned high speed spinning, twisting or doubling of threads or yarns of artificial or natural fibres or filaments by cap, ring and traveller, flyer or other methods; winding or twisting and winding artificial filaments continuously with their formation by the dry or evaporative method and especially cap spinning (i. e. cap twisting and winding) of artificial filaments continuously with their formation by the dry or evaporative method; crêpe twisting or doubling of threads or yarns of artificial or natural filaments or fibres wherein a high twist is required to be imparted to the threads or yarns or in the doubling of same.

The apparatus of the present invention is especially applicable for these operations, but can also be applied generally, especially in cases where it is desired to employ high or very high speed spindles for textile operations such as hereinbefore referred to.

Hitherto it has not been possible to drive textile spindles satisfactorily at high or very high speeds such as mentioned by means of electric motors having their rotors directly coupled to or forming an integral part of the spindles.

It was found that a high or very high speed could not be satisfactorily obtained or maintained when employing the known polyphase electric motors fed by the known types of polyphase generator, which motors and generators have balanced windings i. e. windings having an equal number of "ampere turns" on each phase.

It was found that on attempting to work such motors at the requisite high or very high speeds when fed by such generators, that during acceleration the motors, and consequently the textile spindles with which

their rotors are directly coupled or combined, are very liable to remain at the first, second or other critical speed and that the motors can only be accelerated past such critical speeds by careful manipulation of the generator voltage and frequency, and even if it is managed to accelerate past a critical speed the speed is very unstable and the motors have every tendency to slow down to a critical speed. It may be explained that a critical speed is a period during acceleration of the rotor when the negative torque due to harmonics of the supply rises in value to a degree sufficient to balanced positive main torque, the result being that acceleration is arrested and the rotor speed becomes stable at some submultiple of the synchronous speed. These harmonics accompany all wave forms of electrical energy generated by rotating machines, but their influence appears to be much more manifest at the high frequencies which are necessary to employ for obtaining the high or very high speeds. Thus on applying a polyphase current of the necessary high frequency to the motor with the object of obtaining high or very high speeds, a point is reached beyond which the rotor refuses to accelerate, owing to the combination of the eddy currents formed in the rotor and which are evenly disposed about the rotor. In practice it was found for example that with the high frequency current necessary to obtain the high or very high speeds the first and second critical speeds which developed during acceleration were at about 5,000-6,000 and 11,000-12,000 revolutions per minute, respectively.

I have now found that it is possible to attain and maintain high and very high speeds such as hereinbefore indicated, by employing "polyphase" (preferably not less than three phase) motors having their rotors formed as an integral part of the spindles or otherwise directly coupled with the spindles, provided that either the motors or the high frequency generator supplying the same, or it may be both the motors and the high frequency generator supplying them, has or have "unbalanced windings" which term means that each phase of the unit (motor or generator) having the "unbalanced windings" has a number of "ampere turns" differing from those on each of the other phases thereon. For the best functioning of the apparatus the difference in the number of ampere turns

between the two phases exhibiting maximum difference should not exceed about 15% and preferably should not exceed from about 10% to about 12%, but it is of course understood that I do not limit myself in this respect.

It is to be understood that one high frequency generator may feed the motors of any desired number of textile spindles each directly coupled to or combined with the rotor of its corresponding motors, also that either the motors or the generator supplying them, or both the motors and the generator supplying them may have the unbalanced windings. In some cases a high frequency generator may if desired feed the motor of a single spindle.

In the preferred form of the invention I obtain the differing number of ampere turns by winding the phases with a differing number of turns of wire. I may however obtain the differing number of "ampere turns" by employing both on the motor or motors and the generator an equal number of turns of wire as between phase and phase, and by inserting between the generator and motor or motors a transformer wound with a differing number of turns of wire on each of the phases or by including in the circuits of each of the phases (or it may be on each of the phases except one) resistance or chokes—which in cases where they are included in the circuits of two or more phases are of different values as between phase and phase—or by employing any other known means for causing polyphase current to be supplied at a different voltage on each phase.

It will be seen that in each form of the invention the number of ampere turns on the motor or motors and/or the generator will be different on each phase, as either the number of turns of wire or the current will be different on each of the phases.

The rotors of the motors may be of the ordinary squirrel cage type or may be provided with closed windings, the former, however, being preferable.

I may also, though with less advantage, employ rotors wound with open windings and provided with slip rings, in which case both stator and rotor are preferably provided with open windings (of which either or both may be "unbalanced windings"), though the stator may be of the squirrel cage type or wound with closed coils.

By means of the present invention textile spindles may readily be driven at high or extremely high speeds. It is believed that the reason why the obtainment of such speeds is rendered possible is that on the rotor arriving at any critical speed at which an extra torque is required to overcome the electrically unbalanced forces, an increase in current results, followed by a corresponding increase in the magnetic flux passing

through the rotor core, and that, owing to the unbalanced windings, a strong magnetic couple is formed in the rotating field which is moving much faster than the field (the slip at this point being of course, considerable) the tendency of which magnetic couple is to jerk or whip the rotor over the critical speed. Once past this point, the speed of the rotor rapidly increases, accompanied by falling current, until perhaps another critical speed is met, with a repetition of this particular action, and finally the rotor reaches a synchronous speed governed by the periodicity of the supply and percentage of slip.

By means of the present invention the rotors and spindles can rapidly attain the desired high or very high speeds, it having been found in practice possible to attain for example a synchronous speed of 20,000 revolutions per minute in as short a time as about 14 seconds.

It will be understood in view of the high speeds of rotation especially in view of the high periodicity necessary to obtain such speeds, that special care should be taken to balance the rotating parts of the motor and textile spindle to a very high degree of accuracy and to ensure that the insulation between the iron laminations forming the core of both rotor and stator is preserved intact.

The Figs. 1, 2, 2^a, 3, 4, and 4^a of the accompanying drawings illustrate by way of example two forms of executing the present invention it being of course understood that these two forms are given by way of illustration and are in no way limitative.

In the two forms illustrated a star-wound 3 phase 2 pole 24 slot stator type of motor having unbalanced windings is employed, the motors being fed by an ordinary three phase high frequency generator (not shown) having the ordinary balanced windings and operated in the known manner to supply current at the necessary high frequency.

Figure 1 is a development diagram showing the method of winding the stator of the motor employed in each form, these forms being illustrated respectively in Figures 2 and 3.

Figure 2 shows a form of motor of the character indicated, which is especially suitable for ring or flyer spinning, twisting or doubling, crêpe twisting or doubling, or other high speed spinning, twisting or doubling of artificial silk or other threads or yarns, or other textile operations requiring a high or extremely high spindle speed.

Figure 2^a is an elevation of part of the rotor.

Figure 3, shows a similar form of motor but provided with a hollow spindle enabling the motor to be employed for cap spinning

artificial silk continuously with its production by the dry or evaporative method of formation, or for other textile operations requiring high spindle speeds, with a hollow textile spindle.

Figures 4 and 4^a are horizontal sections respectively of the stator and rotor on the lines 4—4, Figures 2 and 3.

Figures 5, 6, 7, 8 and 9 illustrate diagrammatically forms of the invention in which the high frequency generator is wound with an equal number of turns of wire on each of the phases and in which the motors are wound with an equal number of turns of wire on each of the phases.

Referring to Figure 1, A, B and C represent the commencement of the windings of the first, second and third phases respectively, while the line D E F represents the common point or junction of the windings.

The first phase winding starts at A and makes a number of turns between the stator slots 1 and 12, then a number of turns between slots 2 and 11, then a number of turns between slots 24 and 13 and finally between slots 23 and 14, the end of the first phase winding joining the common junction of the phases at the point E.

The total number of turns on the first phase windings in the examples described and illustrated is 100.

The second phase winding starts at B and makes a number of turns between the stator slots 9 and 20, then a number of turns between slots 10 and 19, then a number of turns between slots 8 and 21 and finally between slots 7 and 22, the end of the second phase winding joining the common junction of the phases at the point F.

The total number of turns on the second phase winding in the examples described and illustrated is 97.

The third phase winding starts at C and makes a number of turns between the stator slots 17 and 4, then a number of turns between slots 18 and 3, then a number of turns between slots 16 and 5 and finally between slots 15 and 6, the end of the third phase winding joining the common junction of the phases at the point D.

The total number of turns on the third phase in the examples described and illustrated is 94.

Referring to Figures 2, 2^a, 4 and 4^a. The spindle 1 of the motor is formed in one with or carries a textile spindle 2 provided with means 3 for carrying a textile bobbin, tube or the like (not shown). The motor spindle 1 runs in the top bearing 4 and lower bearing 5 being supported by the spring mounted thrust bearing 6, a squirrel cage rotor 7 being rigidly fixed to the motor spindle 1. The stator core 8 is rigidly fixed to the enclosing motor casing 9.

The rotor 7 is similar to the usual type of

squirrel cage rotor, comprising a laminated iron core built up from soft iron stampings 10 (care being taken to ensure good insulation between the stampings) and having copper squirrel cage bars 11 passing through the rotor slots and fixed into the squirrel cage end rings 12, the rotor slots being split as shown in Figure 4^a. The bars 11 are staggered to give ease in starting, and also to provide a simple form of ventilation in the following manner:—the bars 11, being staggered, cause the split slots of the rotor to be likewise staggered, and thus the splits of the slots form staggered grooves or channels 11^a on the outer face of the rotor, and the staggered grooves or channels 11^a draw air in through the holes 11^b in the bottom of the motor casing 9, through the armature tunnel and out of the motor casing through the holes 11^c.

The rotor is fixed rigidly to the motor spindle 1, being locked in position by the nut 14 and the screw threaded fly wheel member 15, the latter having also a grub screw 15^a engaging with the spindle 1.

The stator core 8 is built up from laminated slotted soft iron stampings 8^a (care being taken to ensure good insulation between the stampings). The slots 16 are provided with an insulating lining 17 (care being taken to ensure good insulation at this point) and with the unbalanced winding 18 of which Figure 1 is the development diagram, the winding having 100 turns on the first phase, 97 turns on the second phase, and 94 turns on the third phase. In the form of motor shown, the stator slots are not staggered in building up the stator core. If desired, the rotor bars 11 might not be staggered, but in such case the stator slots would preferably be staggered to give ease in starting.

The top bearing 4 is lubricated from the annular oil well 19, provided with an oil wick 20, the oil well 19 being covered by a felt washer 21 and a cover 22. When the spindle is stationary the oil from the wick 20 runs through the channel or boring 23 on to the spindle 1 and through the channel or boring 24 into the annular sump 25. When the spindle is in motion the oil is pumped by the spindle 1 upwards from the sump 25 through the spiral groove 4^a in the bearing 4, thus maintaining lubrication of the bearing. The dish shaped fly wheel member 15 prevents oil from falling on to the rotor or stator, as any oil falling from the sump 25 is thrown out from the fly wheel member 15 by centrifugal action, passing round the top of the casing 9 and back into the sump 25; thus any oil flowing from the sump 25 will be circulated by the fly wheel member 15 back into the sump 25.

The lower bearing 5 is lubricated from oil wells such as 26 disposed in any suitable

number around the spindle and provided with oil wicks 27 which feed the oil to the spindle 1 through channels or borings such as 28; the thrust bearing 6 is lubricated by the wicks 27 which feed the oil through channels or borings such as 29 on to the bearing.

Any other means for lubrication of the bearings may be employed, as for instance forced feed or gravity feed lubrication, care being of course taken to ensure that the lubrication is adequate in view of the high or extremely high speeds.

The bearings 4, 5 and 6 may be made of any metal suitable for the high or extremely high spindle speeds.

As before mentioned the motor shown in Figure 2 is especially useful for ring or flyer spinning twisting or doubling, crêpe twisting or doubling, or other high speed spinning, twisting or doubling of artificial silk or other threads or yarns. The motor and spindle shown in Figure 2 may be used for such purposes in conjunction with the usual types of ring and traveller, flyer, thread guides or the like as employed in such textile operations. For instance in crêpe twisting a small drag type of flyer may be employed. The traverse, where such is desired or necessary, is preferably imparted to the ring, flyer, thread guide or other such device (such device of course depending on the operation to be performed) while the motor and spindle are fixed; the traverse may however be imparted to the motors and spindles if so desired. In view of the high or extremely high speeds, care should be taken that the bobbins or the like adapted to receive the yarn or thread are mechanically balanced to a high degree of accuracy.

Referring to Figures 3, 4 and 4^a, as above stated the Figure 3 shows a motor and spindle similar in type to that shown in Figure 2, but having a hollow spindle. In Figures 3, 4 and 4^a, 30 is the hollow spindle of the motor, driving a hollow textile spindle 31 through the ball and socket joint 32 and the clutch member 33, the clutch member 33 also serving as means for supporting and driving a bobbin, tube or the like (not shown). The motor spindle 30 runs in the top bearing 34 and the lower bearing 35, being supported by the thrust bearing 36. A flywheel member 37 is fixed rigidly to the hollow spindle 30, and a squirrel cage rotor 38 is fixed rigidly to the flywheel member 37 by the screws 39 and clamping ring 40.

The stator core 8 is fixed rigidly to the motor casing.

The rotor is precisely similar to that employed in Figure 2, being built up from laminated soft iron stampings 10 (care being taken to preserve good insulation between the stampings) and having copper squirrel cage

bars 11 passing through the rotor slots and fixed in the squirrel cage end rings 12. The bars 11 are staggered to give ease in starting and to provide a simple form of ventilation by their drawing air through the armature tunnel in a manner analogous to that shown in Figure 2.

The stator core 8 is built up from laminated slotted soft iron stampings 8^a, care being taken to preserve good insulation between the stampings. The slots 16 are provided with an insulating lining 17 (care being taken to ensure good insulation at this point) and the unbalanced winding 18 of which Figure 1 is the development diagram, the winding having in the example 100 turns on the first phase, 97 turns on the second phase, and 94 turns on the third phase.

The motor shown in Figure 3 is provided with simple means of forced feed lubrication, the oil being supplied under the desired pressure to the pipe 41 and passing through the channels 42 and 43 in the motor casing to the bearings; channel 42 feeds the oil to the top bearing 34 which is provided with a channel 44 opening on to the spindle 30, the oil passing downwards through the spiral groove or channel 45 in the bearing 34 into the channel 46 in the bearing 34 and from thence the oil flows through the channel 47 in the motor case into the annular sump 48 and out of the outlet pipe 49 from which it may be drained or returned to the pipe 41 and again circulated through the bearings. The channel 43 feeds the oil to the lower bearing 35 and to the thrust bearing 36 the oil being passed downwards from the channel 50 in bearing 35 through a spiral groove 51 in the bearing 35 passing thence on to the thrust bearing 36 and into the annular sump 52 via the passage 53 in the bearing 35, from which sump the oil flows out through the outlet pipe 49 from which it may be drained or returned to the pipe 41 and again circulated through the bearings.

Passages such as 54 are provided in the bottom of the motor casing to allow any oil escaping from the bearings to drain away into the sump.

As above stated the motor spindle 30 drives the hollow textile spindle 31 through the ball and socket joint 32 and a clutch member 33, this joint and clutch member being fitted to ensure ease of drives and freedom from vibration. The clutch member, when the spindle is running to speed, transmits the drive without slip, and moreover, it allows or facilitates the engagement, doffing or changing of bobbins, tubes or the like without stopping the motor and without causing any very great decrease of the motor speed, as when bobbins, tubes or the like are placed on to or removed from the spindles the clutch can slip and thus pre-

vent or reduce the braking action which such operations could otherwise have on the motor. It may be mentioned in passing that the joint 32 and clutch member can equally well be employed in conjunction with the rotor shown in Figure 2.

In the ball and socket joint 32 the rounded end of the hollow spindle extension piece 55 and which end constitutes the ball of the ball and socket joint 32, fits into the socket in the top of the motor spindle 30, the spindle extension piece and the motor spindle being secured together by the securing pins 56. Around the spindle 30 and the hollow spindle extension piece 55 is fitted a retaining sleeve 58 screwed to the hollow motor spindle 30, and between the spindle extension piece 55, and the retaining sleeve 58 is provided a ring of compressed rubber or other resilient material 59.

The drive is passed from the spindle extension piece 55 to the textile spindle 31 by means of the clutch member 33, this member being formed by the cup shaped top of the spindle extension piece 55, a Ferodo or other frictional washer 60, flanged end 61 of the textile spindle 31, a Ferodo or other frictional washer 62, a spring 63 and a cover 64, the cover being screwed into the cup shaped top of the spindle extension piece 55. The Ferodo or other frictional material washers 60 and 62 are lubricated with graphite or other lubricant.

The motor and spindle shown in Figure 3 may be used for any textile operations requiring high or extremely high spindle speeds and may be employed in conjunction with any known apparatus, as for instance thread guides, flyers, rings, caps and the like used in such operations.

The form shown in Figure 3 is especially suitable for cap spinning threads or yarns and especially cap spinning artificial silk continuously with its production by the dry or evaporative method of formation (which method of spinning is described in British Patent No. 198,023 and in U. S. patent application S. No. 615,682 filed 29th January 1923 in the names of C. W. Palmer and W. Whitehead) the cap being mounted on a rod or spindle (not shown) passing up through the hollow spindles 30 and 31 in the manner usually employed in cap spinning, and to which the required traversing motion may be imparted.

In employing the motor and spindle for such and like textile operations in which high or extremely high spindle speeds are desirable or necessary the traverse, where such is necessary, is preferably applied to the caps or other means employed for guiding the yarns or threads on to the bobbins, tubes or the like, the motor and spindle being simply rotated though however the traverse may be imparted to the motors and

spindles if so desired. In view of the high or extremely high speeds especially in view, care should be taken that the bobbins and the like adapted to receive the yarn or thread are mechanically balanced to a high degree of accuracy.

In the form shown in Figure 5 the differing number of ampere turns is obtained by inserting between the generator and the motors a transformer wound with a differing number of turns of wire on each of the phases.

In the forms shown in Figures 6 and 7 the differing number of ampere turns is obtained by inserting resistances between the generator and the motors.

In the form shown in Figures 8 and 9 the differing number of ampere turns is obtained by inserting chokes between the generator and the motors.

Referring to Figure 5, 100 is the high frequency generator, this generator being of known type wherein the windings 101, 102 and 103 of the respective phases are each wound with the same number of turns of wire as each other. 104 and 105 are the motors, motor 104 being precisely similar to 105 (similar numerals being employed for corresponding parts). The motors are of the squirrel cage type and are each provided with windings 106, 107, 108 on their respective phases, these windings each having an equal number of turns of wire to each other. Between the generator 100 and the motors 104 and 105 is provided a transformer 109 the primary coils 110, 111 and 112 of which are connected with the respective phase windings of the generator 100. The primary coils 110, 111 and 112 have each the same number of turns of wire as each other. The secondary coils 113, 114, and 115 of the transformer 109 are connected with the respective phase windings 106, 108 and 107 of the motors. The secondary coils 113, 114 and 115 are each wound with a different number of turns of wire, the difference between the number of turns of wire between the respective phase windings being such as to produce the required difference in number of ampere turns as between the respective phase windings of the motors. Coil 113 of the transformer has the largest number of turns of wire, hence developing the highest voltage and thus giving the highest figure of ampere turns to the windings 106 of the motors; coil 115 of the transformer has the least number of turns of wire hence developing the lowest voltage and thus giving the lowest figure of ampere turns to the windings 107 of the motors; whilst coil 114 of the transformer has a number of turns of wire intermediate between those of coils 113 and 115, hence developing an intermediate voltage and thus giving a figure of ampere turns to the windings 108 of the motors

which is intermediate between the figures of ampere turns given to the windings 106 and 107.

Referring to Figure 6, 116 is the high frequency generator, this generator being of the known type wherein the windings 119, 120, and 121 of the respective phases are each wound with the same number of turns of wire as each other. 117 and 118 are the motors, motor 117 being precisely similar to motor 118 (similar numerals being employed for the corresponding parts). The motors are of the squirrel cage type and are each provided with windings 122, 123, 124 on their respective phases, these windings each having an equal number of turns of wire to each other. On each of the phase circuits between the generator and the motors is provided a resistance, resistance 125 being fitted in the first phase circuit (i. e. between coil 119 of the generator and the coils 122 of the motors), resistance 126 being fitted in the second phase circuit (i. e. between coil 121 of the generator and coils 124 of the motors) and resistance 127 being fitted in the third phase circuit (i. e. between coil 120 of the generator and coil 123 of the motors). The resistances 125, 126 and 127 are all of different values the difference in their values being such as to produce the required difference in number of ampere turns as between the respective phase windings of the motors. Resistance 125 has the largest value, hence causing the lowest voltage in the first phase circuit and thus giving the lowest figure of ampere turns to the windings 122 of the motors; resistance 127 has the lowest value, hence causing the highest voltage in the third phase circuit and thus giving the highest figure of ampere turns to the windings 123 of the motors; whilst resistance 126 is intermediate in value between resistances 125 and 127, hence causing an intermediate voltage in the second phase circuit and thus giving a figure of ampere turns to the windings 124 of the motor which is intermediate between the figures of ampere turns given to the windings 122 and 123.

Referring to Figure 7 this figure shows a form very similar to that shown in Figure 6, similar numerals in Figure 7 indicating corresponding parts in Figure 6. In Figure 7 however resistances are only provided in two of the phase circuits, resistance 128 being fitted in the first phase circuit (i. e. between coils 122 of the motors and coil 119 of the generator) and resistance 129 being fitted in the second phase circuit (i. e. between coil 124 of the motors and coil 121 of the generator). No resistances are fitted in the third phase circuit (i. e. between coils 123 of the motors and coil 120 of the generator). The resistances 128 and 129 are each of different value such as to produce the

required differences in number of ampere turns as between the respective phase windings of the motors. Resistance 128 has the highest value, hence causing the lowest voltage in the first phase circuit and thus giving the lowest figure of ampere turns to the windings 122 of the motors; no resistance being fitted in the third phase circuit, the highest voltage will be given in that circuit thus giving the highest figure of ampere turns to the windings 123 of the motors; resistance 129 is of less value than resistance 128 hence causing an intermediate voltage in the second phase circuit and thus giving a figure of ampere turns to the windings 124 of the motors intermediate between the figures of ampere turns given to the windings 122 and 123.

Referring to Figure 8, 130 is the high frequency generator, this generator being of the known type wherein the windings 133, 134, 135 of the respective phases are each wound with the same number of turns of wire as each other. 131 and 132 are the motors, motor 131 being precisely similar to motor 132 (similar numerals being employed for the corresponding parts). The motors are of the squirrel cage type and are each provided with windings 136, 137, 138 on their respective phases, these windings each having an equal number of turns of wire to each other. On each of the phase circuits between the motors and the generator is provided a choke, choke 139 being fitted in the first phase circuit (i. e. between coil 133 of the generator and coils 136 of the motors), choke 140 being fitted in the second phase circuit (i. e. between coil 135 of the generator and coils 138 of the motors) and choke 141 being fitted in the third phase circuit (i. e. between coil 134 of the generator and coils 137 of the motors). The chokes 139, 140 and 141 are all of different values the differences in their values being such as to produce the required difference in number of ampere turns as between the respective phase windings of the motors. Choke 139 has the highest value, hence causing the lowest voltage in the first phase circuit and thus giving the lowest figure of ampere turns to the windings 136 of the motors; choke 141 has the lowest value, hence causing the highest voltage in the third phase circuit and thus giving the highest figure of ampere turns to the windings 137 of the motors; whilst choke 140 is intermediate in value between chokes 139 and 141, hence causing an intermediate voltage in the second phase circuit and thus giving a figure of ampere turns to the windings 138 of the motors which is intermediate between the figures of ampere turns given to the windings 136 and 137.

Referring to Figure 9 this figure shows a form very similar to that shown in Figure 8, similar numerals in Figure 9 indicating

corresponding parts in Figure 8. In Figure 9 however chokes are only provided in two of the phase circuits, choke 142 being fitted in the first phase circuit (i. e. between coil 133 of the generator and coils 136 of the motors) and choke 143 being fitted in the second phase circuit (i. e. between coil 135 of the generator and coils 138 of the motors). No chokes are fitted in the third phase circuit (i. e. between coil 134 of the generator and coils 137 of the motors). The chokes 142 and 143 are each of different value, their value being such as to produce the required difference in number of ampere turns as between the respective phase windings of the motors. Choke 142 has the highest value, hence causing the lowest voltage on the first phase circuit and thus giving the lowest figure of ampere turns to the windings 136 of the motors; no choke being fitted in the third phase circuit the highest voltage will be given on that circuit thus giving the highest figure of ampere turns to the windings 137 of the motors; choke 143 is of less value than choke 142 hence causing an intermediate voltage in the second phase circuit and thus giving a figure of ampere turns to the windings 138 of the motors intermediate between the figures of ampere turns given to the windings 136 and 137.

What I claim and desire to secure by Letters Patent is:—

1. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator, and a driven unit consisting of at least one polyphase motor with a textile spindle directly coupled with its rotor, at least one of said units having unbalanced windings.

2. Textile spindle driving apparatus for use in textile operations comprising a driving unit consisting of a polyphase high frequency generator, and a driven unit consisting of at least one polyphase motor with a textile spindle directly coupled with its rotor, at least one of said units having unbalanced windings wherein the difference in the number of ampere turns between the two phases exhibiting the maximum difference is not greater than 12%.

3. Textile spindle driving apparatus for use in textile operations comprising a driving unit consisting of a polyphase high frequency generator, and a driven unit consisting of at least one polyphase motor with a textile spindle directly coupled with its rotor, at least one of said units having unbalanced windings in which each phase is wound with a different number of turns of wire.

4. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator, and a driven unit consist-

ing of at least one polyphase motor with a textile spindle directly coupled with its rotor, at least one of said units having unbalanced windings wherein the difference in the number of ampere turns between the two phases exhibiting the maximum difference is not greater than 12% and in which each phase is wound with a different number of turns of wire.

5. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator, and a driven unit consisting of at least one three phase motor with a textile spindle directly coupled with its rotor, at least one of said units having unbalanced windings.

6. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator, and a driven unit consisting of at least one three phase motor with a textile spindle directly coupled with its rotor, at least one of said units having unbalanced windings wherein the difference in the number of ampere turns between the two phases exhibiting the maximum difference is not greater than 12%.

7. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator, and a driven unit consisting of at least one three phase motor with a textile spindle directly coupled with its rotor, at least one of said units having unbalanced windings in which each phase is wound with a different number of turns of wire.

8. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator, and a driven unit consisting of at least one three phase motor with a textile spindle directly coupled with its rotor, at least one of said units having unbalanced windings wherein the difference in the number of ampere turns between the two phases exhibiting the maximum difference is not greater than 12% and in which each phase is wound with a different number of turns of wire.

9. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator, having balanced windings, and a driven unit consisting of at least one polyphase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having unbalanced windings.

10. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator having balanced windings, and a driven unit consisting of at least one

polyphase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having unbalanced windings wherein the difference in the number of
 5 ampere turns between the two phases exhibiting the maximum difference is not greater than 12%.

11. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator, having balanced windings, and a driven unit consisting of at least one
 10 polyphase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having unbalanced windings in which each phase is wound with a different number of turns of wire.

12. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator having balanced windings, and a driven unit consisting of at least one
 20 polyphase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having unbalanced windings wherein the difference in the number of ampere turns between the two phases exhibiting the maximum difference is not greater than 12% and in which each phase is wound
 25 with a different number of turns of wire.

13. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator having balanced windings, and a driven unit consisting of at least one
 35 three phase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having unbalanced windings.

14. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator having balanced windings, and a driven unit consisting of at least
 40 one three phase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having unbalanced windings wherein the difference in the number of ampere turns between the two phases exhibiting the maximum difference is not greater
 45 than 12%.

15. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator having balanced windings, and a driven unit consisting of at least
 50 one three phase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having unbalanced windings in which each phase is wound with a different number of turns of wire.

16. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator having balanced wind-

ings, and a driven unit consisting of at least one three phase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having unbalanced windings wherein the difference in the number of
 70 ampere turns between the two phases exhibiting the maximum difference is not greater than about 12% and in which each phase is wound with a different number of turns of wire.

17. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator having balanced windings, and a driven unit consisting of at least one
 80 polyphase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having a stator wound with unbalanced windings and a squirrel cage rotor.

18. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator having balanced windings, and a driven unit consisting of at least one
 90 polyphase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having a stator wound with unbalanced windings wherein the difference in the number of ampere turns between the
 95 two phases exhibiting the maximum difference is not greater than 12%, and a squirrel cage rotor.

19. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator having balanced windings, and a driven unit consisting of at least one
 100 polyphase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having a stator wound with unbalanced windings in which each phase is wound with a different number of turns of wire, and a squirrel cage rotor.

20. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator having balanced windings, and a driven unit consisting of at least one
 110 polyphase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having a stator wound with unbalanced windings wherein the difference in the number of ampere turns between the two phases exhibiting the maximum difference
 115 is not greater than 12% and in which each phase is wound with a different number of turns of wire, and a squirrel cage rotor.

21. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator having balanced windings, and a driven unit consisting of at least
 120 one three phase motor with a textile spindle directly coupled with its rotor, each motor

of said driven unit having a stator wound with unbalanced windings, and a squirrel cage rotor.

22. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator having balanced windings, and a driven unit consisting of at least one three phase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having a stator wound with unbalanced windings wherein the difference in the number of ampere turns between the two phases exhibiting the maximum difference is not greater than 12%, and a squirrel cage rotor.

23. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator having balanced windings, and a driven unit consisting of at least one three phase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having a stator wound with unbalanced windings in which each phase is wound with a different number of turns of wire, and a squirrel cage rotor.

24. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator having balanced windings, and a driven unit consisting of at least one three phase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having a stator wound with unbalanced windings wherein the difference in the number of ampere turns between the two phases exhibiting the maximum difference is not greater than 12% and in which each phase is wound with a different number of turns of wire, and a squirrel cage rotor.

25. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator having balanced windings, and a driven unit consisting of at least one three phase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having a stator wound with unbalanced windings wherein the first phase is wound with 100 ampere turns, the second phase is wound with 97 ampere turns and the third phase is wound with 94 ampere turns, and a squirrel cage rotor.

26. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a three phase high frequency generator having balanced windings, and a driven unit consisting of at least one three phase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having a stator wound with

unbalanced windings wherein the first phase is wound with 100 ampere turns, the second phase is wound with 97 turns and the third phase is wound with 94 turns and wherein each phase is wound with a different number of turns of wire, and a squirrel cage rotor.

27. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator having balanced windings, and a driven unit consisting of at least one polyphase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having a stator wound with unbalanced windings, and a squirrel cage rotor comprising staggered squirrel cage bars.

28. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator having balanced windings, and a driven unit consisting of at least one polyphase motor with a textile spindle directly coupled with its rotor, each motor of said driven unit having a stator wound with unbalanced windings, and a squirrel cage rotor comprising staggered squirrel cage bars and comprising staggered grooves on the outer face of said rotor.

29. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator, and a driven unit consisting of at least one polyphase motor with a textile spindle in driven connection with its rotor, at least one of said units having unbalanced windings.

30. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator, and a driven unit consisting of at least one polyphase motor with a textile spindle in driven connection with its rotor, at least one of said units having unbalanced windings wherein the difference in the number of ampere turns between the two phases exhibiting maximum difference is not greater than 12%.

31. Textile spindle driving apparatus for use in textile operations, comprising a driving unit consisting of a polyphase high frequency generator, and a driven unit consisting of at least one polyphase motor with a textile spindle in driven connection with its rotor, at least one of said units having unbalanced windings in which each phase is wound with a different number of turns of wire.

In testimony whereof I have hereunto subscribed my name this 9th day of September, 1926.

ERNEST CECIL COPE.