MANUAL FOR IMS

C2472

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C2472

CORTINA ELECTRIC

SECTION 1

GENERAL DESCRIPTION OF HOIST DRIVE

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GENERAL DESCRIPTION OF HOIST DRIVE

The Hoist Drive System compises a four quadrant DC thyristor converter, a shunt wound DC motor with tachogenerator, and a joystick controller.

The motor is controlled such that it can run in either direction, and can exert torque in either direction.

The motor speed is infinitely variable either from zero to base speed or zero to maximum speed when high speed (low torque) is selected.

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SECTION 2

THYRISTOR POWER CIRCUITS DC

A thyristor is a three terminal semiconductor device with characteristics related to those of a rectifier diode, i.e. it will pass current in one direction only (from anode to cathode). Unlike the diode it has the ability to block current in both directions. If the thyristor is biased in the forward direction it will not pass current until a small signal is applied to its third terminal, the gate. When this happens the thyristor will continue to pass current even if the original gate signal is removed it "latches on".
This situation will persist until such time as the forward current is reduced to zero by external means. At this point the thyristor will revert to its blocking characteristic. This behaviour is explained diagramitically in Fig 1 (a)(d).

If the DC supply in Fig. 1 is replaced by an AC supply then the current will stop at the end of each positive half cycle when the voltage reverses. If the signal to the gate is made a pulse timed to coincide with all or part of the positive half cycle then it is possible to vary the voltage to the lamp. The diagrams in Fig. 2 explain this mode of operation.

From Fig. 2 it can be seen that by advancing the leading edge of gate pulse the thyristor "fires" earlier and the output voltage becomes greater.

Clearly the control by this means can be infinitely variable or stepless control. The gate pulse is shown to extend for the full time that the thyristor is conducting. From the earlier explanation it was stated that, once conducting, the thyristor latches on until the current goes to zero at the end of the half cycle. On this basis it might be thought that a short pulse would be satisfactory, however it is known that Ac supplies, particularly where thyristor drives are used, may have small gaps where the voltage dips to zero. Under these circumstances the thyristor can switch off when a gap appears, bringing about a premature end of conduction. It is for this reason that a pulse the full length of the conduction period is used.

The thyristor circuit in Fig. 2 is not a circuit commonly used because of the "lumpy" output it produces. A practical and commonly used circuit is shown in Fig. 3. It is a "fully controlled single phase" thyristor bridge and may be used for small motor armature regulators, field regulators for DC machines, or as the DC section on inverters.

Several points are immediately evident from Fig. 3. On resistive load the output from the full wave bridge is similar to the single thyristor circuit shown in Fig.2, but with double the number of output pulses.

On inductive load the output of the full wave bridge differs greatly from its output on resistive load. This is because with an inductive load the current cannot be reduced to zero immediately it will continue to flow and this means that there are always two thyristors conducting, even though the voltage is reversed. (it is when the current goes to zero that a thyristor stops conducting).

The single phase bridge can also be used to invert i.e. power can be taken from the load and put back into the AC supply. This property can be used to convert mechanical power into electrical power which then goes back into the supply. Regenerative braking is possible by this means. Inversion may also be used to allow rapid changes in field currents. The inductive energy which is stored in the field is inverted and put back into the supply. The waveforms for this are shown in Fig.4.

The thyristor bridge arrangement used for the majority of Cortina drives is the three phase fully controlled bridge, also known as a "six pulse" convertor. The arrangement of this circuit is shown in Fig. 5 together with "typical waveforms". One important point to note about this waveform is that there are six pulses every full cycle of the mains supply. The waveforms shown are typical of those which might be seen on any six pulse converter supplying an inductive load. It is worth noting that the current waveform shown can be seen across the ACCT burden, where ACCT's are used for feedback purposes and fed into a rectifier. This has the advantage that the hazards of connection to high voltage are avoided.

Like the single phase bridge considered earlier, the three phase full wave bridge can be used to invert or regenerate. If a voltage is applied to the output of the bridge of opposite polarity to that shown in Fig. 5, then current will flow in the same direction, but with the voltage being negative this represents negative power i.e. power flowing back into the supply.

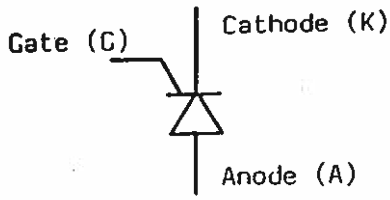
This inversion mode of control can be used where regenerative.

The circuit diagram and typical waveforms are shown in Fig. 6. The drawing of the thyristor bridge has deliberately been drawn upside down but the current is still in the same direction as in Fig. 5. The circuit shown in Fig. 6 can be used for electrical "regenerative" braking in one direction, or motoring in the other direction.

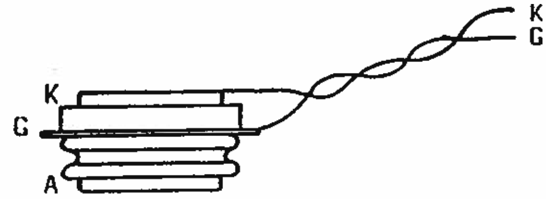
If the circuits of Fig. 5 and Fig. 6 are combined as shown in Fig. 7 then it is possible to have motoring or braking in either direction. This is commonly known as four quadrant control.

The circuitry which produces the firing pulses for the thyristor gates is known as a "firing circuit".

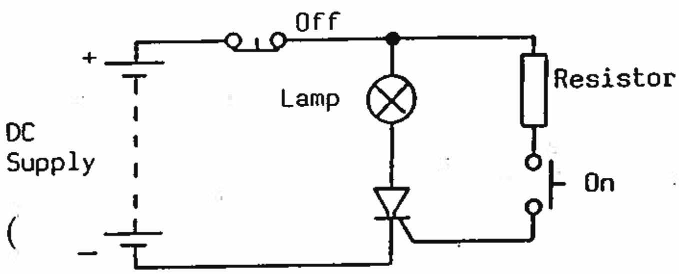
Thyristors are small compared with the amount of power they control and their protection is quite critical. To offer transient protection, capacitors, chokes and resistors are used. If any of these components have to be replaced, only the type and value specified by Cortina Electric may be used.



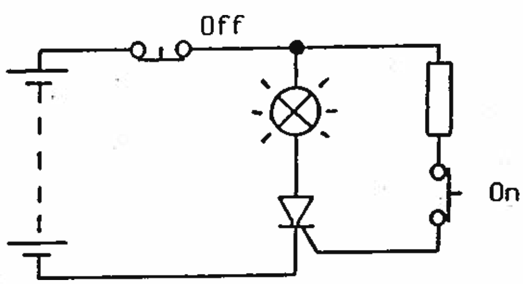
ELECTRICAL SYMBOL



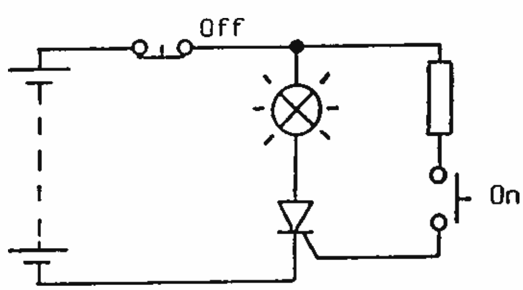
PRESSURE MOUNTED THYRISTOR



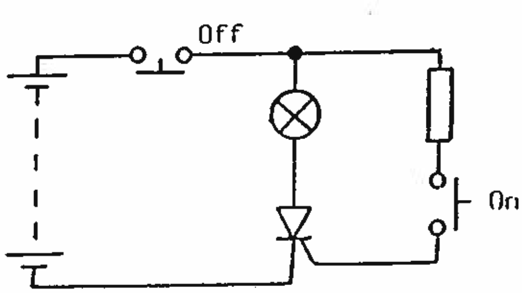
(a) Neither pushbutton operated the lamp is off.



(b) "On" pushbutton closed and the lamp is illuminated.



(c) "On" pushbutton released and the lamp remains lit.



(d) "Off" pushbutton opened and the lamp goes off. When the "off" pushbutton is released the lamp remains off.

FIG 1.
PERTAINING TO THYRISTOR OPERATION

CORTINA ELECTRIC

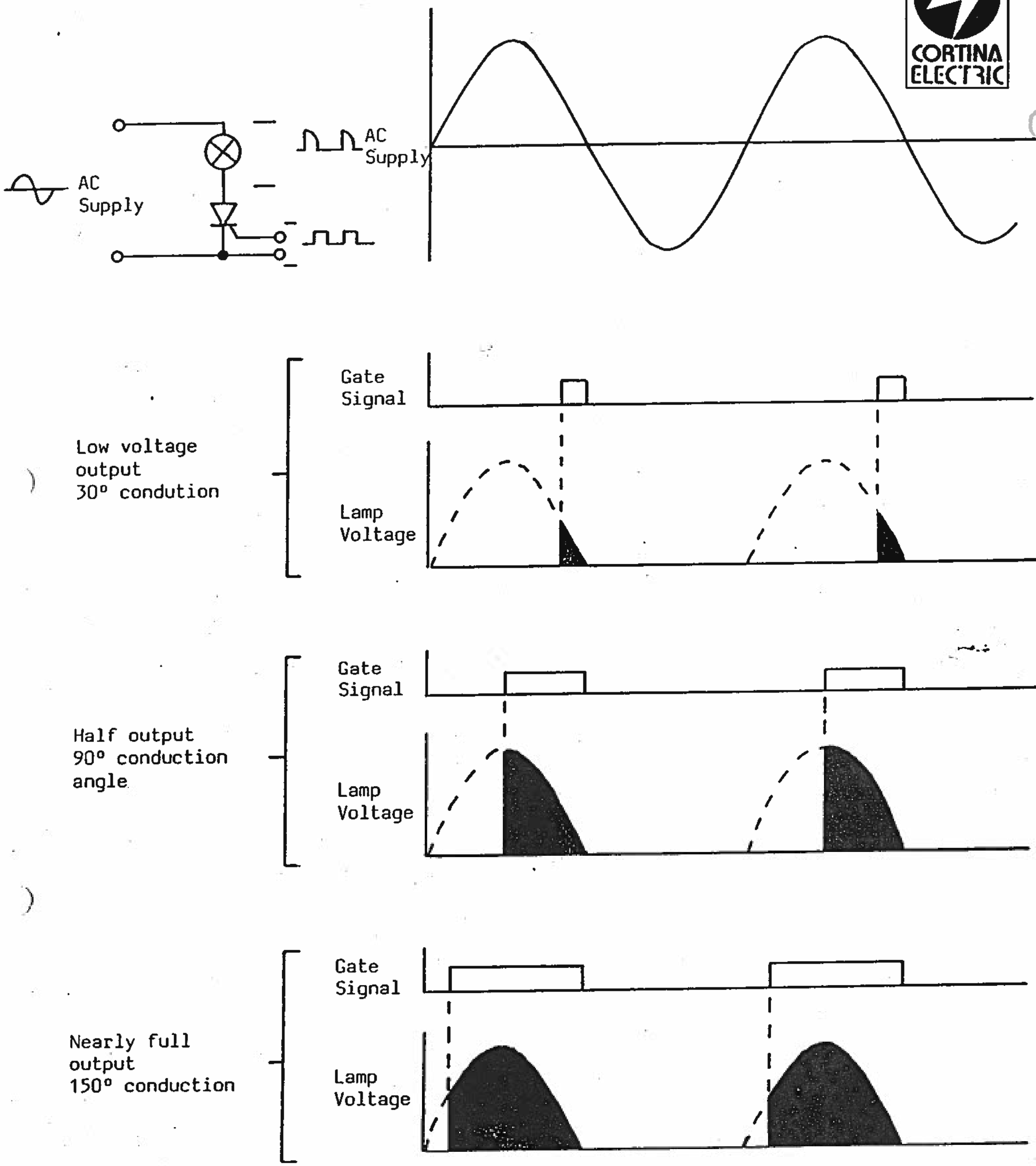


FIG 2.
THYRISTOR OPERATION

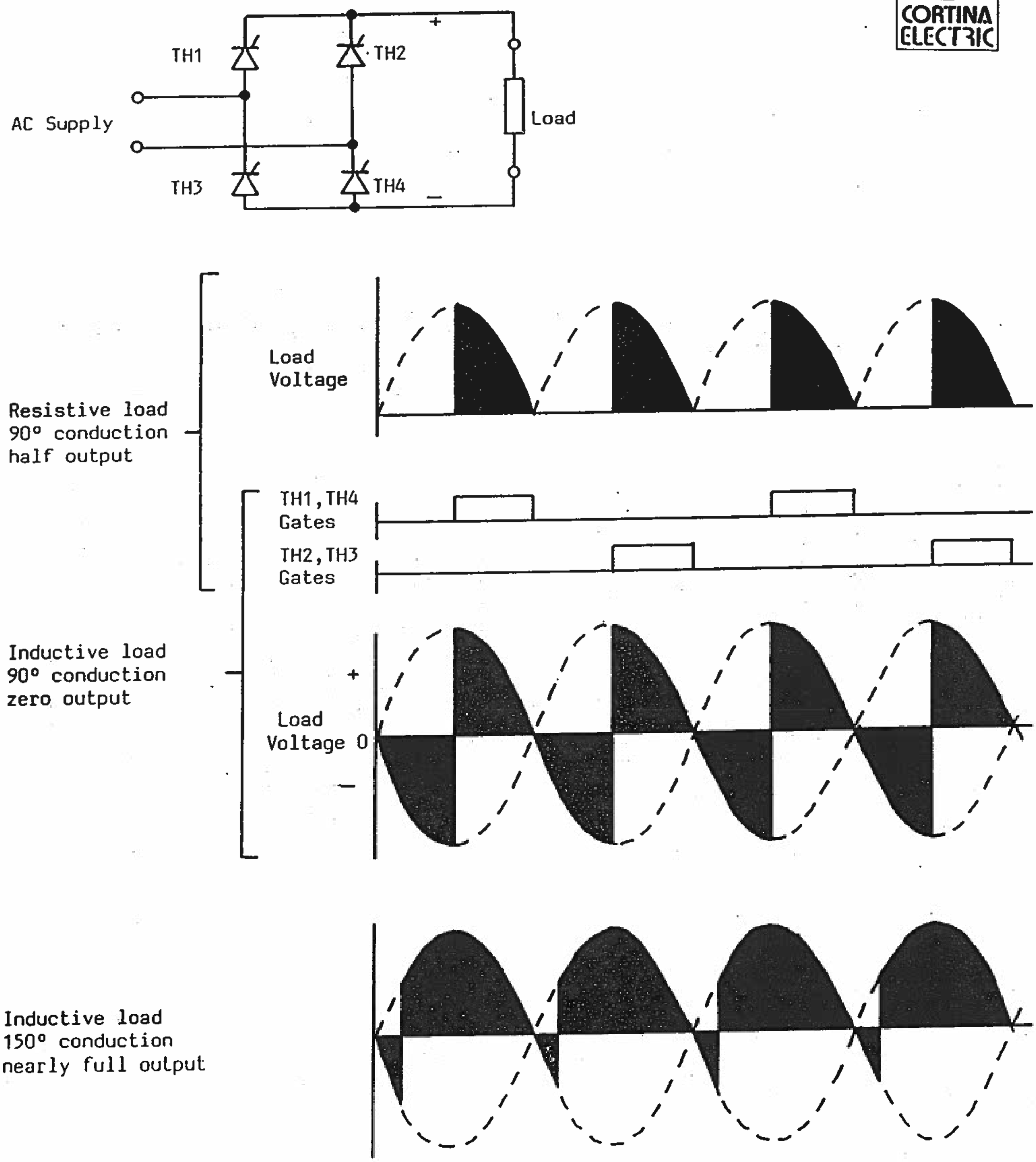
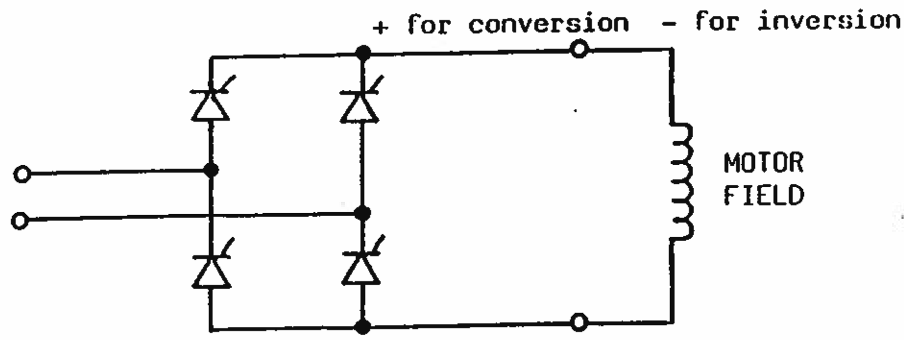
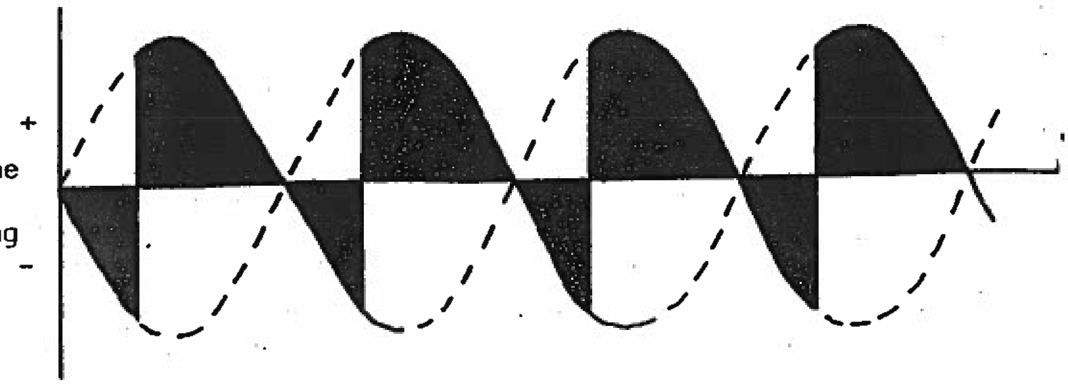


FIG 3.
SINGLE PHASE THYRISTOR BRIDGE



Field Voltage
Showing conversion
Power is taken from the supply, indicated by the positive area being greater than the negative area



Field Voltage
Showing inversion
Power is returned to the supply indicated by the positive area being less than the negative area

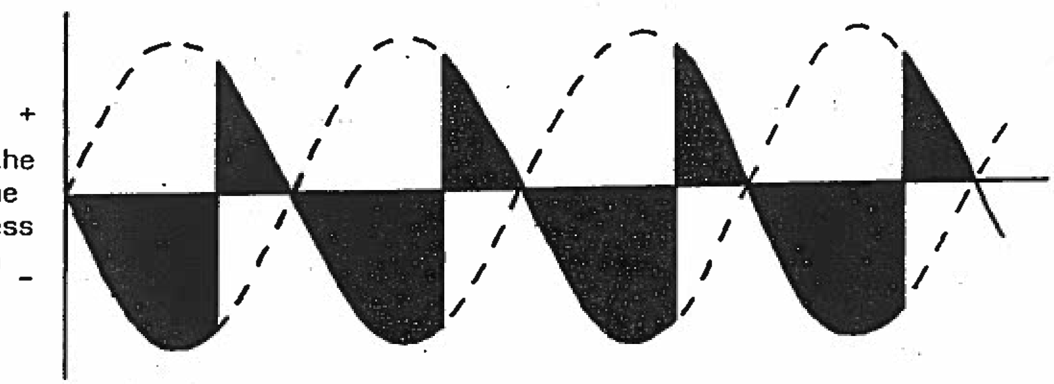


FIG 4

INVERSION

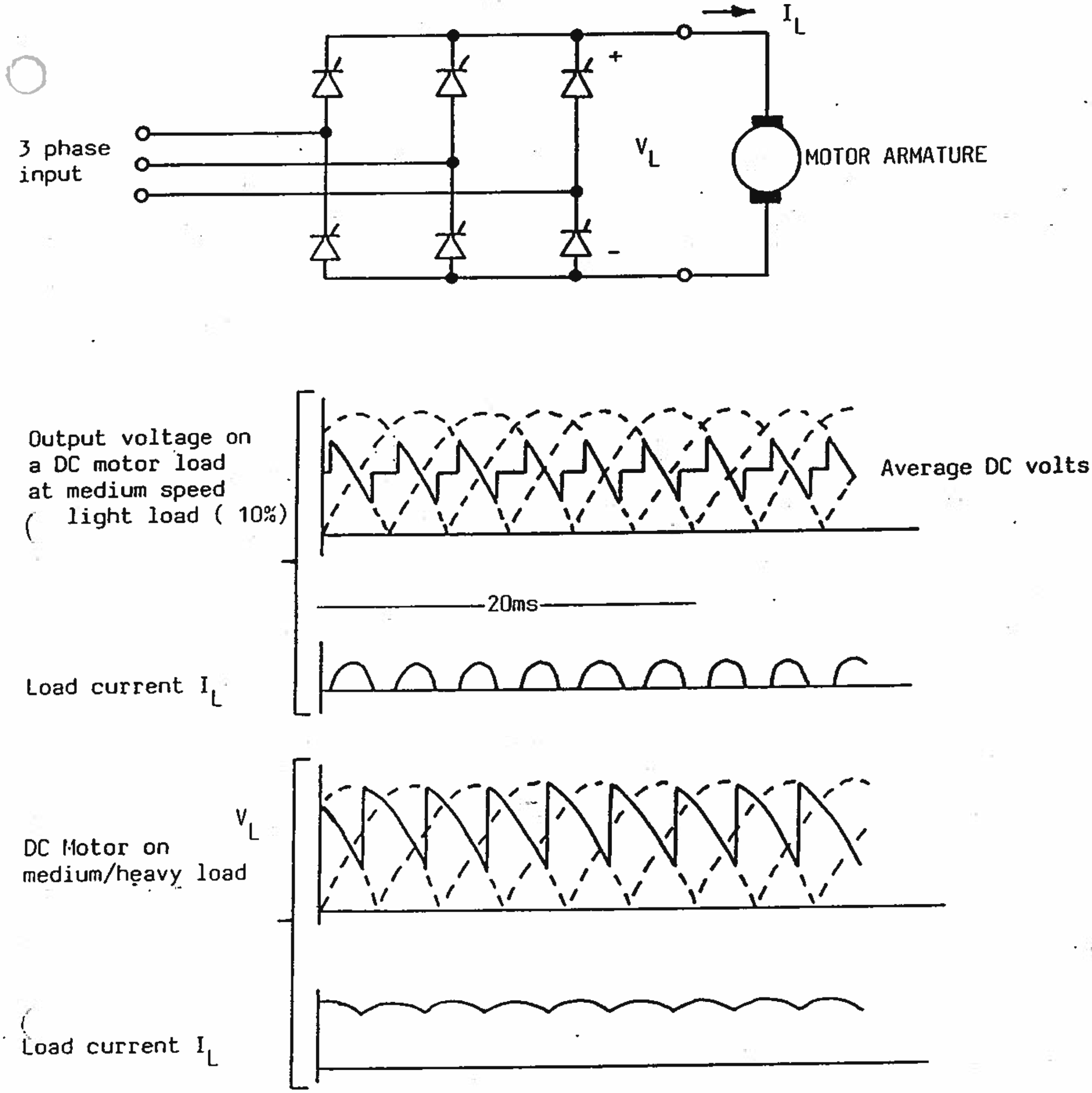


FIG 5

SIX PULSE CONVERTOR

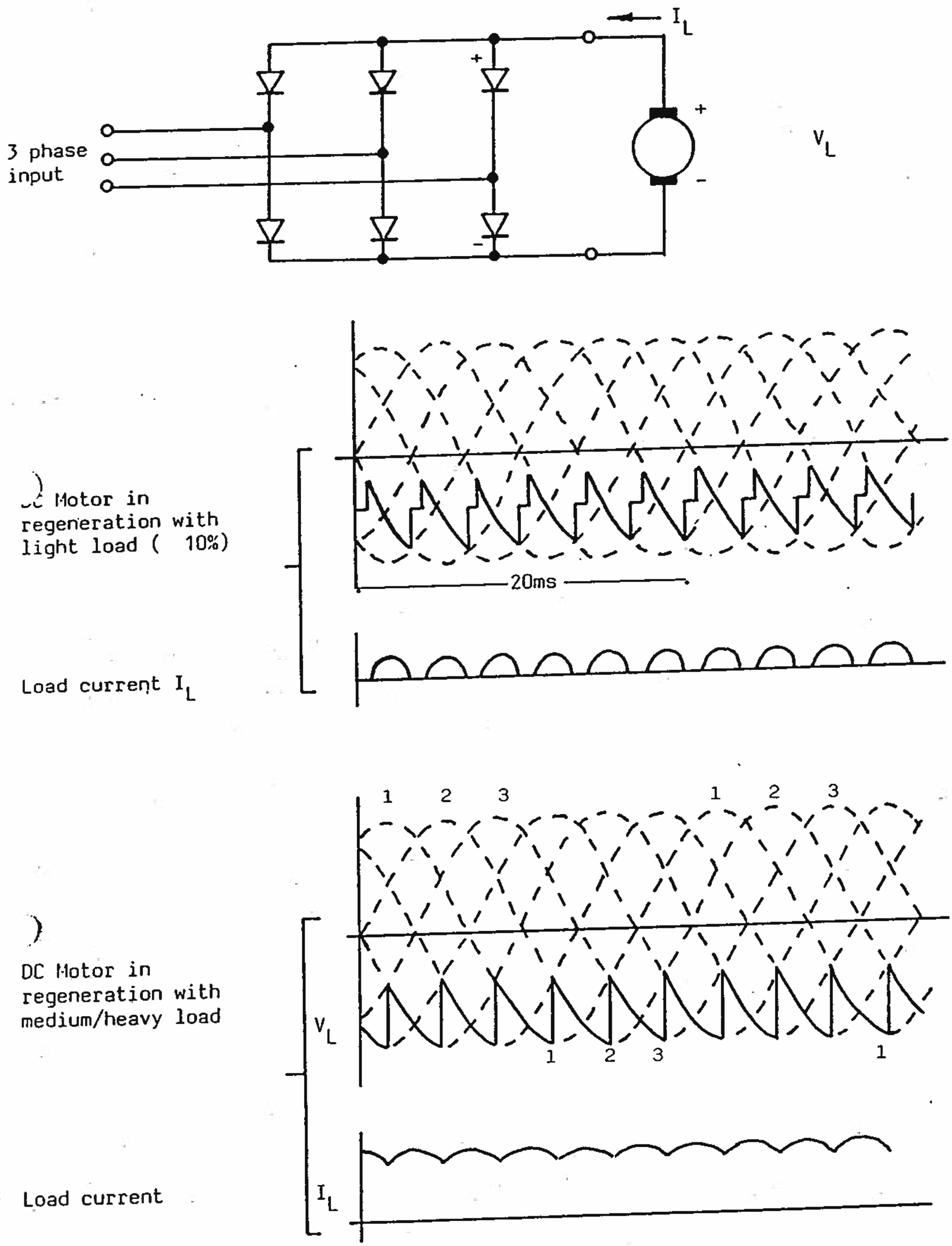


FIG 6

SIX PULSE INVERSION
OR REGENERATION

CORTINA ELECTRIC

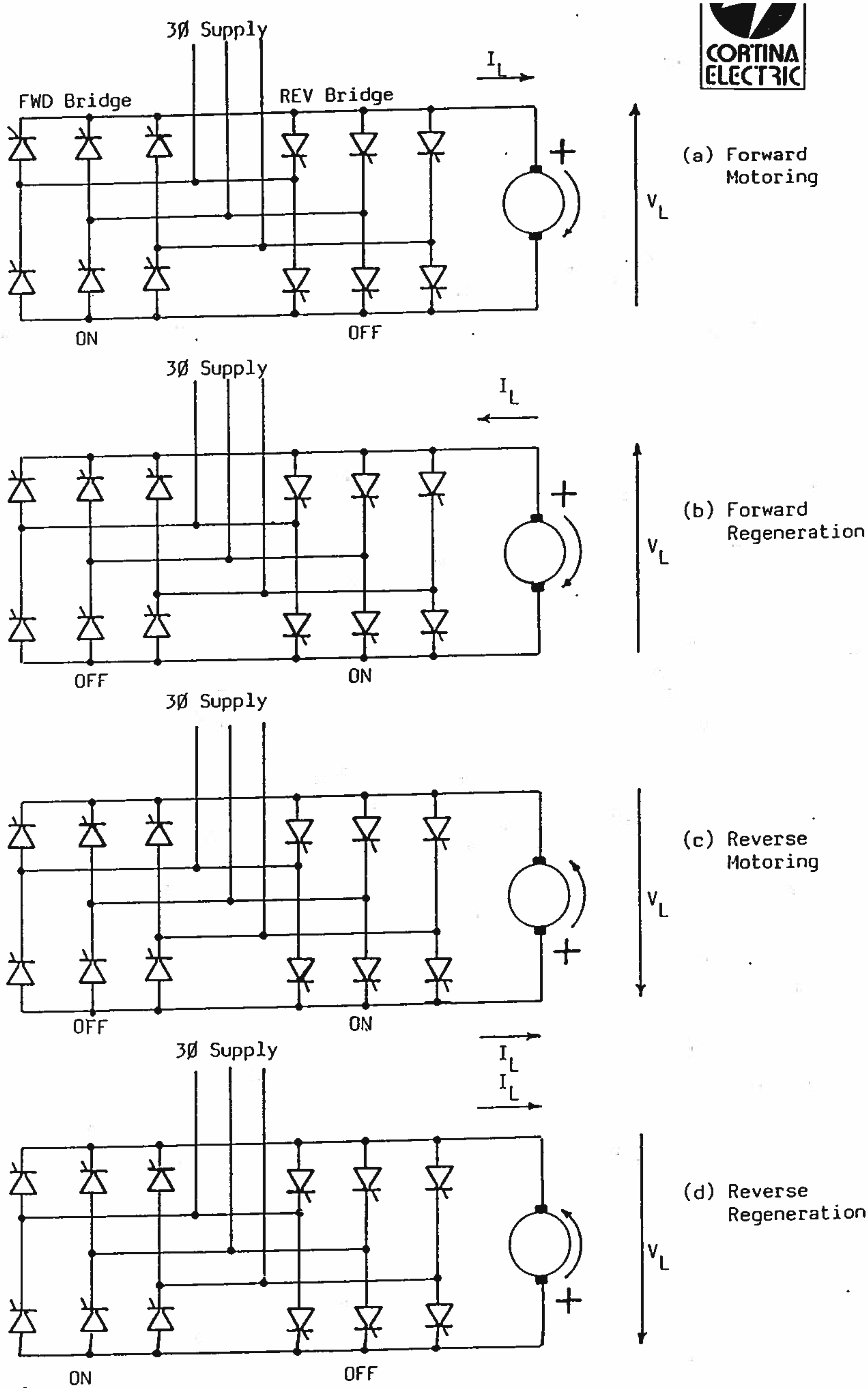


FIG. 7

CORTINA ELECTRIC

SECTION 3

SOME BASIC PRINCIPLES OF DC DRIVES

SOME BASIC PRINCIPLES OF DC DRIVES

DC drives are in common use throughout industry and although there are several types of drive, only thyristor controlled drives will be considered here.

The motors used in conjunction with these drives are generally DC shunt would (or slightly compounded). Several modes of control are available with these machines.

(a) Speed control can be achieved by varying the armature voltage and keeping the field current fixed. Increasing the armature voltage increases the speed and the relationship is linear e.g. doubling the armature voltage will double the speed. This means of speed control can be used over a wide speed range extending from zero speed up to "base speed" of the motor. It is the most common type of speed control used, and may be referred to as constant torque control.

(b) Speed control over a limited range normally above base speed is possible by controlling the motor field current. Decreasing the motor field current allows it to run at increased speed. This mode of operation is known as constant horsepower. It is quite common to employ methods (a) and (b) together to give operation over a very wide speed range.

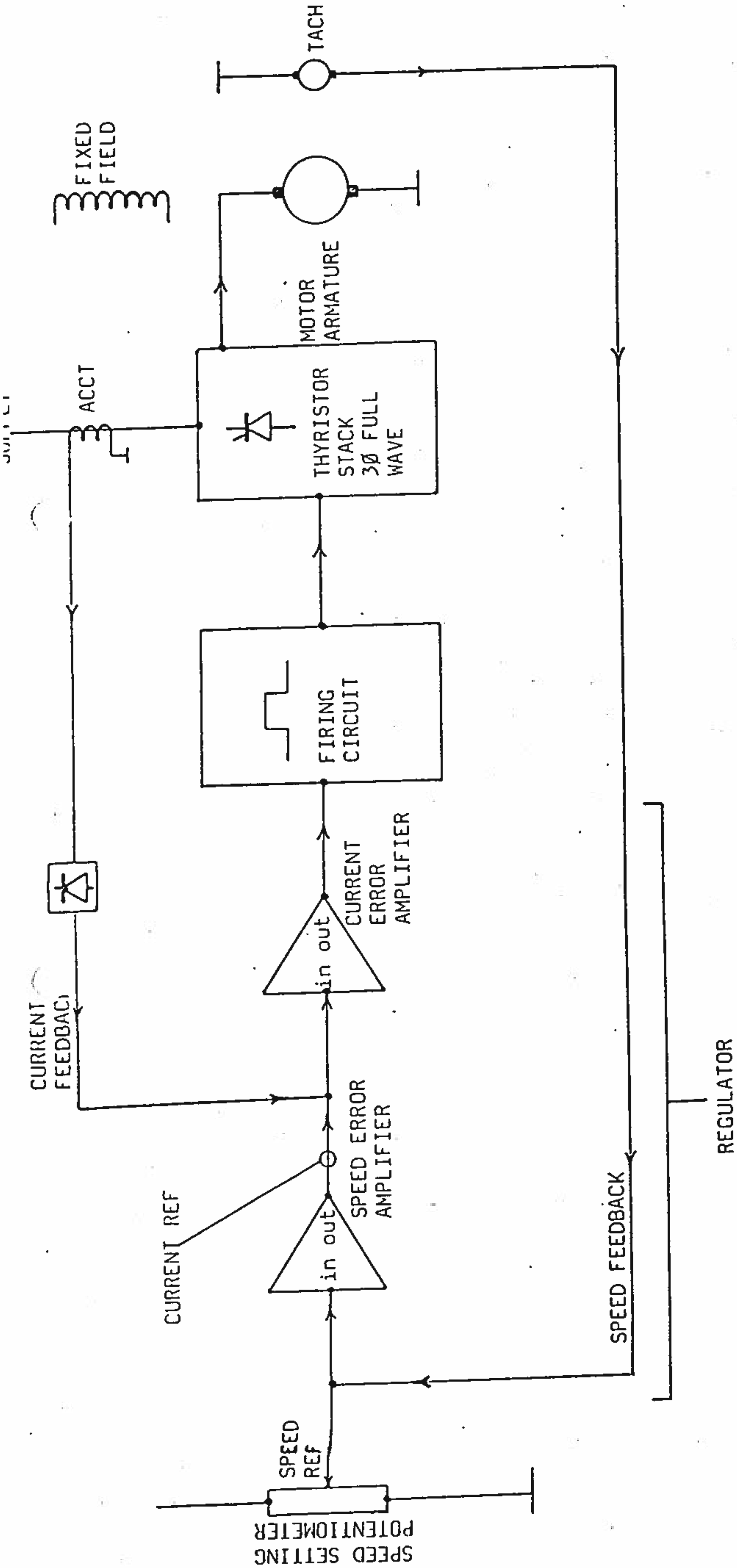


FIG. 1
BLOCK DIAGRAM OF
SPEED CONTROL SYS

(c) The torque developed by the motor depends on the armature current, increased current giving increased torque, and relationship is linear so that an increase of 50% in armature current will give a 50% increase in torque. Therefore by controlling the armature current it is possible to control the torque of the machine. This is equally applicable whether the machine runs as a motor or is driven as a generator.

A simplified block diagram of a speed control thyristor drive is shown in Fig. 1, consider first the firing circuit and thyristor stack. The thyristor stack consists of six power thyristors which control the output voltage to the motor. The thyristors are in turn controlled by tate pulses generated by the firing circuit. The output voltage from the thyristor stack is determined by the relative position of the pulses from the firing circuit, and this depends on the input voltage to the firing circuit. Taken as a whole the output voltage from the stack depends on the input voltage to the firing circuit - this part of the system can be considered simply as a voltage amplifier.

The current and speed amplifiers determine the voltage which will be fed to a firing circuit. Each of these amplifiers has two signals arriving at its input, a reference and a feedback. The two signals are compared and the output of the amplifier is proportional to the difference between the two signals, provided this is small. If the difference is not small the amplifier output will go to its saturation level.

Suppose that the drive is started up with a speed reference of say 50%. Initially there will be no speed and therefore no feedback voltage from the tachogenerator. In this case the speed amplifier will sit in saturation and give maximum reference signal to the current amplifier. This in turn will send a signal to the firing circuit which will shift the pulses to the thyristor stack causing it to "phase on" producing volts on the motor. The motor will take current from the thyristor stack which gets its supply from the AC line input. The current taken by the motor (and therefore the AC lines) will increase until the signal from the current feedback circuit equals the current reference signal. At this point the current will remain constant under current limit conditions. The current in the motor armature will cause it to accelerate thus producing speed feedback. When the speed feedback signal is equal to the speed reference signal the output of the speed amplifier will be reduced. This in turn will reduce the current reference and hence the current to such a level as to just maintain the motor running at preset speed, 50% in the case considered.

If the motor is now subjected to an increase in mechanical load it will slow down <u>very</u> slightly. This speed reduction results in less speed feedback and consequently an increase in the output of the speed amplifier. The increased output from the speed amplifier is an increase in current reference resulting in additional current into the motor armature. This increase in the motor current prevents the motor from slowing down significantly.

The above relates to normal speed control. If the mechanical load on the motor is such that the motor can never reach preset speed it will remain in current limit, producing a fixed torque. Replacing the speed amplifier with a potentiometer would give a means of controlling the current reference, hence the current and torque could be controlled.

In Fig. 1 the thyristor stack used is a three phase full wave bridge. When this type of bridge is used the current can flow in one direction only. As a result, if the speed reference is suddenly reduced the current will go to zero and the motor will coast down to its new preset speed. In some applications it is necessary to be able to have control during deceleration, or rapid deceleration for emergency stopping. Such applications require the use of a regenerative or four quadrant controller. This will allow controlled braking rather than coasting, and can also be made use of where the load is overhauling or driving the motor.

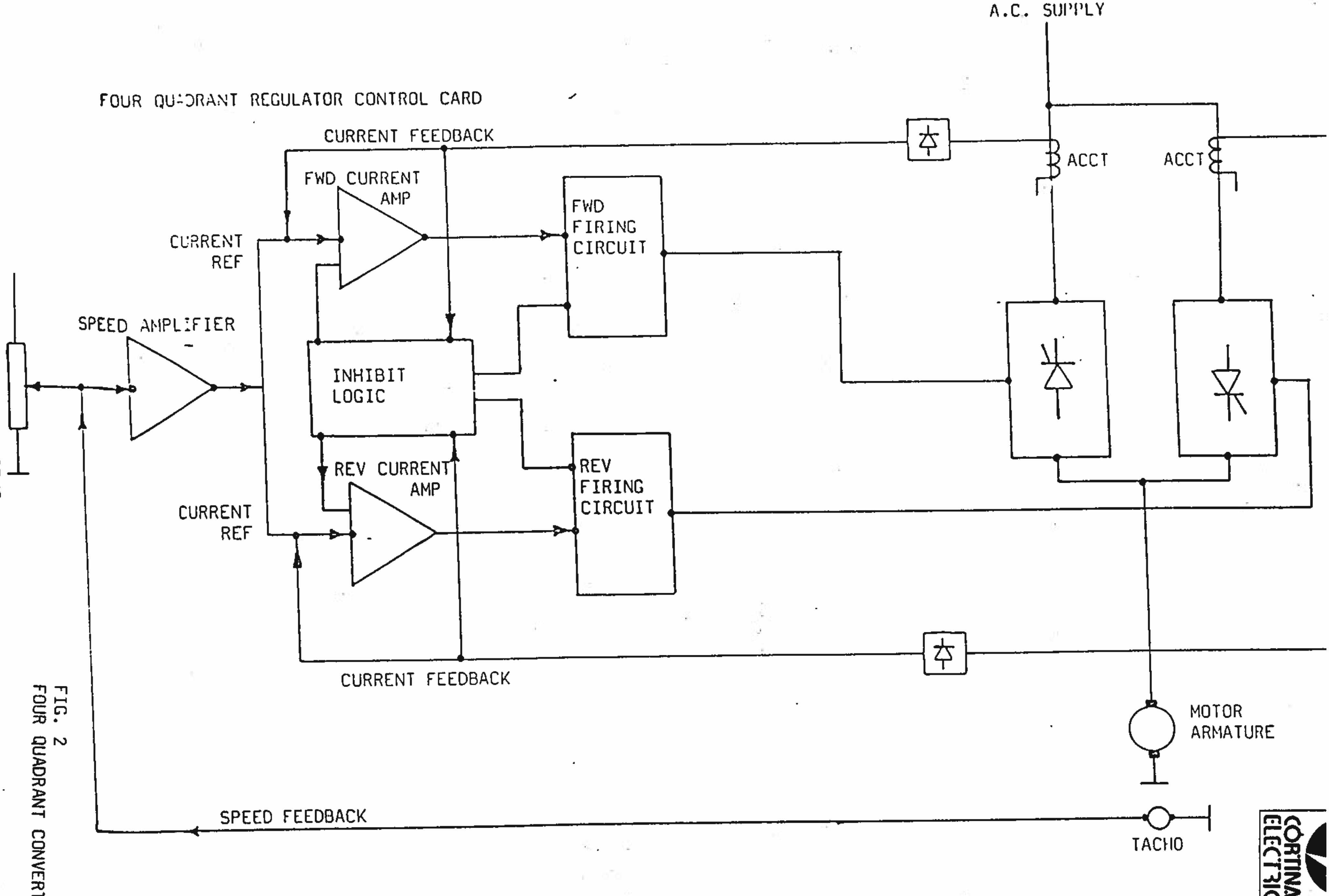


FIG. 2
FOUR QUADRANT CONVERTER

The thyristor stack arrangement for four quadrant operation is dealt with in Section 2.1. The block diagram of a four quadrant regulator is shown in Fig. 2. This is almost like two of the systems as shown in Fig. 1 - i.e. two current amplifiers, two firing circuits, two thyristor stacks, two current feedback circuits. Common elements are the speed loop motor and tachogenerator.

As in the simple speed control system, the speed reference is compared with the speed feedback. When the difference is positive the output of the speed amplifier will be of the correct polarity to send a current reference for the forward current amplifier. Assuming there is no inhibit operating, this current amplifier will give an input signal to the forward firing circuit and forward bridge calling for forward current in the motor.

The difference between the speed reference and speed feedback will be positive for two conditions:- the first is when the motor is driving in the forward direction, the second is when the motor is being pulled backwards by the load.

If the difference between the speed reference and feedback is negative the operation of the circuit follows the same sequence as above but all of the reverse elements come into operation, resulting in reverse current in the motor.

The reverse thyristor stack comes into operation if the motor drives in reverse or is pulled in the forward direction.

The inhibit circuitry is included to prevent the reverse bridge being phased on while the forward bridge is passing current or vice versa. This means that if the forward bridge is conducting the reverse current amplifier has an inhibit signal sent to it which will override its reference from the speed amplifier, even if this reference is of the correct polarity to turn the reverse bridge on. In addition the inhibit is fed into the reverse firing circuit to give further protection against the possibility of both thyristor bridges being on at the same time. In the event of this happening there will be a path between two phases through two thyristors which will then latch on. The conduction will be terminated when fuse failure occurs.

As in the control system shown in Fig. 1, the four quadrant system can be used to control current or torque, this feature being available in both clockwise and counter-clockwise rotations.

SECTION 4

DESCRIPTION OF 1500 CARD

6 - PULSE CONTROL ELECTRONICS DRG 1500/A1

1. GENERAL

The 1500/A1 PCB is designed to provide the control and firing circuit for all six-pulse thyristor control systems, e.g. dc drives, dc stage of voltage fed inverters, anodising and plating rectifiers, etc.

2. SPECIFICATION

POWER INPUT:- 3 phase, 415V, 45-65 Hz, 60VA.

REFERENCE INPUTS:- 0 to -10V 10mA into firing circuit.

0 to +10V 1mA into ramp.

0 to +10V into speed/voltage regulator, or may be programmed to set other values.

0 to 20V 1mA or 0 to -150V 1mA into voltage feedback circuit.

0 to - 10V 1mA into current regulator.

0 to +5V 1mA into current feedback.

OUTPUTS

Firing Pulse outputs 60° to 120° E duration 0° to 180° shift 14V 0.5A, pulses at 60° intervals to give symmetrical displacement round 360°.

Power Supply Outputs:-

+/-25V at 0.5A unregulated.

+/-14V at 2A unregulated.

+/-12V at 0.1A regulated.

Regulator outputs:-

Ramp. 0 to 10V 10mA.

Voltage/Speed error. -10V to 0V to +0.7V at 10mA.

Current error. +10V to 0 to -10V. 10mA.

Inverter. -10V to 0 to +10V. 10mA.

3. OPERATION

3.1 POWER SUPPLIES

A three phase supply is applied to terminals 5, 3, and 1 in that sequence. This supply is fed to transformers TX1, TX2 and TX3 which have outputs of 0-50V, 0-12V and 0-20V, the latter two being used to provide low voltage dc supplies.

The 12V windings are connected in delta and rectified by a three phase bridge (D11 - D16). The resulting dc (approx 14V) is available as an output from terminal 2. It is normally used to power the output stages of the firing circuit(s).

The 20V windings are star connected and rectified by D17, D18 and D19 to give +25V unregulated w.r.t. the star point which is used as the zero volt rail. A large electrolytic capacitor C4 is used for smoothing, and +25V is available as an output from terminal 46. The negative 25V rail is produced by diodes D40, D41 and D42 with C10 as the smoothing capacitor. Terminal 52 connects with the -25V supply. A further -25V supply is generated by diodes D20 to D22; this supply is used for phase loss detection and is dealt with in another section.

Regulated supplies of +12V and -12V are derived from the 25V supplies by means of voltage regulator IC's, 7812 for +12V and 7912 for -12V. The status of these supplies is indicated by light emitting diodes L4 and L5.

3.2 RELAY LOGIC

Four 24V dc relays are used to interface with external command signals.

The fault relay, RL1, picks up in the event of incorrect phase sequence, phase loss or overcurrent. A link or a normally closed "RESET" pushbutton connected between terminals 46 and 47 feeds power to RL1 coil. When thyristor TH2 is triggered it latches RL1 on. The operation of the fault circuits is described in detail in another section. The +25V supply is fed, via a normally closed contact of RL1, to terminal 51 where it is generally used to power RL2 and RL3, thus ensuring that RL2 and RL3 are de-energised if RL1 picks up.

Independently of relay operation, an "instantaneous" shut down function is operated by TR7. As well as local interlocking an extra "voltage free" changeover contact of RL1 connected to terminals 48, 49 and 50, can be used for remote indication or interlocking.

When relay RL2 is de-energised all the control amplifiers are biased to the "off" condition, and when RL2 is picked up the amplifiers are allowed to come into control. If RL2 is picked up but not RL3 the "CRAWL" function will be selected. When relay RL3 is picked up the run function is selected, and RL2 is held in via D25. A hold in contact for RL2 is connected to terminal 68 and likewise for RL3 to terminal 45.

Relay RL4 is normally used to detect zero speed but maybe used to detect other parameters. The signal to be detected is connected to the inputs of amplifier A3b via terminal 71. When the output of this amplifier goes positive transistor TR8 turns on and RL4 becomes energised. A normally open contact of RL4 is connected to terminals 64 and 65.

The output of A3b is connected to terminal 72 therefore this amplifier maybe used for other functions.

3.3 PHASE SEQUENCE/PHASE LOSS/OVERLOAD CIRCUIT

Thyristor TH1 is used to detect phase sequence. The blue phase is applied to its anode and the red phase delayed by 60° (using R23/C5) to its gate so that anode and gate are out of phase by 180° when normal phase sequence prevails. With incorrect sequence TH1 anode and gate signals will be nearly in phase and TH1 will turn on causing TH2 to fire. When TH2 fires it latches, energising fault relay RL1.

Diodes D20, D21 and D22 are used in the phase loss circuit. When all three phases are present the common anodes sit at -25Vdc and the junction of potential divider R22-R31 assumes a negative level thus reverse biasing D25. If one phase is absent even for one cycle (C6 being small) the -25V supply from D20-22 will collapse and D25 will conduct as R22-R31 junction goes positive. As a consequence TH2 will be fired and fault relay RL1 will be energised.

Resistors R64 and R65 form a potential divider between the current feedback signal (which is positive) from terminal 43 and the -12V supply. In the event of excessive current even for one pulse the potential of R64-R65 junction will become positive and TH2 will be fired via D39, and fault relay RL1 will be energised.

In the event of RL1 being energised by any of the above fault conditions relay logic is used to stop the drive. Additionally, when RL1 is energised transistor TR7 (normally conducting) is simultaneously cut off and this instantly removes the firing pulses. This gives a very fast shut-down procedure which is not dependent on any relay operating times.

3.4 RAMP CIRCUIT

The purpose of the ramp circuit is to provide a controlled rate of acceleration regardless of the rate at which the input reference is changed.

The ramp utilizes two op amps A2a and A2b (which are housed in the same package) and timing components R46 with capacitors C14-C16. The input signal to the ramp is fed to A2a inverting input via R42 or R43 depending on the status of RL3. The output is fed from A2b to terminal 59, and also back to A2a non-inverting input.

To understand the operation of this circuit first assume that A2b output is at zero and a step input of say +5V is presented to A2(a) input. The output of A2(a) will go to negative saturation at about -10V and the integrator comprising A2(b) R46 and C14-C16 will ramp linearly to a positive value. When the output of A2(b) reaches +5V then both inverting and non-inverting inputs to A2(a) will be at the same level and its output will go to zero. At this point A2(b) integration will stop and the output will remain fixed. Any tendancy for A2(b) to drift will result in a difference into A2(a) which will send a signal to A2(b) integrator such as to correct the drift.

The ramp rate can be adjusted by altering RV5 which varies the strength of signal into the integrator. The range of adjustment can be changed by adding or removing capacitors in the C14-C16 bank. More capacitors give a slower rate. The fastest setting can be calculated from the relationship.

t.min = CR with C in Farads
and R in ohms
(R46 on 1500/A1)

For reliable operating the maximum time should not be set at more than ten times the minimum time. When the equipment is not in operation the output of the ramp can be quickly brought to zero by discharge resistor R47 and RL2 contact.

3.5 SPEED/VOLTAGE REGULATOR

Amplifier A3 functions as an error signal amplifier. The reference is fed in via R48 and *R49 from terminal 31, and the feedback which may* be voltage or a speed signal from a dc tachogenerator is fed into the summing junction via the chain R50, R51, RV6. Potentiometer RV6 can be used to trim top speed on dc drives or V/Hz ratio on inverters. Components R54, R53 and C18 set the system gain and stability. Capacitors C17 and C19 are used to filter noisy signals. Zener diode Z3 limits the negative excursions of A3 output to -10V max. The purpose of this is to put a defined limit on A3 output which normally acts as a current reference for the current regulator. The zener diode also serves to clamp the positive output of A3 to 0.7V. The output of A3 controls only in the negative region and it is generally undesirable for A3 to go far out of control in the positive region.

When the equipment is not in operation a strong -12V signal is fed via RL2, 047 and R52 to A3 input, causing its output to go to the positive "off" state.

3.6 CURRENT REGULATOR

Amplifier A4(a) functions as a current error amplifier. The reference (which is normally A3 output as described in section 3.5) is fed in via R55 to the summing junction. Current feedback is ***formally derived from two ACCT's. The secondaries*** of these CT's are connected to terminals 61,62 and 63. It is then rectified by diodes D50 to D55. R72 and R73 are connected across this bridge and are used as burden resistors. The positive side of the rectifier is connected to terminal 43 and is fed via R59 and R60 to A4(a) input. The current feedback signal is also used to operate the instantaneous overload circuit described in section 3.3.

Components R58, R57, C20 and C21 set the gain and stability of the current loop.

Amplifier A4(b) is used as a unity gain inverter following the current amplifier to give correct polarity to the firing circuit. When the equipment is in the stop condition contacts of RL2 send strong +12V and -12V signals to A4(a) and A4(b) respectively to bias them to the "off" state..

3.7 FIRING CIRCUIT

The firing circuit is designed to produce firing pulses to control all configuration of six pulse thyristor stacks. It accepts a dc input signal and produces output pulses from 6 channels.

The circuit for each of the six channels is identical and each channel produces a series of output pulses, one every 20ms or 360°E, whose leading edges are used to fire thyristors. The six outputs are phase displaced from each other such that an output pulse is produced every 60°E. The pulse width varies from zero (or 60° if R12 is fitted) to 120°E maximum and its phase relationship with the supply can be shifted by 180°E.

Consider the R+ channel which is at the top of drg. 1500/A1. The operational amplifier A1 is the heart of the phase shifting circuit. Three signals are fed into A1 input. A fixed dc bias (VB) is fed via R4 from R67, R68 attenuator (TR7 is normally in the "ON" state during running). The second input signal is a variable dc reference (Vdc) from terminal 28 via R3 and RV1 if fitted. The third input is a cosine wave (Vsync) derived from TX1 output via filter R21-C2 and input resistor R5 and RV2 if fitted.

Amplifier A1 adds the three signals together and at its output produces the inverted sum, i.e. if the sum is positive the output of A1 is negative and vice versa.

The result of adding the three signals together is shown in Fig. 1. Because the gain of amplifier A1 signal is also fed into the amplifier A1 input thus providing an additional means of suppressing the pulses.

In some applications it is not desirable to allow the pulses to disappear. An "end stop" pulse is produced by TR3 when it is in the "off" state. This pulse overrides the output from A1 but is overridden by TR3.

4. TESTING AND FAULTFINDING

4.1 GENERAL

If it is suspected that the card is faulty the normal procedure is to replace it with a spare. For most applications production down time dictates this course of action. However it is worth making a few checks to ensure that it is the card at fault and not an apparent fault induced by a malfunction in the external circuitry.

Check that the three phase supply is present on terminals 1, 3 and 5. This should be done carefully because the presence of transformers can artificially produce volts on a line where the supply is not made. Check all low voltage power supplies and ensure that they are within the spec given earlier. If they are not within the spec disconnect any external loading and recheck. If external loading is causing the supplies to change the fault is probably external to the card. Check all the terminal screws to ensure that all the connections are tight.

Inspect both sides of the card for physical damage, broken components and particularly for any foreign bodies touching the tracks or shorting to earth. Strands trimmed off cable ends, cable armour and drops of solder are likely culprits.

It is also worth testing the firing circuit section of the card in situ as this will often pinpoint faults elsewhere in the equipment, e.g. faulty thyristor, pulse transformers, current feedback. For this test it is necessary to have a load connected to the thyristor stack. If the test is done carefully the normal motor can be used, otherwise a resistive load capable of passing 5A or more should be used. The procedure is detailed in section 4.5.

If it is decided that the card is faulty and it is removed from the equipment then a number of bench tests can be carried out. It is necessary to have available a three phase 415V supply, a high impedance multimeter, and if possible a general purpose oscilliscope.

4.2 POWER SUPPLIES

(a) +14V supply. This may be slightly high in the unloaded condition. If it is otherwise out of spec check the 12Vac from TX1, TX2 and TX3. If any output is low it may be because one of the diodes D11 to D16 is faulty or C3 short circuit. Check and replace these components (including the transformers) as necessary.

(b) +/- 12V and +/-25V supplies. Since the +/-12V is very high the sum is seen as either positive or negative with no intermediate values, and therefore A1 output is a square-wave. With the dc level shown the output pulse from A1 is a 180° pulse. Clearly the pulse will start earlier and last longer if Vdc is increased (made more negative). The leading edge of the pulse varies in accordance with the phase shift requirements of firing the thyristor but a pulse length of more than 120°E is not permissible. Transistor TR3 is used to bring about the termination of the pulse after 120°E. The Y+ channel (the second from the top of 1500/A1) produces a pulse which will commence 120° after the R+ channel. A signal from the Y+ channel via R18 is fed into TR3 base, turning it on and thus shorting the signal on TR4 base 120° after the start of the R+ pulse from A1. Similar inhibit signals are sent from B+ to V+ and from R+ to B+. A "ring of three" circuit is formed which ensures that no pulses can extend beyond 120°. (The same conditions apply to R-, Y- and B- channels).

Under fault conditions when TR7 is no longer conducting a strong positive signal is applied to TR3 base via R8 from R67, R68 junction. In this situation the output pulses are suppressed. In *addition to operating on TR3 base the positive* supplies are derived from the +/-25V supplies then it is worth first checking the 25V if the 12V malfunctions.

To test the +/- 25V proceed generally as in (a) above noting that in this case the supply is derived from a star connected 20V winding. If necessary the effect of any fault on the +/- 12V supplies reflecting back into the +/- 25V can be isolated by removing R36 and R38.

Checking the +/- 12V supplies is not so straightforward because it is not practical to disconnect the load. If either supply is high the voltage regulator is the most likely faulty component. If the supply is low again it may be excessive loading causing the regulator to sit down in current limit. Generally this fault is caused either by tracks shorting together with some conductive material or faulty components. The former requires careful inspection and the latter can be checked by touch to find any component which is overheating.

4.3 RAMP CIRCUIT

A functional check of the ramp circuit can be made by connecting a positive voltage signal into terminal 57 and energising RL3. The positive voltage signal should be in the range 0 to +/- 12V and can be obtained from RV4 via terminal 55. Prior to energising RL3 the ramp output (terminal 59) should be at zero volts. Energising RL3 (which also energises RL2) should cause the ramp output to increase to a level about 20% less than the input at terminal 57. The exact proportions depend on the ratio of potential devider R40, R41. When RL3 is released the ramp output should go back to zero volts - quickly if R47 is fitted.

4.4 VOLTAGE/SPEED AND CURRENT REGULATORS

These circuits form part of a closed loop system and without the remainder of the system (which may include a motor and mechanical load) it is clearly not possible to perform a full and conclusive test. The following bench tests should prove that the circuits are healthy statically but not necessarily dynamically.

With RL2 de-energised A3 output should be + 0.7V, A4a output -10V and A4(b) output +10V. These values are approximate. For the rest of the tests RL2 should remain energised.

(a) VOLTAGE/SPEED REGULATOR

Connect +12V to terminal 31 and A3 output should go to -10V. Connect -12V to terminal 31 and A3 output should go to +0.7V. Carry out the same test using terminal 32 as the input and the same output voltages should be obtained.

(b) CURRENT REGULATOR

Connect +12V to terminal 39 and A4b output should go to +10V. Connect -12V to terminal 39 and A4b output should go to -10V. Carry out the same test using terminal 43 as an input and the same output voltages should be obtained. Note that when +12V is fed into terminal 43 the overload may trip. If it does not trip then connect +25V to terminal 43 and this should trip the overload, otherwise there is a malfunction of the overload.

4.5 FIRING CIRCUIT

A test potentiometer, RV3, is provided to enable operation of the firing circuit and associated thyristor stack to be tested "open loop" i.e. independently of the regulator system. The test procedure is straightforward.

1. Switch off
2. Remove the external wire from terminal 28
3. Link 28 to 29
4. Turn RV3 fully anti clockwise
5. Switch on and energise RL2 or otherwise ensure that TR7 is biased into the conducting state. Operating the start pushbutton for the

equipment normally energises RL2. The status of RL3 is not important but RL1 must not be energised.

6. Slowly phase on the thyristors by turning RV2 clockwise. Observe the thyristor stack output or current feedback using an oscilliscope. There should be six equal pulses every 20ms. If this test proves satisfactory this indicates that the firing circuit and thyristor stack are healthy, and together these normally represent a considerable part of the total equipment.

7. If an incorrect result is obtained in 6 above then check, with the stack phased on, the output voltage from each channel. This should be approx. 4.3Vdc and all channels should be equal. If they are not equal then disconnect all six outputs and check again. If the outputs are now equal the fault lies with the pulse transformers or associated wiring. It should be noted that a faulty pulse transformer may cause damage to the firing circuit.

4.6 PHASE ROTATION/PHASE LOSS

This circuit can be readily checked by removing a phase for phase loss and by reversing two phases for phase rotation. In either case RL1 should be energised and L1 extinguished.

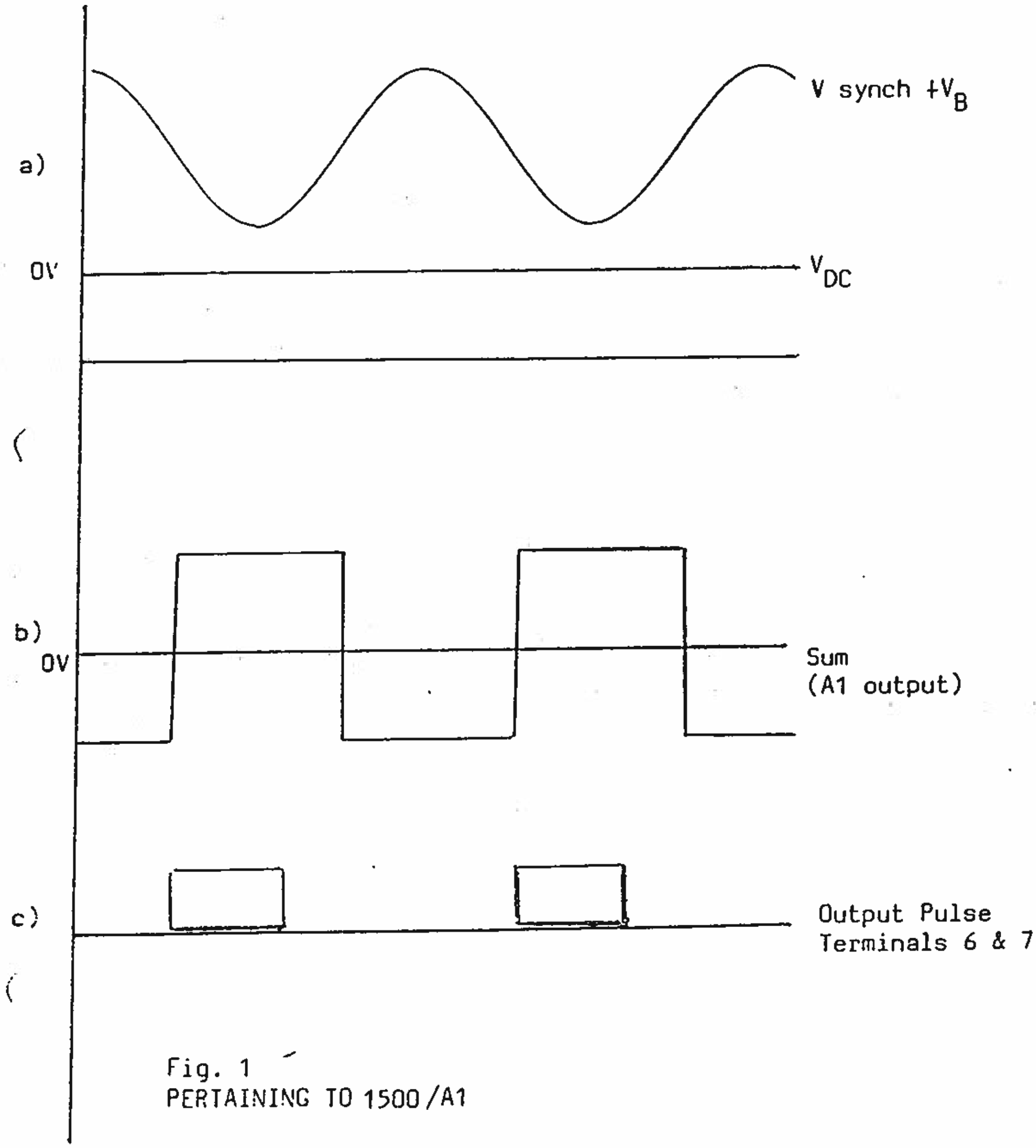


Fig. 1
PERTAINING TO 1500/A1

FIRING CIRCUIT

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SECTION 5

DESCRIPTION OF 669 CARD

REGULATOR 669/A1

This circuit is intended to provide the necessary controls for a fully regenerative drive system.

The circuit comprises the following sections:-

(i) Speed amplifier.

(ii) Acceleration amplifier.

(iii) Forward current amplifier.

(iv) Reverse current amplifier.

(v) Forward inhibit.

(vi) Reverse inhibit.

(vii) Zero speed detector.

(viii) Power supply.

(xi) Trip circuit.

(i) Speed Amplifier

The speed amplifier comprises amplifier A1 and associated components. A speed reference is fed into A1 via R1, R2 and R3 in series from terminal 33. For forward control the reference will be positive. Speed feedback (normally from a tachogenerator) is connected to terminal 32 and is negative for forward running. Potentiometer RV2 is used to set the correct strength of speed feedback and therefore set top speed. Transistors TR2 and TR3 are used to boost the current output of A1. Components RV1, R7 and C1 form the stability network round A1. In some cases these components may not be fitted when external stability components are fitted, (usually on printed circuit 746/A3). The steady state gain of the speed amplifier is set by R5 or an external resistor connected electrically in the same position. When the drive is not in the run condition TR1 assumes minimum resistance state and therefore set A1 to a low gain. (When A1 has a low gain its output is held to a low value). In the run mode a negative signal is applied to terminal 15 and this biases TR1 to the high resistance state. The negative "GO" signal on terminal 15 is normally applied via relay RL3 on the relay logic card 608/2. If L1 is on it indicates that a "GO" signal is not present, i.e. inhibit conditions prevail.

(ii) Acceleration Amplifier

If the tachogenerator signal is applied to terminal 31 then A2 and associated components will control the rate of acceleration. Capacitors C4 and C5 form a differentiating circuit and therefore pass a current proportioned to rate of change of tacho voltage, i.e. rate of change of speed. This current is balanced against the current in R15 which is proportional to RV3 setting. When the two currents are equal A2 comes into control and its output, if more positive than that of A1 will forward bias D8 and reverse bias D4. In this situation the voltage on terminal 27 is a function of the acceleration amplifier output rather than the speed amplifier output. Terminal 27 may be used as the current reference.

When the acceleration amplifier is not in use RV3 may be used as a crawl speed potentiometer or other positive bias, its output being taken to terminal 10.

(iii) Forward Current Amplifier

The current amplifiers take their input from terminal 16. Except in the case of a current controlled drive this reference will be derived from the speed amplifier output on either 27 or 28. The forward current amplifier comprises A7 and associated components. The reference is fed in via R48 and is negative when the forward current amplifier is in operation, i.e. forward motoring or regeneration when the motor is running in the reverse direction. Current feedback, applied to terminal 24, is positive under all conditions. The strength of current feedback is adjusted by RV6 which therefore sets the current limit. The stability network comprises RV5, R90 and C14, and, as in the case of the speed amplifier, they may be fitted externally. The gain of the current amplifier (and therefore its output) can be set to a low value by biasing TR11 to the conducting state. This circuit allows the current amplifier to be inhibited. Following the current amplifier is an inverter, A8, which is used to achieve correct polarity output for the 290/A1 firing circuit. The output is taken from terminal 22.

(iv) Reverse Current Amplifier

The reverse current amplifier gets its reference from terminal 16 via inverting amplifier A9. Because of this inverter the reverse current amplifier accepts from terminal 16 a positive reference, i.e. regeneration when the motor is running forward (braking from speed) or motoring in the reverse direction. Apart from the current reference inverter, the operation of the reverse current amplifier is the same as the forward current amplifier. The output for the reverse firing circuit is teken from terminal 19.

(v) Forward Inhibit

In order to prevent both forward and reverse current amplifiers coming into control at the same time it is necessary to include inhibit circuitry.

The forward inhibit employs A12 whose output feeds TR11 which, as described in (iii) can be used to de-gain the forward current amplifier. This will be the case when A12 output goes positive. Amplifier A14 provides the reverse inhibit.

Prior to starting, when there is not negative signal on terminal 15 a positive signal is fed into the non inverting inputs of both A12 and A14 via R10 and D38, R69 for forward and D35, R83 for reverse. This ensures that both A12 and A14 outputs sit at positive saturation. In this condition L7 and L8 are both lit (indicating inhibit for forward and reverse), TR11 and TR12 are biased into conduction and TR7 and TR9 are cut off. Transistors TR7 and TR9, when in the cut off state, inhibit the operation of the firing circuits. With switches SW1 and SW2 in the "UP" position TR7 and TR9 assume the cut-off condition (high resistance) permanently thus inhibiting the operation of the firing circuits. The switches are for test procedures to allow one firing circuit at a time to be brought into operation. They must not be moved when there is power on the drive.

When the drive is started a negative signal is applied to terminal 15. This removes the clamp from the speed amplifier, the acceleration amplifier and both inhibit amplifiers. If a positive speed reference is applied to the speed amplifier its output will go negative (assuming the motor is initially stationary). This negative signal is inverted by A9 and sends a positive signal to A12 inverting input, causing its output to go negative.

The negative output from A12 turns TR7 on, TR11 off, extinguishes L7 and sends an inhibit signal to A14 via R73 and D27.

With TR7 conducting and TR11 cut off, A7 (forward current amplifier) comes into control and the drive starts in the forward direction. When forward current flows the current feedback signal arriving at terminal 24 sends the output of the forward current sensing amplifier A13 positive. This positive signal is fed via D29 to reverse inhibit amplifier A14 non-inverting input where it acts as a very strong inhibit signal overriding all other inputs. The output of A13 also feeds into the inverting input of A12 to keep it in the released condition as long as there is forward current. This release can be overriden by the trip circuit or the absence of a "GO" signal on terminal 15.

(vi) Reverse Inhibit

The reverse inhibit circuit, A14 and associated components are identical in operation to the forward inhibit, but is released by a positive signal from the speed amplifier output. The following conditions must prevail to release the reverse inhibit:-

There must be no forward current.

Terminal 15 must be negative.

Forward inhibit must be on (inhibited).

The trip circuit must be healthy.

The speed amplifier output fed into terminal 16 must be positive.

When the reverse inhibit is released L8 will be extinguished and the reverse current amplifier will come into operation.

(vii) Zero Speed Detector

The zero speed detector circuit uses tachogenerator feedback as means of detecting speed. The tacho feedback is applied to terminal 9, where, after passing through R20 it is clipped by Z1 and Z22. The resulting voltage goes to

A3 non-inverting input and A4 inverting input. If it is a positive voltage A3 output goes positive, and if it is a negative voltage A4 output goes positive. In either case L2 is lit and TR5 conducts. When TR5 conducts it can energise an external relay, normally RL1 on the relay logic PCB 608/A2. The relay is energised if there is tacho feedback of either polarity and dropped out when there is no feedback. The actual level at which the detector operates is very low, much lower than normal crawling or jog speeds.

(viii) Power Supply

The power for the regulator card may be either three phase AC 35V L-L and neutral connected to terminals 1,2,3 and 5 or +24V,0, -24V connected to terminals 7,5 and 4. In the case of the AC supply it is rectified by the bridge comprising D41 to D46, which produces a 24-0-24V DC supply. The regulator chips 7812 and 7912 step the voltage down to +12V and -12V respectively. These regulated 12V supplies are used to power all the amplifier circuits. The unregulated 24V supplies are generally used for relays.

(xi) Trip Circuit

Amplifiers A5 and A6 together with THY1 and associated components make up the trip circuit, which offers protection against low power supplies and overcurrent.

In the healthy condition THY1 is switched off. This is ensured at start up by a negative pulse on TR6 base causing it to conduct momentarily thus shunting any current from THY1 allowing it to turn off. THY1 may be on when power is first applied to the card. The negative pulse for TR6 comes from the "GO" signal applied on terminal 15.

The +/- 24V supplies are monitored by A5. With normal voltages the junction of R32 and D41 sits at or near zero volts. A positive bias from RV4 therefore ensures that A5 output sits in negative saturation. If the +/- 24V supply goes low R32-D41 junction will go positive sending A5 output positive, which will then turn on THY1. A similar circuit comprising R42, D13 and A6 monitors the low voltage supply, but in this case a fixed positive bias is generated by D14. If the supplies go low A6 output goes positive feeding into the forward and reverse inhibit circuits, this initiating a trip. The output of A6 will also go positive if THY1 conducts since this will remove the positive bias from A6 inverting input. Thyristor THY1 can be triggered into conduction by A5 output going positive as stated above or by an excessive current feedback signal from either forward or reverse current feedback. The current feedback signals via D39 or D40 and R38 are balanced against the normally negative output of A5.

If the signal on R38 exceeds the signal from A5 then THY1 will be triggered into conduction, operating the trip circuit. When the trip is operated L6 is lit and the drive is inhibited. If this occurs when the motor is running it will coast to a stop (except in the case of a motor which is being driven by the load, e.g. paper machine drying section on heavy grade product). No contactors or relays will trip except the zero speed relay when the motor comes to rest.

To clear the trip the drive has be have "STOP" selected and then re-started. Before re-starting some attempt should be made to ascertain the cause of the trip, e.g.

Loss of volts during regeneration.

Loss of current feedback.

Faulty firing circuit.

For a full list of possible faults consult the troubleshooting section of the manual.

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SECTION 6

DESCRIPTION OF CONTROL CIRCUIT

Drg. 1665/A1 Sheets 1 & 2

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6.1 OVERALL SHEMATIC

The three phase supply is connected to a high speed circuit breaker. All the circuits in the drive panel (except the anti-condensation heaters and socket) are supplied from this circuit breaker.

The main power for the armature circuit is fed to the four quadrant thyristor controller, TH1-TH12, via the main contactor MC and a motor protection relay MCOL. One leg of the DC output to the motor is fitted with a high speed fuse to protect the thyristor stack in the event of a motor fault (eg earth fault or commutation failure). The other leg of the DC output has a current transducer to provide current feedback for control and indication purposes. Provision is made for the connection of an external armature voltage voltmeter.

The three phase supply is transformed down to 415V by TX3 to provide a supply for the electronics and down to 110V by TX1 to provide a supply for the control relays.

6.2 Electronic Controls

The electronic controls are contained on two main PCB's, the 1500/A1 and the 669/A1. Detailed descriptions of these cards are given elsewhere in this manual. The 1500/A1 performs the following major functions:-

a) Produces all the low voltage power supplies.

b) Produces the thyristor firing pulses.

c) Provides a ramp interface between the joystick controller and the speed control circuit.

The 669/A1 performes the following major functions:-

a) Speed Control.

b) Current limit control.

c) Selection of forward or reverse thyristor stacks.

d) Zero speed detection.

In addition to the two main cards there are two auxilliary cards. The first (1701/A3) is a switching circuit which will direct the firing pulses to the forward or reverse thyristor stacks according to the selection made by the 669/A1. The other card, the 746/A3 card contains the components for the stability networks for the speed and current amplifiers and the trimming components for the reference and feedback circuits.

One particular feature is the non-linear feedback circuit from the tachogenerator which gives very fine control at low speeds.

Adjustment of the potentiometer on the electronic cards may only be carried out by a qualified thyristor drive expert in liason with Cortina Electric.

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zero speed. In the event of an emergency stop the brake is applied immediately.

RR This is the run relay. It is automatically energised by operation of the joystick.

MCP This is the main contactor pilot relay and is brought in by RR and held in by ZSR until the drive has remained stationary for a short period. This is to allow time for the brake to operate before disabling the drive. It should be noted that if the motor runs for any reason ZSR will pick up, this will energise MCP and the drive will start but attempt to run at zero speed so if, for example, the brake starts to slip ZSR will detect this and the drive will assist the brake in preventing further slip.

INH When the is de-energised it inhibits operation of the thyristor converter.

MC Main line contactor.

TFR This monitors the status of the high speed fuses and it interlocked with the drive fault circuit.

ESR Emergency stop relay.

VF1 This monitors the drive speed to ensure that strong field is not available at high speed.

VF2 This detects when the drive has high current and prevents weak field being selected unless weak field already

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exists.

Both VR1 and VR2 have hysteresis to prevent mal-operation of the control circuit near the operating levels of VR1 and VR2.

JSR1) These detect which joystick is being used and lock out
JSR2) the other.

HSRR This relay allows high speed (weak field) to be selected if the drive current is not too high. See VR2.

HSR This relay selects weak field and high speed reference when high speed is selected and the current is not excessive. Weak field will remain selected even when HSRR is de-energised until the voltage falls below a safe level (detected by VR1) for strong field to be applied.

Undervoltage.

If the system voltage drops to such a low level that regenerative operation of the thyristor converter would be unsafe relay RL1 on the undervoltage detector operates and shuts the drive down immediately.