APPENDIX 4

Rotork Valve Actuator Electrical Specifications

rotork

Catalog section 4
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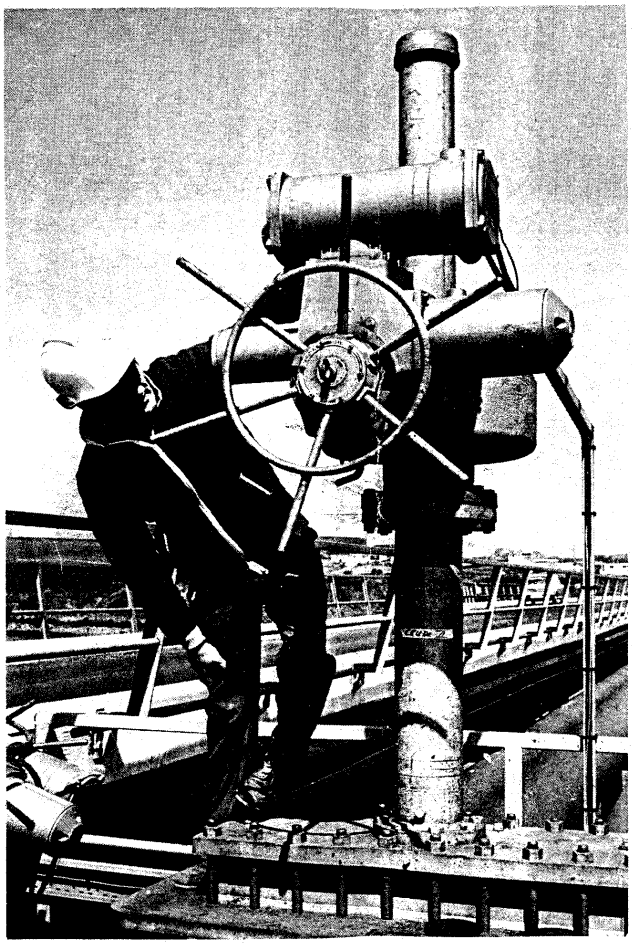
Valve Actuator electrical specifications. Syncropak 1400 series and Syncroset.



Rotork A-Range electric actuators with their O-ring sealed enclosures have established an enviable reputation worldwide for reliable operation of motorized valves. The advantages of the Syncropak design with integral control package have become very apparent — reduced costs of hardware, building, cabling and installation, with simplified engineering, procurement and field start-up.

During recent years the increased use of Syncropak actuators in automatic sequencing, supervisory and computer control systems has given rise to a number of additional requirements, dealt with by special wiring diagrams. As a result of this experience, the specification of Rotork Syncropak is now further advanced by the introduction of the new 1400-series of wiring diagrams which supersede the present 1200-series (1210-40 to 1211-53). 1400-series Syncropak not only covers all the basic control requirements as hitherto but also readily provides for the most sophisticated supervisory and sequencing requirements. Use of these standard diagrams brings all the added advantages of ready availability and assured reliability from established quality control procedures on proven products.

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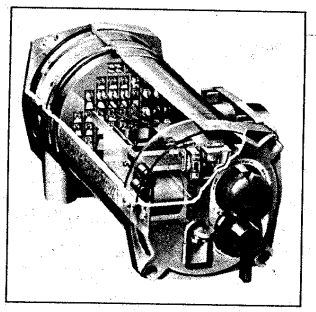
Rotork A Range electric valve actuators for centralized control systems

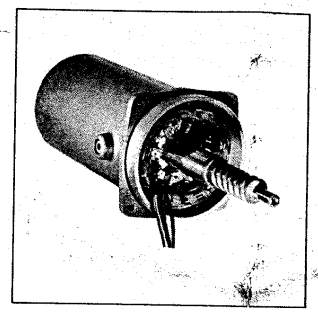
This long established world-proved range of electro-mechanical actuators is described in Publication E1. All units comprise a 3-phase motor, single stage worm gearbox, emergency handwheel with power-preference mechanical interlock, and torque and limit switches for control and indication for all types of valves. Syncroset actuators bring motor and switches to a common terminal compartment for cabling to a reversing contactor starter separately purchased and installed by customer; Syncropak actuators incorporate reversing contactor starter, local controls and optional extra relays. While the specification of Syncroset actuators is unchanged, Syncropak has been further enhanced by the introduction of the 1400-series of wiring diagrams. They utilize exactly the same electrical components proved in service throughout the world, with a pair of auxiliary contactor contacts brought out to the terminals. This seemingly minor change, together with an optional monitoring relay facility, enables the most demanding requirements of supervisory and computer control systems to be met. At the same time, the basic control functions remain with no change to external wiring, so that a 1400-series Syncropak can be substituted for a 1200-series with no problem. Externally, the only change is in the Local/Off/Remote switch, from which the fourth position (Local and Remote) has been omitted, as most users prefer that control should be assigned to one position or the other, but not both.



Syncropak starter
Mechanically and electrically interlocked reversing contactors are of the spring throw-off block type, suitable for operation at any mounting angle. They are mounted on a draw-out chassis, together with the 40va 120V control transformer, Open/Stop/Close, Local and Remote switches and control fuse, for which a spare fuse cartridge is provided. All wiring connection points are number identified, and the wire ends are similarly numbered. Flexible stranded cable connects the components to the back of the terminal block which seals the electrical components from the environment -- see Page 3.

Local controls
The sleeve-jointed O-ring sealed front cover carries a red three-way spring-return push button (press for Stop, turn left for Close, turn right for Open). The black Local/Off/Remote selector is padlockable in each of the three positions, the Off position depressing the Stop button to make electrical disconnection visibly obvious. The two O-ring sealed stainless steel shafts provide an explosionproof and watertight interface between the components within and the environment.

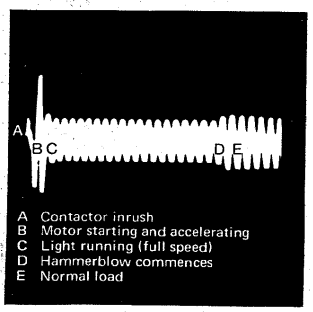
Quality control
Every Rotork actuator is performance tested before despatch. Because no access to the starter is required by the valve maker for testing or by the installation contractor for site wiring, the Syncropak cover is sealed by Rotork Quality Control, and the seal should be intact at start-up.



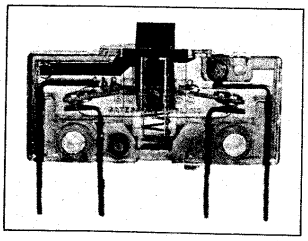
Motor
The built-in three-phase squirrel cage Class B insulated motor with winding thermostat is specially designed for valve actuation, combining low inertia with a high starting and stalling torque. This provides a substantial reserve of power to assure torque switch operation at maximum setting with a voltage drop as much as 10% below the nominal system voltage of 380, 415, or 500 volts 50Hz; 230, 460 or 575 volts 60Hz. Other system voltages catered for at extra cost. The motors are 15-minute rated at an average load corresponding to approximately 33% of rated torque. Because of the low inertia and the lost-motion hammer blow effect, starting is instantaneous within three cycles as shown by the oscillogram.

Motor thermostat
This enables the control circuit to be disconnected if the maximum permitted winding temperature is reached. This protection is independent of ambient temperature variation and motor currents, and provides optimum usage of motor thermal capacity.

Power fuses or circuit breakers
These should be at the supply point, and should be sized to interrupt if locked rotor current persists for 20 seconds maximum.



Power isolation
Because the actuator or motorized valve may have to be removed for valve maintenance, power isolation should be separate from the actuator at a convenient point. Power disconnect switches are not provided by Rotork.



Switches
Standard switches used for the Rotork switch mechanism and Syncropak push-button and selector functions are of the enclosed double break snap action type with wiping contacts as illustrated. Contact ratings on inductive circuits as follows:

Voltage	AC amps	DC amps
460	15	–
230	15	0.25
125	15	0.5
50	15	2
24	15	2

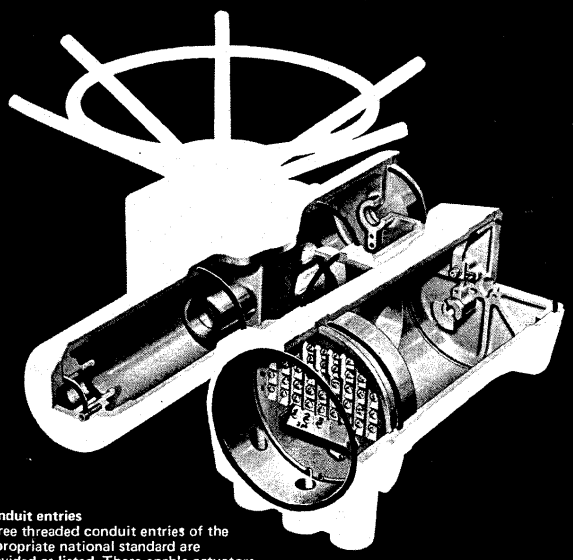
Environmental protection

Motorized valves are normally inactive, and frequently installed in exposed and hazardous locations. The highest degree of electrical specification is of no avail unless the design provides superior environmental protection, particularly during site installation and wiring, when the actuator is most vulnerable. Rotork actuators excel in that, not only are they made fully water and dust-tight by the use of 'O' ring sealed sleeve-joints; the terminal block itself is 'O' ring sealed to maintain a water and dust-tight barrier between the terminal compartment, which must be exposed on site, and the electrical components within. This double sealing provides that vital extra level of quality control to ensure reliable start up, because electrical components remain sealed during site wiring.

Note that Explosionproof and Flameproof actuators are also O-ring sealed watertight, and do not rely on the metal-to-metal explosionproof joints for prevention of moisture ingress, so breathing is eliminated.

Terminals
The purpose-designed terminal block of high tracking resistance dough moulding compound provides stud terminals angled for convenient wiring, segregated by generous "staircase" tracking paths and flash barriers. Stainless steel power terminals are shrouded from the remainder, while an internal stud terminal and an external drilled lug are provided for ground connections.

Terminal identification is by moulded numbers on the terminal block, and also by the printed Code Card inside the terminal cover. Internal wiring is number identified in line with the terminal block.



Conduit entries
Three threaded conduit entries of the appropriate national standard are provided as listed. These enable actuators to be despatched to any country with the appropriate thread standard; thread reducers and cable glands are normally provided by the customer or cabling contractor and not by Rotork. Conduit entries are protected by temporary bungs, and unused conduit entries should be stopped with metal plugs. Standard conduit entry threads available are coded as follows:

A: Two 1¼" and One 1½" ASA
P : Two PG 21 and One PG 29
E: Two 1¼" and One 1½" ET
M: Two 32mm and One 40mm (British metric)

Hazardous locations

Rotork Syncropak actuators are approved for use in Division 1 locations with certification by the appropriate National Testing Authorities. Because there are minor constructional variations required to meet particular National codes, which also affect cost, the National requirement must be specified with enquiries and orders.

The commonest requirements are covered by Rotork standard enclosures as follows:

Syncropak and Syncroset

EP Explosionproof Class 1 Groups A, B, C and D Division 1. This is based on USA codes of practice:

EPC As above with Canadian Standards Authority approval.

FLP Flameproof to BS 229 for Groups II and III gases based on British codes of practice and certification.

ADF Explosionproof Group III Class A to JO 1228 with LCIE approval in accordance with French codes of practice.

SEN Explosionproof Xt2 T4 to SEN 2108 with certification by Statensprovningsanstalt in line with codes of practice acceptable in Scandinavia and most East European countries.

Syncroset only (with 30 terminals maximum)

NB: All the above also suitable for Division 2 locations, which are less hazardous than Division 1.

Non-hazardous locations

Syncropak and Syncroset

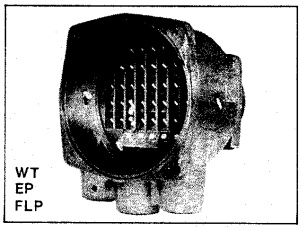
WT Watertight, dust tight and hoseproof, capable of electrical operation during 48 hours submersion in water or oil up to 3m (10ft) head, providing conduit entries sealed by customer by suitable waterproof compound. Comply with following specifications:

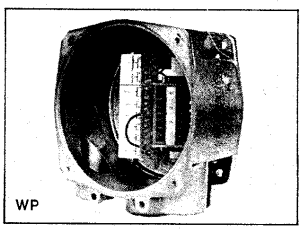
UK: BS2817
USA : NEMA 3, 4 and 6
Europe: IP 54 & 67
to IEC 144 & 34.5

WTC
As above, with CSA approved wiring, complying with CSA 1V.

Syncroset Only:

WP Weatherproof to BS2817, NEMA 3, IP 54 to IEC 144 and 34.5
NB: Terminal compartment not separate.

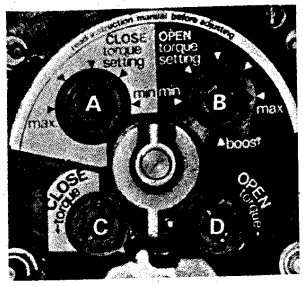




Torque and limit switches

Rotork's unique torque and limit switch mechanism meets all the varying requirements of different valve types and sizes using a common switch mechanism and a single wiring diagram. The mechanism incorporates a pack of three switches for each end of travel. Two of the three are end position auxiliary limit switches for remote indication and interlock only; they are not required for the control circuit. The third switch at the front of each set functions primarily as a torque switch, to disconnect the appropriate contactor at the preset torque limit. The torque settings are independently adjustable by cams A and B. The same switch can also be tripped when the valve has reached its end position, irrespective of the torque value. Whether it acts in this way as a position limit switch or not is simply chosen by the customer by moving selector cams C/D to Close/Open on torque or limit. Cam D is normally set to open on limit, unless the valve is specifically designed for power back-seating.

Closing direction
All illustrations and diagrams are shown for clockwise closing actuators. For anticlock closing, actuators must be specially ordered, when all Open/Close functions and labels are reversed.

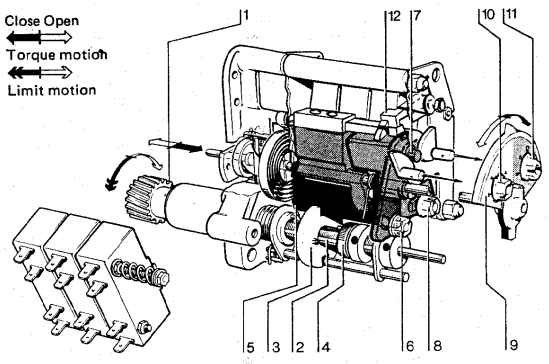


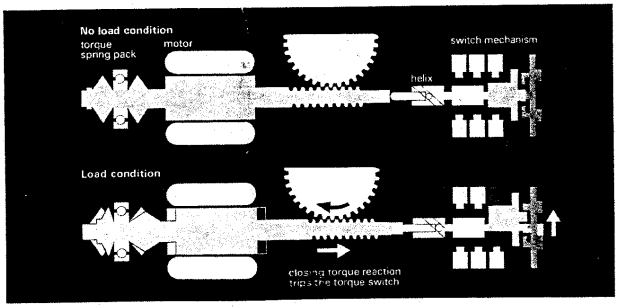
Limit switch action

A pinion 1 is driven by a worm on the output shaft, after lost motion 'hammer blow' has been taken up. Lead Screw 2, driven from pinion 1 via an overload clutch, causes Traveller 3 to move axially until forced to rotate clockwise by the adjustable Open Stop Nut 4 or anti-clockwise by the fixed close stop at the inner end. This rotation trips the two open or close Auxiliary Limit Switches via striker plate 5. If the close torque limit selector 6 is turned inwards to "limit" striker 5 will also trip the close Torque Limit Switch via striker 7 to stop the valve on position limit after the auxiliary switches have tripped. This slight differential is important, ensuring remote position signalling before the valve stops (see Page 6). Auxiliary switches should therefore not be used as end position limits. If turned out to "torque", only the auxiliary switches are tripped, so the valve runs until it torque-seats. Note when "limit" is selected the actuator can still trip out on torque if an overload occurs during travel, but the Auxiliary Limit Switches will not be tripped, so that indication remains correct. Open Torque/Limit selector 8 operates similarly. The limit switch stroke is easily set by adjusting the distance between the fixed close stop and the adjustable Stop Nut 4 when the actuator is mounted on the valve.

Torque limit action
Output torque reaction results in axial movement of the wormshaft against preloaded disc spring packs at the outer end of the motor. This linear motion is converted to rotary by a helix, turning Front Plate 9. Torque Adjusters 10 and 11 enable the switch tripping points to be independently preset for close and open torque. Open torque limit can be removed if required by setting open adjuster to 'Boost'. Torque Striker 7 only trips the front two Torque/Limit Switches.

Torque switch latch
An important feature is Latch 12, which eliminates the need for electrical interlocking as customary on earlier designs, for which up to six switches may be needed in the control circuit as shown in Figure 1. Here the torque and limit switches are separate; open travel is terminated by the open limit switch, with the open torque switch in series for back up protection. In the closing direction torque seated valves like wedgegate and globe can only have a close torque switch in circuit. Valves requiring position limit control have a close limit switch in series with the close torque switch, the latter serving for protection only. The wiring diagram, therefore, has to change for different valve types. When opening a valve against differential pressure, the highest torque is at the moment of unseating, which may





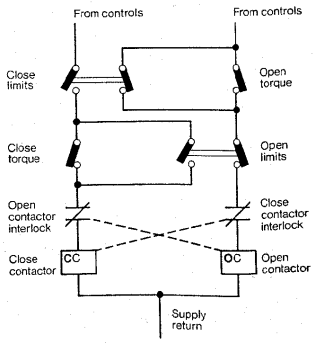


Figure 1
Conventional six-switch circuit with electrical selection and interlock.

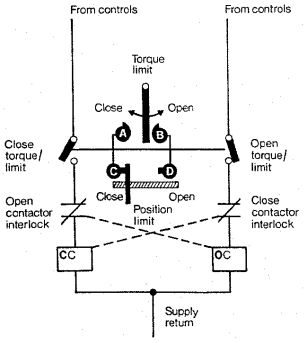
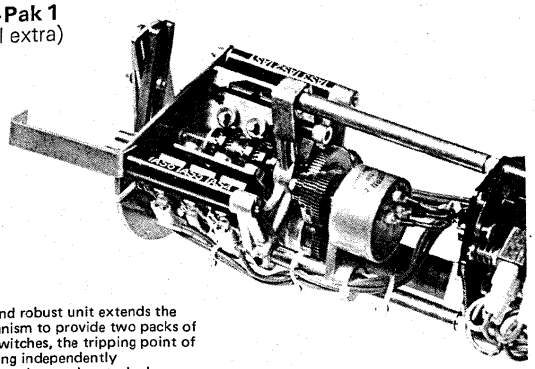
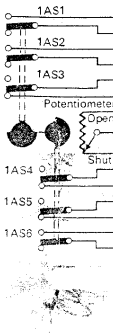


Figure 2
Rotork two-switch circuit with mechanical selection and interlock.

Add-on-Pak 1
(Optional extra)



This simple and robust unit extends the switch mechanism to provide two packs of three micro-switches, the tripping point of each pack being independently adjustable throughout valve stroke by means of two cams. These are driven from the limit switch shaft through a simple cluster of spur gears adjustable to cover the full range of valve requirements. The gear train is also utilized to drive a sealed 3-watt potentiometer for continuous remote position transmission, and an anti-backlash spring is incorporated to minimise hysteresis.



O Open
C Close
T/LS Torque/Limit switches
AS1 Auxiliary limit switches make contact at end of travel*
AS2 Auxiliary limit switches break contact at end of travel*
* Contact functions reversible by reconnection at switch
IAS Intermediate 1 to 6 auxiliary switches
Contact functions may be reversed by setting cam to release instead of depress switch as illustrated.

As neither switches nor potentiometer are involved in the actuator control circuit, they are not shown in the ensuing schematic diagrams, but are complementary to all of them as indicated in the Diagram Index, page 12. Switch contact ratings (inductive):

AC: 15A up to 480v
DC: 0.25A 250v; 0.5A 125v

Torque and Limit Switch operation

Switch	Open	Intermediate	Shut
OT/LS		■	■
CT/LS	■	■	
OAS1	■		
CAS1			■
OAS2		■	■
CAS2	■	■	

Add-on-Pak 1 Switch operation

Switch	Open	Intermediate	Shut
1AS1	■	■	
1AS2	■	■	
1AS3		■	■
1AS4		■	■
1AS5		■	■
1AS6	■	■	

Tripping point of IAS 1, 2 & 3 adjustable to any valve position (drawn as for Extra Open Auxiliaries).

Tripping point of IAS 4, 5 & 6 adjustable to any valve position (drawn as for Extra Close Auxiliaries).

trip the open torque switch, which then interferes with operation. It is therefore necessary to inhibit the open torque switch at this point, and a close auxiliary limit switch with a 'make' contact must be paralleled with the open torque switch, so that it is bypassed until the valve has moved enough to reset the limit switches. Similarly the close torque switch can be bypassed by an open auxiliary limit switch.

The Rotork Latch obviates the need for bypass switches. As striker 5 moves to trip the auxiliary switches, it releases Latch 12. When Striker 7 moves to trip the front Torque/Limit Switch, it latches with the switch tripped until the valve is moved in the reverse direction to reset Striker 5. The latch thus prevents unwanted tripping on torque during unseating, and also provides an additional important safeguard. At higher speeds the wormgear will be non-self locking; this permits resetting of the torque switch by the spring pack after the motor has stopped. A sustained closing signal would then cause the motor to restart and trip out again on torque, with a repetitive hammering action. The latch also prevents this occurrence at the end of travel.

Thus two switches only with mechanical selection of torque or limit control and mechanical latching, replace the five or six switches of Figure 1, to produce the standard Rotork arrangement of Figure 2. This results in increased reliability through simplicity, and no need to change circuit diagrams or field wiring for different types of valve.

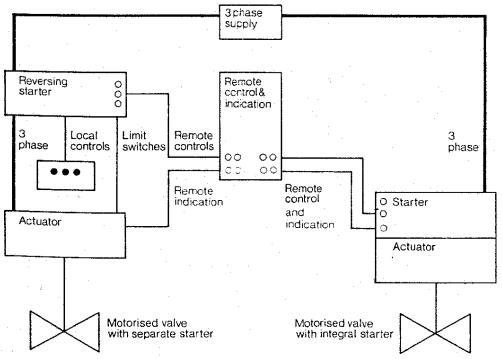
Reversing contactor starter

Syncropak electrical system
Any motorized valve requires a starter to switch the three-phase motor in response to control signals. Rotork Syncropak actuators incorporate the starter and local controls, with considerable economy in site wiring as shown. This arrangement also enables the essential elements of the valve control system to be factory-wired and tested, and sealed by Rotork Quality Control. They can be proved on local control by valve maker and site contractor using only a three-phase supply, with undivided contractual responsibility for reliable operation. Note that operation is so intermittent that contact wear and tear is insignificant and no electrical routine maintenance is required because of the superior environmental protection (Page 3).

Syncroset electrical system
Syncroset actuators incorporate motor, limit and torque switch mechanism, heater and terminal box only. The reversing starter is separately specified, purchased, installed and wired by customer.

The valve control system is therefore incomplete until wired in the field; the installed reliability of the motorized valve is thus dependent on the correctness and quality of the wiring installation.

Local control
With Syncroset actuators, local control pushbuttons should be separately installed at the most convenient operating point for each group of valves. The pushbuttons are part of the starter circuit and do not require wiring to the actuators. However, integral local controls are available as an optional extra. See Diagram Index page 12.



Comparison of electric actuator installation with and without integral starter.

Syncropak control circuit

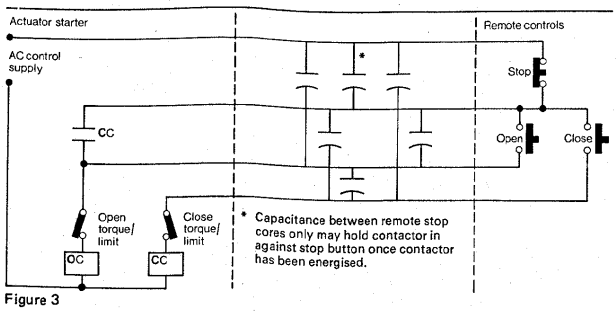


Figure 3

The integral controls are designed to provide Valve Maker, Installation Contractor and Plant User with all the facilities they need for initial testing, installation, operation and maintenance. To achieve all these, the contactor coil supply must be derived from the 3-phase power, so that no other power source is required for initial testing of the motorized valve and for subsequent operation on local control. A tapped transformer provides 100 - 120 volts for control, one side of the secondary being fused, the other connected to the two contactor coils, and also via a terminal link to frame. This ensures that on a ground fault the contactors drop out. The interlocked coils are connected to their respective torque/limit switches which provide primary protection and control of the valve. Back up protection is by motor thermostat. A Local/Off/Remote selector switch, padlockable in the three positions, assigns control positively to the Syncropak Open/Stop/Close pushbutton or to the remote station, or renders the unit electrically inoperable. The schematic diagram is shown on page 7.
Local control is maintained by contactor auxiliary contacts OC2 and CC2; momentary initiation causes full travel unless the stop button is depressed.

Phase Discriminator (Optional Extra)
This relay disconnects the contactors to prevent starting on single phase or incorrect phase rotation, which renders torque and limit switches useless and can therefore cause valve damage.

Interlock Links
Removing Link 34-40 prevents electrical operation in either direction; removing 37-43 prevents closing, and 38-44 opening. Remote interlocking is therefore conveniently accomplished using the appropriate switching (See page 10).

AC remote control
The transformer may also feed remote controls via terminal 39 with the selector switch set to Remote. Contactor auxiliary contacts OC2 and CC2 are available at terminal 36 to provide maintained control, with a stop button connected between 39 and 36 as shown in schematic Form A. Without the stop button, two push buttons can be back connected as shown in schematic Form B to give open/close maintained control with the ability to reverse in mid travel, for which a link 39 - 26 must be added by customer. Alternatively, non-maintained push-to-run (incremental) control is obtained as indicated in schematic Form C.
A second pair of contactor auxiliary contacts OC3 and CC3 is brought to terminals for running indication (See page 8).

Local and Remote Control
If a Syncropak actuator is to operate with both Local and Remote Open-Stop-Close controls available at the same time, connect the remote Stop in place of Link 34–40, remote Open to 34–38 and Close to 34–37. Set Local/Remote Switch to Local, and both sets of controls will be operable.

Distance (Figure 3)
The principal distance limitation is for the remote stop button, because cable capacitance on AC in excess of 0.25 mfd may cause the contactor coil to hold in. Cable capacitance should be checked if distances in excess of about 600m or yards are involved, or if there is more than one live AC feed in the multi-core cable.

Remote indication - isolating valves
Two lamps fed from end position auxiliary limit switches give the remote operator all the essential information for isolating valves, and are normally connected as shown in Schematic Diagrams Form A. CAS2 disconnects the Open and OAS2 the Close lamp, both lamps being on during travel. An alternative connection with both lamps out during travel is shown on Schematic Form B on page 7. The switches trip just before the end of travel, and reset just after movement has started from either end. The slight position differential enables the operator to sense the following:

1. Steady state condition: one lamp only lit.
2. Response to control signal: shortly after initiating movement, the second lamp lights. It will not do so unless the relays and contactors have functioned properly, the motor has started, the actuator drive is satisfactory and sufficient movement has resulted to reset the auxiliary limit switches.
3. Intermediate: two lamps remain lit until the valve reaches the other end of travel.
4. Return to steady state: on reaching the end of travel only one lamp will be on.
5. Lamp failure: indicated by no light in the steady state condition, or failure of second lamp to light soon after initiating movement.

There may also be indication of flow, pressure, temperature, etc. influenced by the valve in question, so the operator may have more information than is given by the indicating lamps alone. For 120v AC the lamp supply may be derived from the Syncropak control transformer up to a maximum load of 20VA via terminals 4 and 5.

Remote indication - regulating valves (Figure 4)
While the best indication is of the flow regulated, continuous remote indication of the valve position is also useful, because it enables the valve to be pre-set to a position known by experience to give the results required. Add-on-Pak 1 (optional extra), incorporates a three watt potentiometer of resistance 1K for 50v maximum, 5K for 125v, or 20K for 250v maximum, and this is always brought out to terminals 14, 23 and 32. Our recommended connection to the customer's remote voltmeter-type indicator is as shown below. For 120v AC the indicator supply may be derived from the Syncropak transformer by linking 14 to 5 and 32 to 4.

Because the potentiometer has to be gear-driven from a variable number of valve turns, scale adjustment must be possible to allow for steps of gearing, as well as voltage drops. The scale adjustment should allow for anything between 75% and 100% of full travel of the potentiometer to correspond with 100% valve travel. It is therefore important that full scale deflection of a voltmeter should not be 100% of supply voltage but 75% of it, the trimming resistor catering for the remainder. The trimmer should be located adjacent to the indicator for ease of scale setting; it is not provided as part of the actuator.

Stabilised current indication
When a standardized signal range, e.g. 4-20 mA is required, an electronic position monitor unit is needed for each indicator. This measures the potentiometer resistance and converts it into a current signal. This facility is provided by the Rotork Millipot stabilised current transmitter. See publication number AE4/0.2.

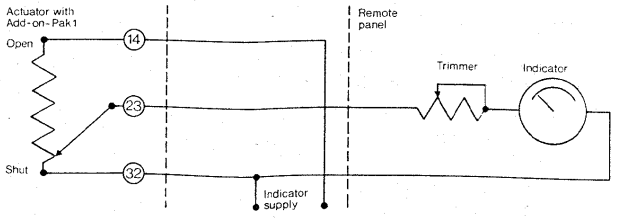
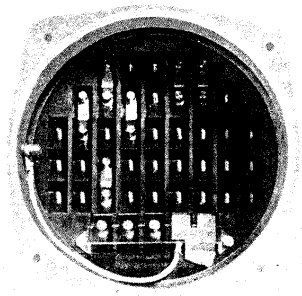
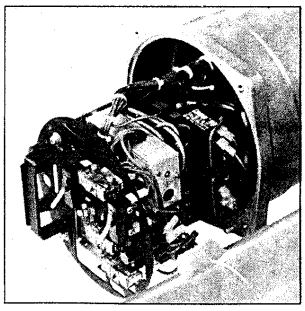


Figure 4

Terminal links

All the remote control and indication functions shown under each of the schematic diagrams can be achieved using the standard actuator by interconnection of terminals by links as shown. All actuators are despatched with links arranged in form A, so that the electrician responsible for wiring starts from the same point every time. While several variations may be required on the same contract, experience has proved that attempting to despatch actuators with particular linking arrangements for particular valves can lead to difficulties in identification, because the actuators are externally identical, and so may be the valves on which different terminal arrangements are required. It is therefore much more practical to have exactly the same terminal linking to start with on all actuators, and standard prices cover this arrangement only.



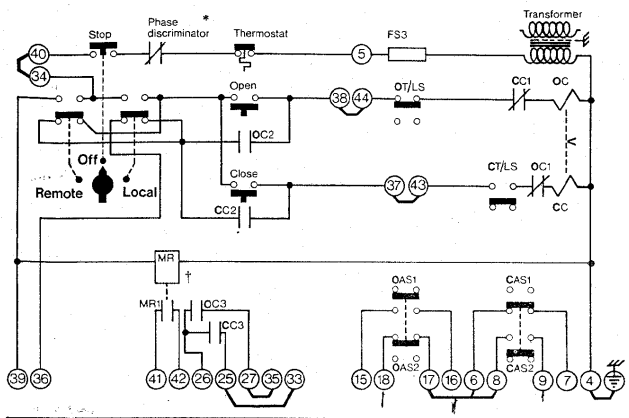


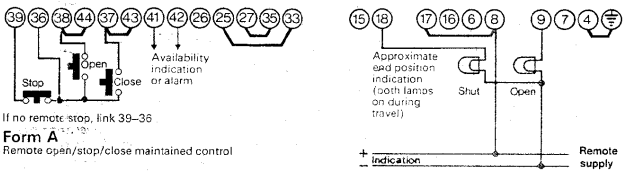
Syncropak starter withdrawn for access, (including optional Phase discriminator).

Schematic diagram for AC control

(Circuit is drawn for valve shut)

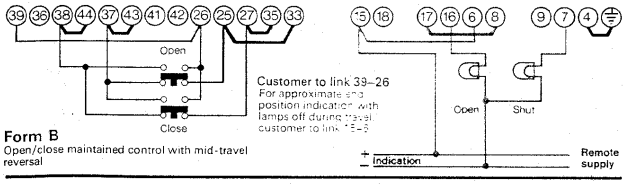
Applicable to Wiring Diagrams:	Without AOP1	With AOP1
Syncropak AC remote control	1410–40	1411–40
Syncropak AC remote control with Phase discriminator*	1410–50*	1411–50*
Syncropak with AC monitor relay†	1410–41†	1411–41†
Syncropak with AC monitor relay† and Phase discriminator*	1410–51†*	1411–51†*



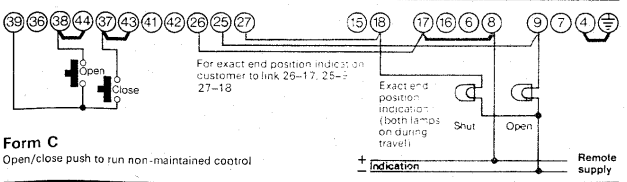


If no remote stop, link 39–36

Form A
Remote open/stop/close maintained control



Form B
Open/close maintained control with mid-travel reversal



Form C
Open/close push to run non-maintained control

* Phase discriminator diagrams 1410–50, 1411–50, 1410–51 and 1411–51.

† Monitor relay diagrams 1410–41, 1411–41, 1410–51 and 1411–51 only.

O Open
C Close
C Contactors
C1 Contactor interlocks
C2 Local maintaining contacts
C3 Remote auxiliary contacts
T/LS Torque/Limit switches
AS1 Auxiliary limit switches *make contact at end of travel***
AS2 Auxiliary limit switches *break contact at end of travel***
** Contact functions reversible by reconnection at switch
Links supplied by Rotork

Monitoring and alarm circuits for supervisory and computer control

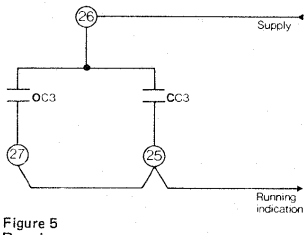


Figure 5
Running

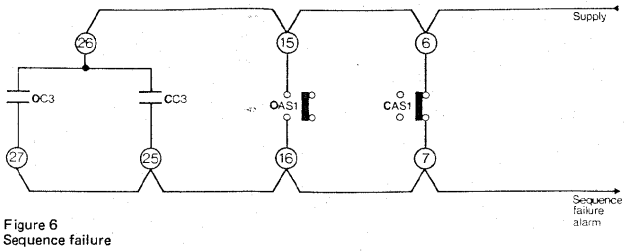


Figure 6
Sequence failure

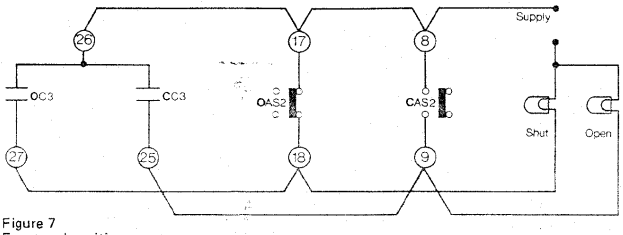


Figure 7
Exact end position

The 1400-series of wiring diagrams enables the most demanding requirements of more sophisticated control systems to be met at standard prices and deliveries without special ordering and with all the quality control benefits which accrue from the use of jig-built and tested standard wiring looms. They provide the following special features:

1. Running indication (contactor response Figure 5). Because auxiliary contacts OC3 and CC3 are available at the terminals, they can be connected in parallel to give a simple running indication. More usefully, however, they can be used in conjunction with auxiliary limit switches as indicated below.

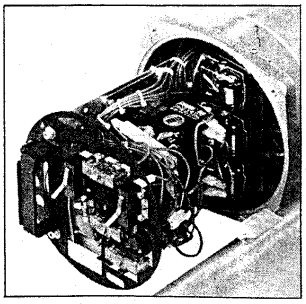
2. Sequence failure alarm (valve stopped in mid-travel Figure 6). With automatic sequencing it is important to know if the valve has failed to complete its travel. This may be due to loss of three phase supply, loss of control supply, unauthorized local stop or, very rarely, valve obstruction causing torque switch trip in mid-travel. Connecting OC3 and CC3 in parallel with auxiliary limit switches OAS 1 and CAS 1 as shown in Schematics Form B on Pages 7 and 9 enables this failure to be detected. An alarm relay normally energised through these contacts will only be de-energised in the event of contactor trip at an intermediate position.

3. Exact end position indication (Figure 7). When non-maintained push-to-run or incremental control is used, and particularly when derived from a computer, the normal end position indication from an auxiliary limit switch is inadequate. Because it must trip before the valve seats, it will cause premature disconnection of the control signal. Connecting OC3 in parallel with OAS 2 and CC3 in parallel with CAS 2 gives the required result, as shown in Schematic diagrams Form C. With the valve open, for instance, the Open lamp will be lit by CAS 2. Pressing the Close button will close CC3 which will not affect the indication. Actuator movement will be indicated when OAS 2 resets to light the close lamp. Both lamps will be on during travel, and the Open lamp will not go out until CAS2 has been tripped, and CC3 also drops out. This signifies the disconnection of the contactor by its travel limit or torque switch, and indicates the exact moment at which the control signal should be removed. This circuit can therefore also be connected directly or via a relay into the customer's remote control system.

4. Monitor relay (Optional extra). Loss of local three phase or control supply, motor thermostat trip, local stop button locked off, or local/remote switch set to local, all make the actuator non-available for remote control. It is unfortunate if this is only discovered at the time valve operation is required, and many supervisory systems need an alarm to draw attention to this condition. Diagrams 1410-41 (51) and 1411-41 (51) for AC control, and 1410-45 (55) and 1411-45 (55) for DC control, provide this in the form of an AC monitor relay connected across the contactor supply from the remote side of the selector switch. The power and control supplies must be healthy, thermostat not tripped, stop button not depressed, Local/Remote switch set to remote, (and phase rotation correct if Phase discriminator fitted) for the circuit to be live to this point, otherwise the relay will drop out, disconnecting a relay in the customer's control system to give an alarm. The relay contact can also be connected to a lamp to give availability indication.

NB: These features can be obtained with Syncroset actuators if the separate control gear is specified to incorporate the same facilities as Rotork Syncropak 1400-series.

Combined facilities.
Note that requirements for several facilities in combination can be met by customer repeating OC3, CC3 and auxiliary limit switches by relay or logic systems as necessary.



Syncropak starter with AC monitor relay and two DC interposing relays.

DC remote control
(Optional extra)

When the distance between actuator and remote station is great, there are considerable advantages in using a low voltage DC power source at the remote control point to feed interposing relays in the integral starter:

1. Problems due to cable capacitance are eliminated by using DC.
2. The relay coil burden is much lower than the contactor coil, which reduces the size of cable required.
3. Dropping the voltage to 50 or below reduces the cable cost further. (Telephone type can be used).
4. The actuator becomes directly compatible with low voltage instrumentation systems.
5. The field cabling is simplified, as only three phase power and light current low voltage DC are involved, the contactor supply voltage wiring being internal to the actuator only.

While it would be feasible to derive a rectified supply from the control transformer for remote control, this is not recommended. When remote control is fed from the actuator, any short circuit or ground fault in wiring or junction boxes may cause spurious valve operation, whereas the same fault fed from remote control end will simply blow a fuse.

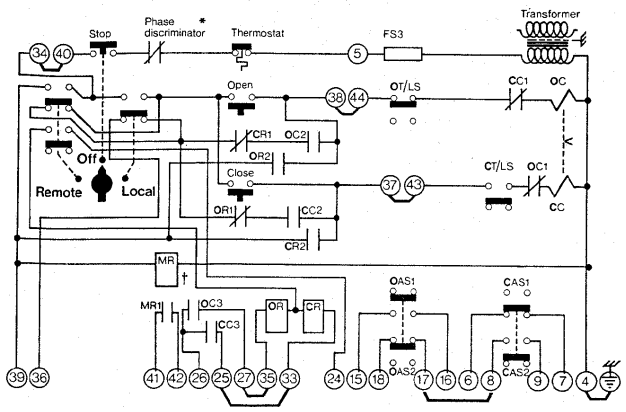
Operational security is therefore enhanced. In addition, the remote control supply will logically be used for remote indication, the loading requirements of which will vary considerably in different applications. It is therefore more satisfactory for a single cable fed only from the remote end to be utilized for control and indication. Rotork's standard relay voltages are 24, 48 and 110, with a maximum coil burden of 2 watts. Diagrams 1410-42 (52) and 1411-42 (52) incorporate the two DC relays, while 1410-45 (55) and 1411-45 (55) also provide the AC monitor relay (Schematic diagrams, pages 9 and 10). Standard linking to Form A provides remote Open-Stop-Close maintained control. There is no requirement for a third Stop relay because contactor auxiliary contacts OC3 and CC3 can be used to maintain the DC supply across the remote Open and Close pushbuttons. The remote stop contact is therefore normally closed (whereas a normally open contact was required when a separate stop relay was used in 1200 series diagrams).

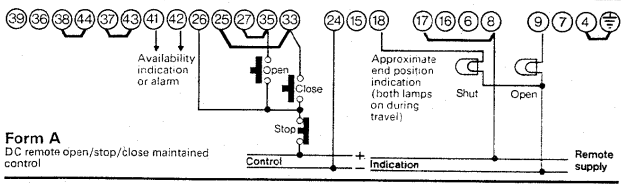
Schematic Form B shows how Open/Close maintained control with mid-travel reversal capability is achieved. This uses contactor auxiliary contacts OC2 and CC2 to maintain the AC feed to the contactors across relay contacts OR1 and CR1, while normally-closed relay contacts OR2 and CR2 will break the maintaining circuit if the other relay is energized. So the actuator will always respond to the last signal given; erroneous instruction can be cancelled without waiting for the valves to reach the end of travel.

For remote push-to-run non-maintained control, the re-arranged connections and links are shown in Schematic Form C, OC3 and CC3 being omitted from the control circuit.

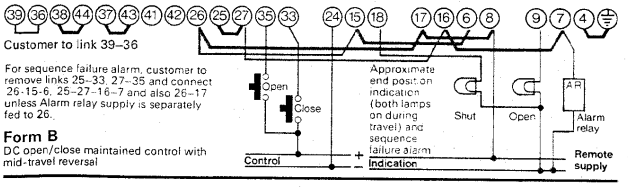
Schematic diagram for DC remote control
(Circuit is drawn for valve shut)

Applicable to Wiring Diagrams:	Without AOP1	With AOP1
Syncropak with two DC relays	1410–42	1411–42
Syncropak with two DC relays and Phase discriminator*	1410–52*	1411–52*
Syncropak with two DC relays and AC monitor relay†	1410–45†	1411–45†
Syncropak with two DC relays, AC monitor relay† and Phase discriminator*	1410–55†*	1411–55†*

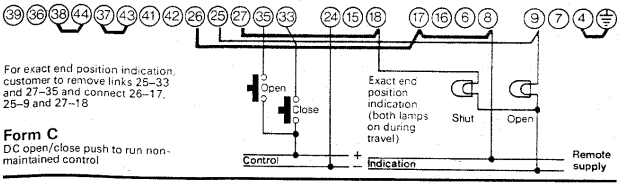




Form A
DC remote open/stop/close maintained control



Form B
DC open/close maintained control with mid-travel reversal



Form C
DC open/close push to run non-maintained control

* Phase discriminator diagrams 1410–55, 1411–55, 1410–52 and 1411–52.

† Monitor relay diagrams 1410–45, 1411–45, 1410–55 and 1411–55 only. Contact MR2 also insures that local control is always maintained. Otherwise, sustained remote DC signal causing OR1 or CR1 to open makes local control push-to-run in opposite direction.

O	Open	AS1	Auxiliary limit switches *make contact at end of travel* **
C	Close	AS2	Auxiliary limit switches *break contact at end of travel* **
C	Contactors	**	Contact functions reversible by reconnection at switch
C1	Contactor interlocks		Links supplied by Rotork
C2	Local maintaining contacts		
C3	Remote auxiliary contacts		
T/LS	Torque/Limit switches		
R	Relays		
R1	Relay contacts		

Automatic and sequence control systems

Sequence interlocking
Safety considerations often require that the valve operation should follow a particular sequence in relation to other valves, pumps, etc. Electrical interlocking can be used to prevent starting of a pump or valve motor unless valve positions are correct, and the auxiliary limit switches of Rotork actuators are used for this purpose. For hand operated valves, the Rotork VPSU (see separate publication) enables auxiliary limit switches to be added to hand operated valves.

Syncropak actuators incorporate links in the control circuit for the connection of external interlocks (Page 6). A typical preventive interlock between two Syncropak actuators for main and bypass steam valves is shown in figure 8. Main valve Open contactor cannot be energized unless bypass valve is open; bypass valve Close contactor cannot be energized unless main valve in shut.

Automatic sequence control
Besides preventing valve operation out of sequence, actuators may be required to initiate other operations in sequence. Auxiliary Limit switches alone do not suffice, because the same signal is given from an open auxiliary switch, for example, when the valve is reaching the fully open position from shut, is stationary fully open, or is beginning its closing movement. For satisfactory sequence initiation it is usually necessary to combine indication of valve movement and direction with valve position. One method is to use a contactor auxiliary contact in series with an auxiliary limit switch as in figure 9. Connecting OC3 in series with OAS1 will only give a signal between terminals 26 and 16 for the brief period between OAS1 making and the valve tripping out on open limit, while similarly a signal is only derived between terminals 26 and 7 between the making of CAS1 and the breaking of CC3 when the valve trips out on close limit or torque.

A momentary signal is therefore given only when the valve reaches the end of travel.

Exactly the same effect can be achieved by combining a signal derived from the initiating relay or computer and the appropriate auxiliary limit switch as indicated in Table 2 Page 11.

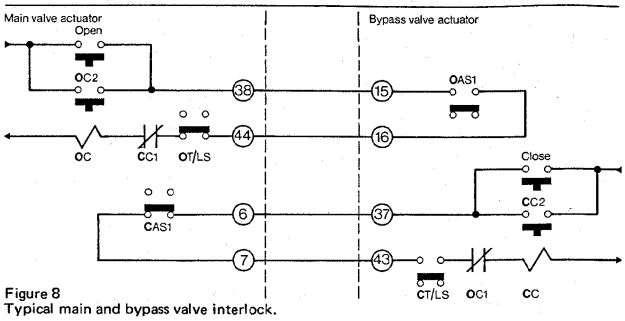


Figure 8
Typical main and bypass valve interlock.

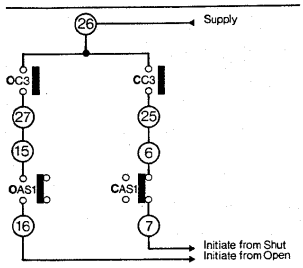


Figure 9
Momentary contact for sequence initiation.

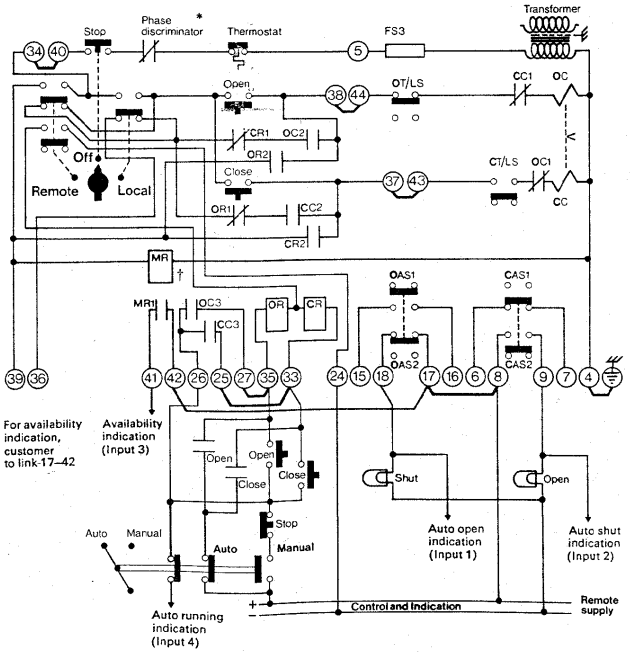
Automatic incremental control with Remote manual standby
Schematic Form D of diagram 1410-42 (52) shows how a typical computer control system can be superimposed on a remote manual control system, using a remote Manual/Auto Switch with the appropriate connections. Contactor contacts OC3 and CC3 which provide the maintaining circuit for the remote manual control also provide the contactor response feedback to the automatic system. This information, in conjunction with the normal end position indication, plus availability Monitor Relay if required, enables the total functioning of the valve control system to be monitored, and the computer output to be disconnected only when the valve is properly seated or on fault, as set out in the Truth Tables for Logic Systems on Page 11. In all cases the reference to "computer" is to any form of programmed hardware, be it relay, solid state logic or digital computer. With the latter, it is obvious that the standard 1400-series diagrams provide not only for the highest degree of operational supervision, but also the facility to print out the appropriate trouble shooting instructions immediately a fault occurs.

Schematic Form D

Applicable to Wiring Diagrams:
1410–42 1411–42 1410–52* 1411–52*
1410–45† 1411–45† 1410–55†* 1411–55†*

Schematic Form D

Typical Remote DC manual open/stop/close maintained control and auto open/close push-to-run control with remote auto/manual switch.
Auto indication inputs refer to Logic truth tables, page 11.



* Phase discriminator diagrams 1410–52, 1411–52, 1410–55, 1411–55 only.
† Monitor relay diagrams 1410–45, 1410–55, 1411–45 and 1411–55 only.

Truth tables for supervisory control by computer.

(Using any form of programmable hardware).

Table 1

Two or three inputs to computer per valve

Time is typical percentage of full stroke time.

Input 1: Open Auxiliary Limit Switch to break contact when valve open, in parallel with Normally Open Auxiliary Contact of Open Contactor, giving 0=Exact Open, 1=Not Fully Open.
Input 2: Close Auxiliary Limit Switch to break contact when valve shut, in parallel with Normally Open Auxiliary Contact of Close Contactor, giving 0=Exact Shut, 1=Not Fully Shut.
Input 3: Monitor relay Normally Open Contact gives 0 unless local three phase supply, control fuses and transformer healthy, local stop not depressed, local/remote selector set to Remote, motor thermostat not tripped.

Computer Output	Input 1 (Open)	Input 2 (Shut)	Input 3 (Available)	Time (Approx)	Indication	Condition	Action Required (Alarm trip, computer off)
Off	1	0	1	0	Valve shut	Shut, stopped Available	Alarm B if Input 3 becomes 0 Alarm A if Input 2 becomes 1
Open	1	0	1	5%	Valve shut	Unseating, Available	If Input 2 remains 0, Alarm C
Open	1	0	0	60 seconds	Valve shut	Valve stuck	Alarm D
Open	1	1	1	5–100%	Mid travel	Unseated Available	If Input 1 remains 1 for more than 100% time, Alarm E
Off*	1	1	1	Any	Mid travel	Stop	In Input 1 changes to 0, Alarm F.
Open	0	1	1	100%	Exact Open	Stopped	Computer Off
Off	0	1	1	0	Valve Open	Open, Stopped	Alarm B if Input 3 becomes 0 Alarm A if Input 1 becomes 1

*For stop in mid travel only

Closing sequence is similar with Inputs 1 and 2 reversed.

Table 2

Computer with four inputs per valve

Time is typical percentage of full stroke time, or typical response time.

Input 1: Open Auxiliary Limit Switch, 0=Open
Input 2: Close Auxiliary Limit Switch, 0=Shut.
Input 3: Monitor Relay, 0=Not available electrically.
Input 4: Auxiliary Contacts of both contactors in parallel, 1=Running.

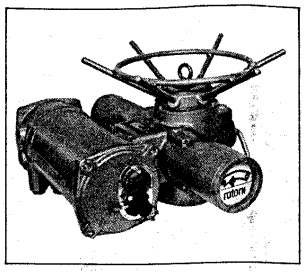
Computer Output	Input 1 (Open)	Input 2 (Shut)	Input 3 (Avlble)	Input 4 (Running)	Time (Approx)	Indication	Condition	Action Required (Alarms trip, computer off)
Off	1	0	1	0	0	Shut	Available	Alarm A if Input 2 changes to 1. Alarm G if Input 4 becomes 1. Alarm B if Input 3 changes to 0
Open	1	0	1	1	30ms	Shut	Started	Alarm H if Input 4 stays 0
Open	1	0	1	1	5%	Shut	Running	If Input 2 remains 0 too long, Alarm J. If Input 4 reverts to 0, Alarm K. If Input 3 and 4 revert to 0, Alarm L
Open	1	1	1	1	5–95%	Mid travel	Unseated Running	If Input 4 reverts to 0, Alarm E
Off*	1	1	1	0	Any	Mid travel	Stop	If Input 4 remains 1, Alarm F
Open	0	1	1	1	95%	Open	Almost Open	Next Sequence Start if required
Open	0	1	1	0	100%	Open	Open Stopped	Computer Off. If Input 4 stays 1 for over 100% time, Alarm M
Off	0	1	1	0	0	Open	Stopped Available	Alarm A if Input 1 changes to 1. Alarm G if Input 4 becomes 1. Alarm B if Input 3 changes to 0

Alarms:

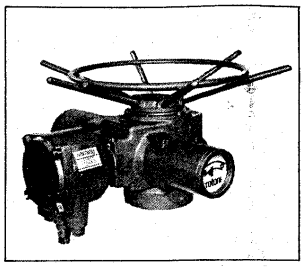
A. Valve manually operated locally.
B. Actuator not available through loss of local control supply.
C. Valve did not unseat, local or remote electrical fault, or actuator locked in handwheel drive.
D. As B but occurrence about one minute from start indicates motor thermostat trip through stuck valve as most likely cause.
E. Valve stopped in mid travel. Probably torque trip.
F. Valve fails to stop. Could be local or remote electrical fault.
G. Valve electrically operated locally.
H. Electrical fault, try Remote Manual, then Local Manual, then Local Supply.
J. Valve stuck, or locked in hand drive.
K. Valve stuck and tripped on torque.
L. Valve stuck, with motor thermostat trip or local supply failure.
M. Limit or Torque Switch failed to trip, or Contactor stuck.

Electrical specification

Syncropak
Rotork Syncropak means a self contained package-unit actuator for intermittent electric motor operation of valves, comprising integral reversing contactor starter with local controls, three phase motor, reduction gearbox, limit and torque switch mechanism and a separate terminal compartment, requiring only a three phase supply for local electrical operation.



Syncroset
Rotork Syncroset means a self contained actuator for intermittent electric motor operation of valves, comprising three phase motor, reduction gearbox, limit and torque switch mechanism and terminal compartment, for use in conjunction with reversing contactors separately procured and installed by customer.



Syncropak and Syncroset

Motor

Three phase Class B insulated cage motor of special high torque low inertia design, 15 minute rated at standard voltages of 380, 415 and 500 volts 50 Hz, 230, 460 and 575 volts 60 Hz. Burn-out protection by embedded thermostat and thus independent of ambient temperature and motor currents.

Torque and Limit switches

Open and Close torque and/or position limit switches with mechanical selection and latch to provide correct travel limitation for all types of valve, plus two auxiliary limit switches at each end of travel.

Position indicator

Open-Intermediate-Shut pointer and dial.

Heater

10-12 watts, 240v max. for Syncroset (internally fed 120v only for Syncropak).

Wiring

Jig-built harness of individually numbered stranded wires, tropical grade PVC insulated, connects internal components to sealed terminal block. Vibration-proof Faston connectors used for all except motor power connections for maximum reliability and easy servicing.

Standard enclosure

WT weatherproof and watertight — See Page 3.

Terminals (Except Syncroset Weatherproof only-see Optional Reductions).

Separately sealed compartment with well-spaced studs angled for wiring convenience and segregated for power and control functions, with internal ground terminal. Cover carries terminal identification Code Card; instruction handbook and wiring diagram enclosed with each actuator.

Conduit entries

Three threaded entries of appropriate national thread standard are provided — see Page 3, together with external drilled lug for external ground connection.

Syncropak Only

Integral controls

Mechanically and electrically interlocked contactors with two NO and one NC auxiliary contacts and 120v coils, fed from screened 40 VA transformer with fused secondary, mounted with pushbuttons and selector switches on draw-out frame. Switches operated externally by three-way Open/Stop/Close pushbutton and three-way padlockable Local/Off/Remote selector, via O-ring sealed stainless steel rods.

Illuminated dial indicator

12v lamp under-run from 6v short-circuit-proof tap on control transformer indicates Syncropak is live and also lights red/white/green spectrum on mechanical dial indicator for open/intermediate/shut positions.

Standard Wiring Diagrams
(Clockwise closing only, for anti-clock apply to Rotork)

	Without AOP1	With AOP1
Syncropak (AC remote control)	1410–40	1411–40
Plus Phase discriminator	1410–50	1411–50
Syncropak plus AC monitor relay	1410–41	1411–41
Plus Phase discriminator	1410–51	1411–51
Syncropak plus two DC relays	1410–42	1411–42
Plus Phase discriminator	1410–52	1411–52
Syncropak plus AC monitor and two DC relays	1410–45	1411–45
Plus Phase discriminator	1410–55	1411–55
Syncroset	2220–00	2221–00
Syncroset with Pushbuttons and local/off/remote switch	2320–00	2321–00

Optional extras

Syncropak and Syncroset

Enclosure

All actuators available explosionproof/watertight to various national standards — see Page 3

Add on Pak 1

Six extra auxiliary limit switches for end or intermediate positions plus continuous position indicator and potentiometer — see Page 5.

Millipot stabilised current transmitter
Provides a stabilised 4/20 mA current signal output proportional to valve position to facilitate data scanning and logging by computer systems etc. — see publication AE4/0.2.

Syncropak only

Interposing Relays

Two DC plug in relays provide for three-button Open/Stop/Close remote control, or two button Open/Close control, non-maintained or maintained with facility to reverse in mid travel — see Page 8.

Monitor Relay

120v AC relay with volt-free normally open contact for monitoring actuator electrical availability for remote control — see Page 8.

Phase discriminator

This simple patented relay disconnects the contactor supply to prevent starting with incorrect phase rotation or one phase dead. It thus eliminates the major cause of jammed or damaged valves during start up and any subsequent wiring changes. (Not available for C.S.A. approved enclosures).

Folomatic Control Unit
Enables the actuator to control the position of a valve in proportion to a continuous current or voltage signal — see publication AE4/0.1.

Syncroset only

Integral Open/Stop/Close pushbutton and padlockable Local/Off/Remote Selector switch of similar construction to Syncropak.

Optional Reductions — Syncroset Only

WP weatherproof instead of watertight, has 3 phase stud terminal block and Klippon insertion terminals for control (maximum cable size 4mm^2, 12 AWG), without separate sealing from internal components, for indoor or outdoor situations not subject to flooding.

No Indicator

Actuator can be supplied with blank cover over switch mechanism and Add-on-Pak 1.

Nuclear actuators
Rotork type NA actuators are special versions of Syncroset developed and qualified for safety related duties in Nuclear Reactor Containments. For information apply detailing reactor type, valve location and normal and accident conditions of operation and environment.

As we are continually developing our products the design of Rotork actuators is subject to change without notice.

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