

**ADVANCED GCE****DESIGN AND TECHNOLOGY**

Unit 8: Systems and Control Technology 2

2525/01

Papers 2525/01 and 2525/02 should both be available to candidates for the full 2 hours 30 minutes examination session.

Candidates answer on the Answer Booklet

OCR Supplied Materials:

- Formulae Sheet (Inserted)
- 8 page Answer Booklet

Other Materials Required:

None

Friday 25 June 2010
Morning

Duration: 1 hour**INSTRUCTIONS TO CANDIDATES**

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Answer Booklet.
- Use black ink. Pencil may be used for graphs and diagrams only.
- **This paper is to be taken with 2525/02 in the same examination session of 2 hours 30 minutes.**
- This paper contains **six** questions.
- You are required to answer **two** questions.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is **120**.
(2525/01 = 48 marks, 2525/02 = 72 marks)
- Please note that the instruction 'discuss' denotes that you should:
 - identify **three** relevant issues/points raised by the question;
 - explain why you consider these issues to be relevant;
 - use **two** specific examples/evidence to support your answer.
- This document consists of **16** pages. Any blank pages are indicated.

Questions 1 and 2 are electrical / electronic systems questions.

1 A student is developing a device that controls the flow of cold and hot water into a bath.

Fig. 1 shows a circuit containing a thermistor TH_1 which monitors the temperature of the bath water. The characteristic curve of the thermistor is also shown in Fig. 1.

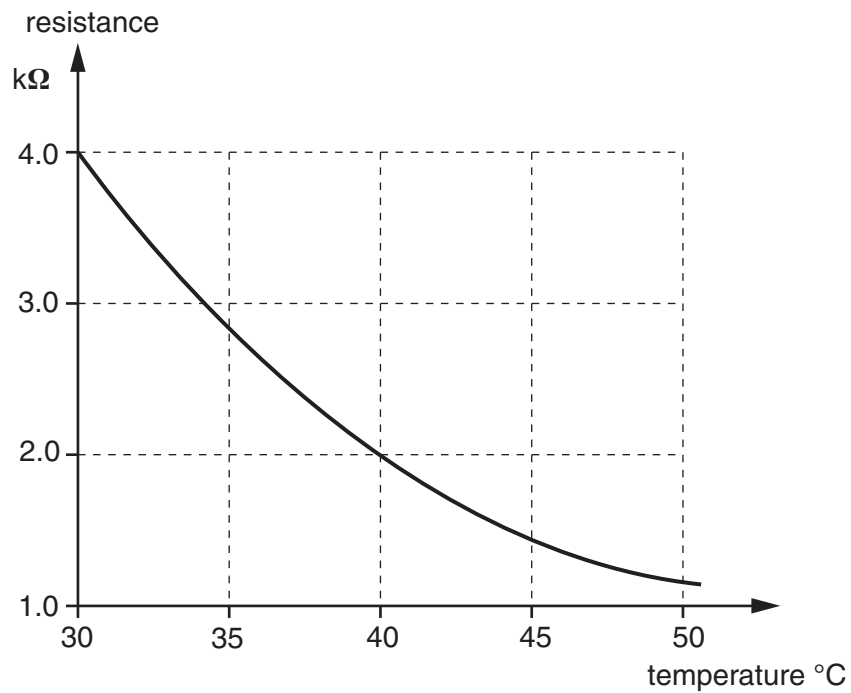
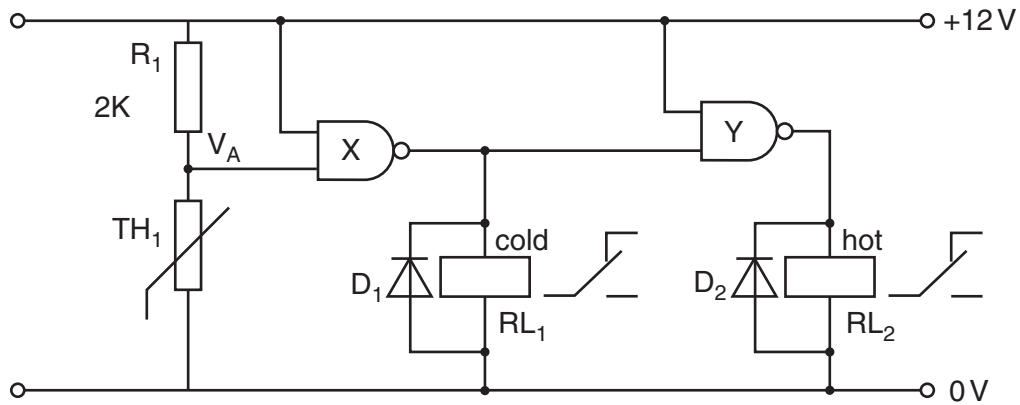


Fig. 1

- (a) (i) State how the voltage V_A varies as the temperature of the thermistor increases. [1]
- (ii) Calculate the value of V_A at 45°C . [3]
- (iii) Give **one** benefit of using CMOS ICs. [1]

- (b) (i) The relay coils, **RL₁** and **RL₂**, operate contacts to switch two solenoid valves. They control the flow of **cold** and **hot** water into the bath. Explain how the circuit controls the flow of water to produce a constant bath temperature. [5]
- (ii) Explain the purpose of diodes **D₁** and **D₂**. [2]
- (iii) Use notes and sketches to show how the circuit in Fig. 1 can be modified to allow the user to select between a **hot** bath (45°C), a **warm** bath (40°C) or a **cool** bath (35°C). [4]
- (c) Discuss the implications for the user of making their home more energy-efficient. [8]

[Total: 24]

- 2 Fig. 2 shows the outline design of a headlight-triggered driveway light system. At night, when car headlights illuminate a sensor, a timer is started and a floodlight, **L**, lights for ten minutes.

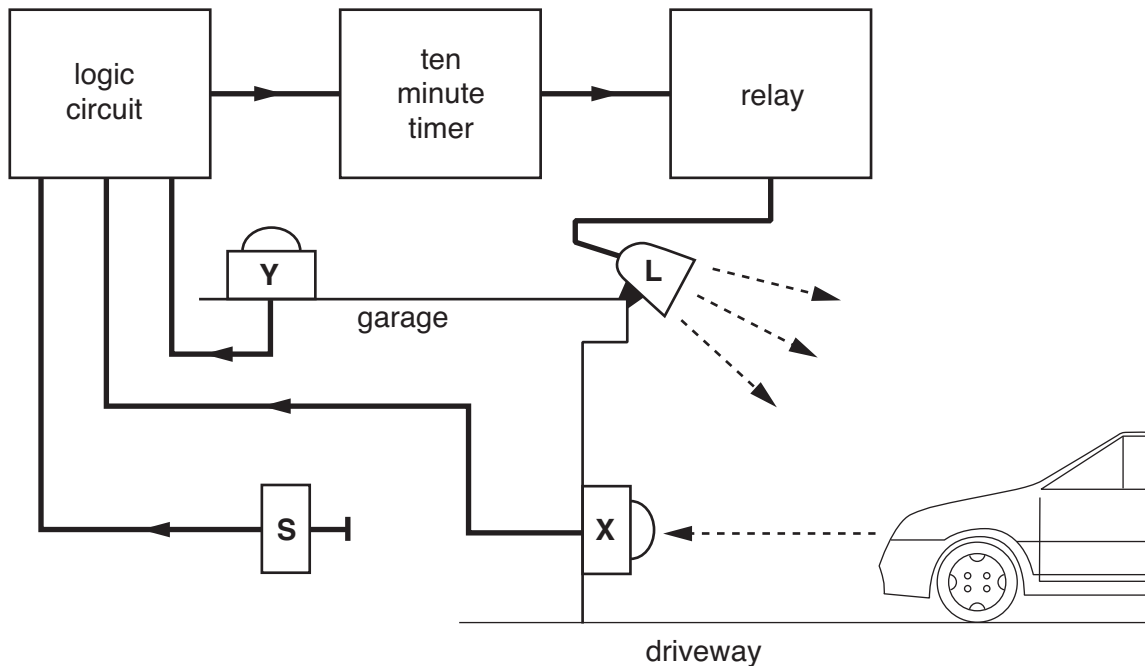


Fig. 2

The logic circuit has three digital input sensors which operate as follows:

- Sensor **X** monitors the light at the front of the garage and gives a low (logic 0) output in the dark and a high (logic 1) output when it receives light. Its output is also high (logic 1) in daylight.
- Sensor **Y** monitors the ambient light level and is shielded from the headlights. It gives a low (logic 0) output in the dark and a high output (logic 1) output in the light.
- Sensor **S** is a pushbutton which, when pressed at any time, night or day, gives a high output (logic 1) and switches on the floodlight for ten minutes. It gives a low (logic 0) output at all other times.

(a) (i) Produce a truth table for the driveway light system, with inputs **X**, **Y** and **S** and output **L**. [3]

(ii) Give the logical expression for the correct operation of the system by car headlights only. [1]

(b) (i) Design and draw a logic circuit for the driveway light system. A high output from your circuit should trigger the ten minute timer. [4]

(ii) Re-design your logic circuit from part (b) (i) using the minimum number of two-input gates of the same type.

Either **NAND** or **NOR** gates may be used. [4]

(iii) Explain **one** practical reason for using only one type of gate. [2]

- (c) The floodlight, **L**, is 240Vac and uses a 500W halogen tube. Calculate the resistance of the floodlight. [2]
- (d) Discuss the implications for consumers of using home security systems. [8]

[Total: 24]

Questions 3 and 4 are mechanical systems questions.

3 Fig. 3 shows a vehicle recovery lorry.

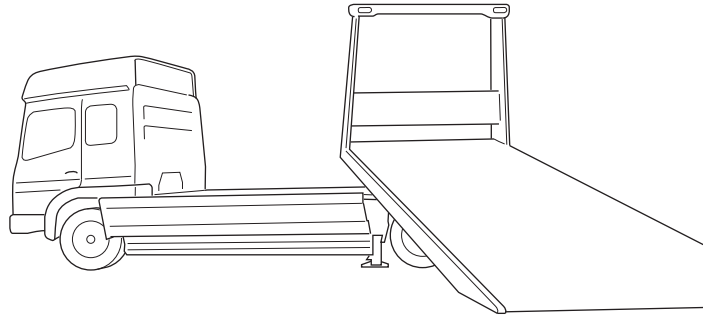


Fig. 3

The broken down vehicle is winched up the inclined plane of the recovery vehicle.

(a) Name **two** other areas where an inclined plane is used.

[2]

(b) Fig. 4 shows a manual winch.

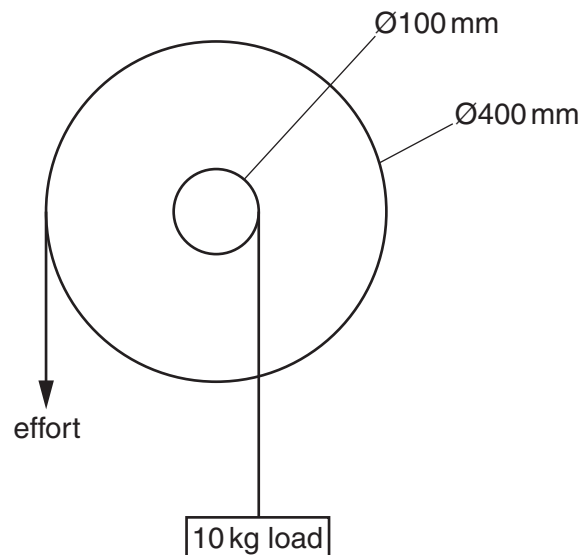


Fig. 4

Calculate the velocity ratio of the manual winch.

[2]

- (c) (i) The recovery vehicle has an electric winch with a safe working load of 3600 kg.
The top of the recovery vehicle slope is at a height of 2600 mm;
The angle of slope is 20 degrees.

Formula for length of slope is:

$$s = \frac{h}{\sin\theta} \quad \text{where } s \text{ is the length of slope, } h \text{ is the height of the slope and } \theta \text{ is the angle of slope.}$$

Formula for effort is:

$$E = \frac{Lh}{s} \quad \text{where } L \text{ is the load.}$$

Calculate, using the formula above, the effort needed to winch the maximum load up the slope. [4]

- (ii) Using the formula $S = F/A$
where S is stress, F is force and A is cross sectional area.

$$A = \frac{\pi D^2}{4}$$

Calculate the stress in the cable for the maximum expected load when:

- the cable is $\varnothing 12$ mm;
- the effort is 7,200 N.

[4]

- (d) The electrically-powered winch must have a mechanical safety device to ensure it cannot rotate in the wrong direction.

Describe using notes and sketches, a suitable mechanical safety device.

[4]

- (e) Discuss the Health and Safety implications of using powerful mechanical systems.

[8]

4 Fig. 5 shows a circular saw.

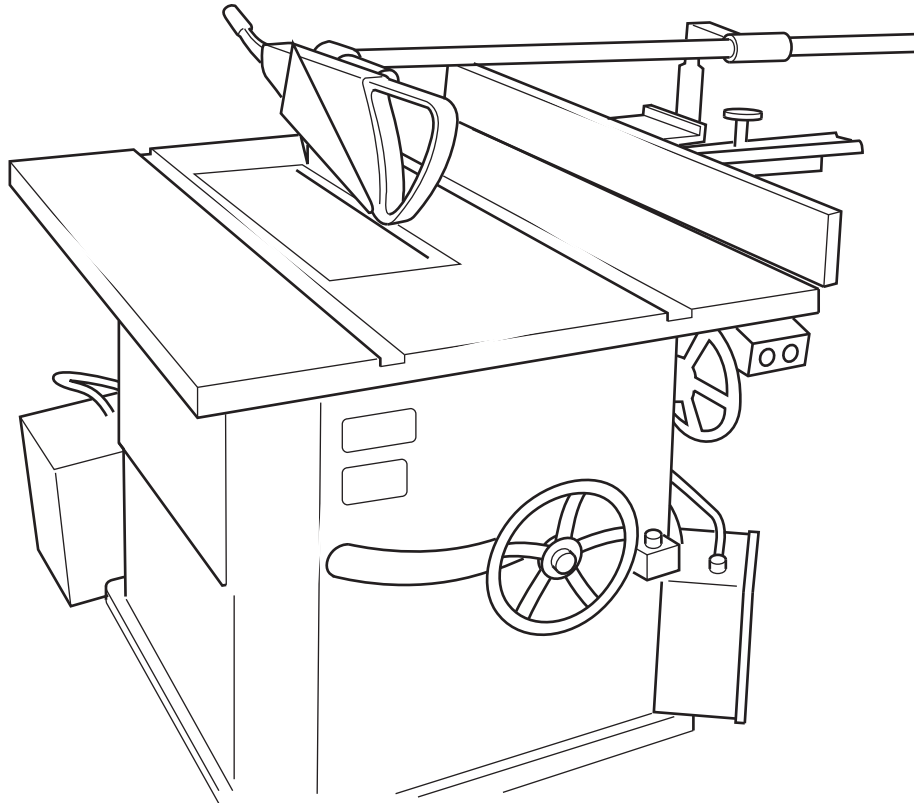


Fig. 5

- (a) (i) The saw blade shaft is belt driven.
Explain why 'belt slip' can be both an advantage and a disadvantage. [4]
- (ii) Fig. 6 shows the keyway in the driver pulley of the circular saw. [2]

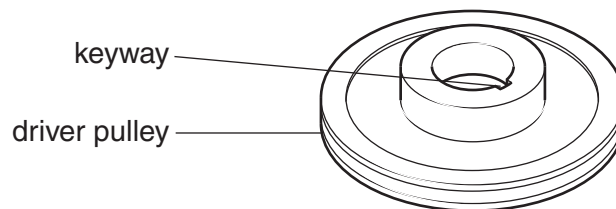


Fig. 6

- Explain the purpose of the keyway shown in Fig. 6. [2]
- (iii) Describe a non-permanent method, other than a keyway, of securing a pulley to a rotating shaft. [2]

- (b) Fig. 7 shows a diagram of the drive mechanism of the circular saw. The saw blade is $\text{\O}400\text{ mm}$ and must produce a force of 5 N at 2500 rpm to cut wood effectively. The efficiency of the system is 80% .

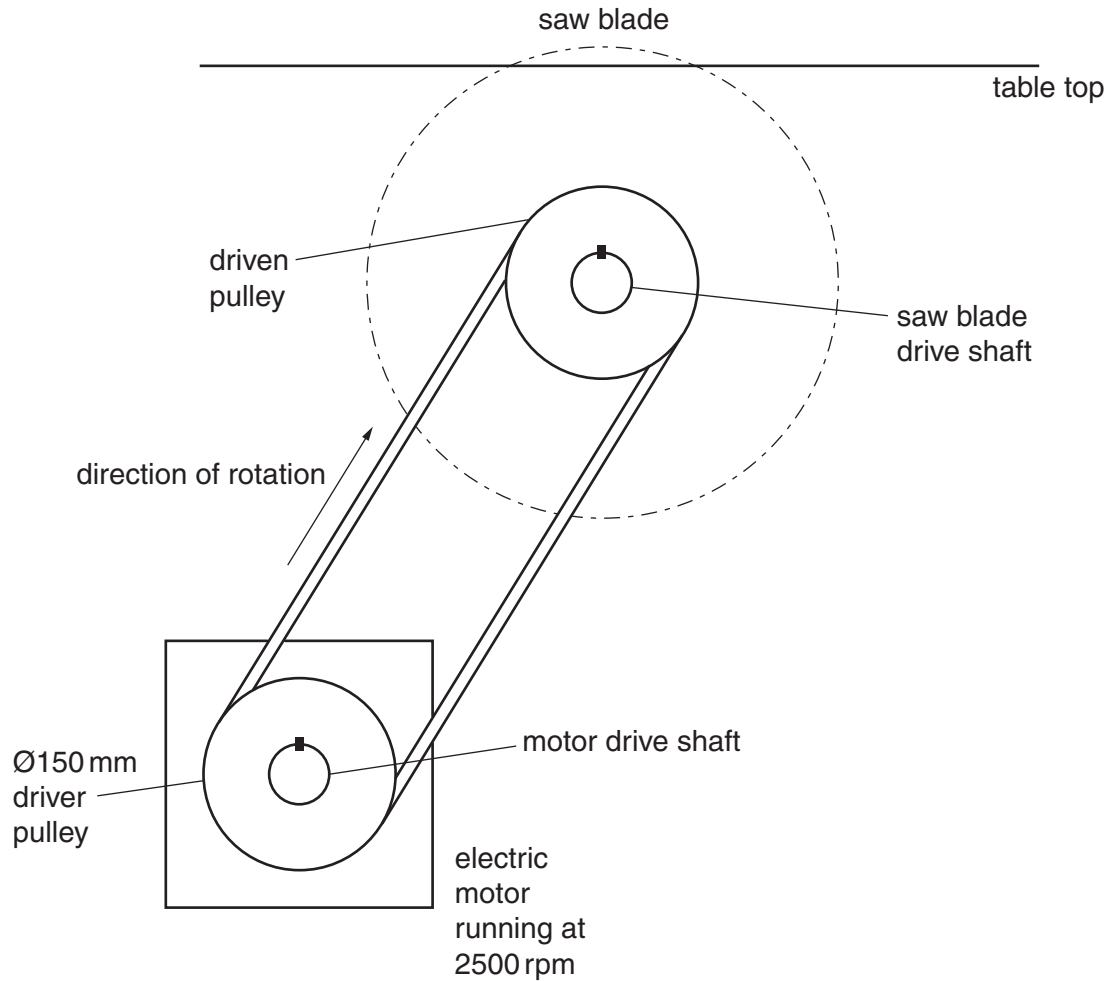


Fig. 7

- (i) Using the formula: $P = T\omega$ where P is power, T is torque and ω is angular velocity. Calculate the power the motor will produce. [4]
- (ii) Explain **two** ways of varying the speed of a driven pulley. [4]
- (c) Discuss the implications of supplying extended warranties. [8]

[Total: 24]

Questions 5 and 6 are pneumatic systems questions.

5 Fig. 8 shows part of a plan view of a conveyor system.

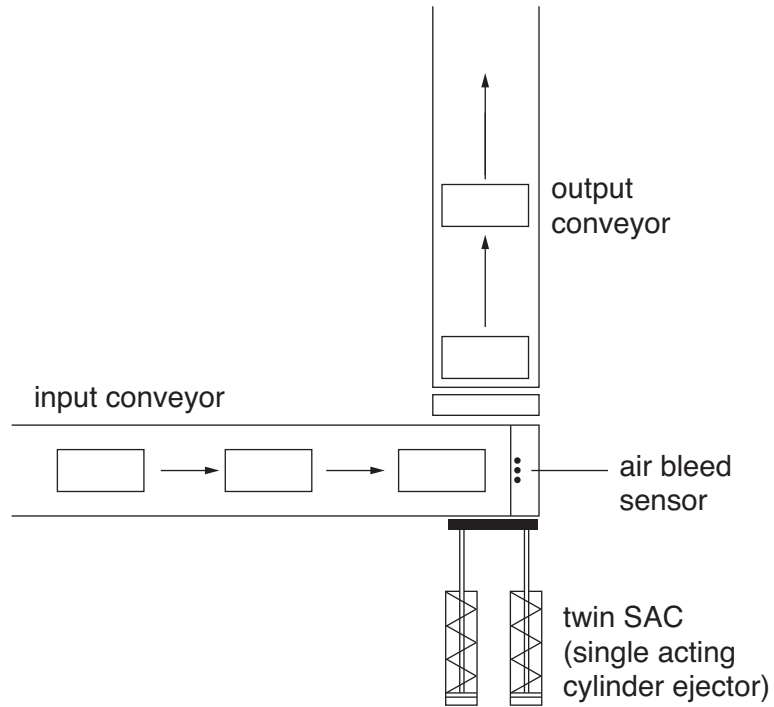


Fig. 8

- (a) Programmable control devices are used to control electro-pneumatic circuits.
- (i) Name **two** programmable control devices that could be used for the operation of an electro-pneumatic circuit. [2]
- (ii) State **two** benefits of using programmable control devices. [2]

- (b) Fig. 9 shows part of the pneumatic circuit for the conveyor system. When a box blocks all air bleed sensors, an ejector pushes the box onto an output conveyor placed at 90° to the input conveyor.

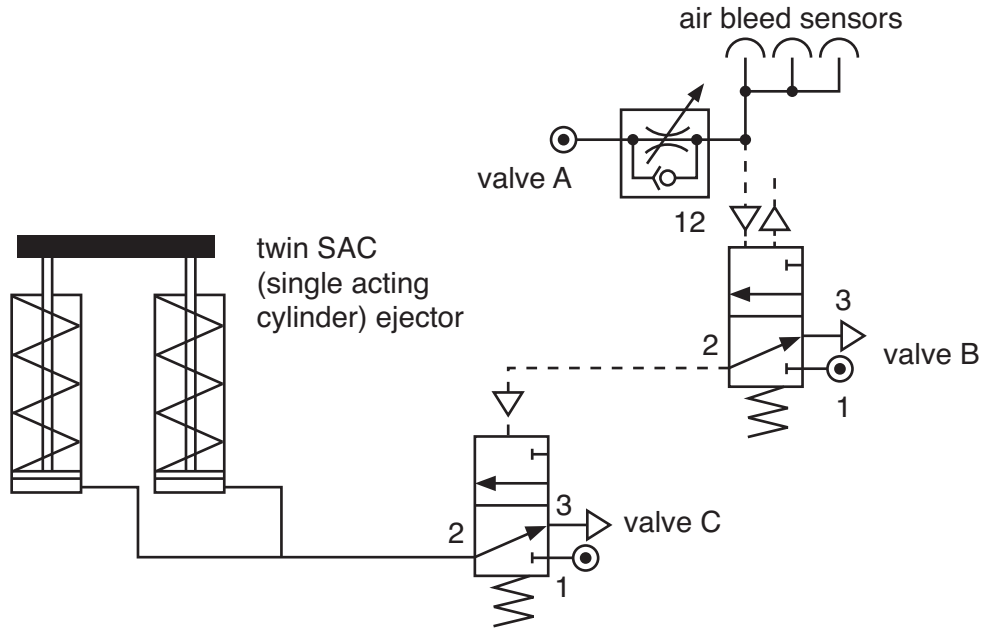


Fig. 9

- (i) Explain how the circuit operates once the air bleed sensors are blocked. [4]
- (ii) The twin ejector cylinders must act in the same direction simultaneously. Explain how this can be ensured. [2]
- (iii) A foot pedal operated 3-port valve was piped in parallel with valve C. The operator can now manually eject a box. Sketch the changes to the circuit diagram, naming any additional components. [3]
- (c) Both ejector cylinders are $\varnothing 40$ mm and air is supplied at a pressure of 0.6 N/mm^2 . Using the formula: $F = P \times A$, where F is force, P is pressure and A is cross sectional area
- $$A = \frac{\pi D^2}{4}$$
- Calculate the force exerted by the pair of cylinders if the efficiency of both is 95%. [3]
- (d) Discuss the implications for the manufacturer of using ICT in developing prototypes for volume production. [8]

[Total: 24]

6 Fig. 10 shows the pneumatic circuit for closing the guard on a hydraulic press.

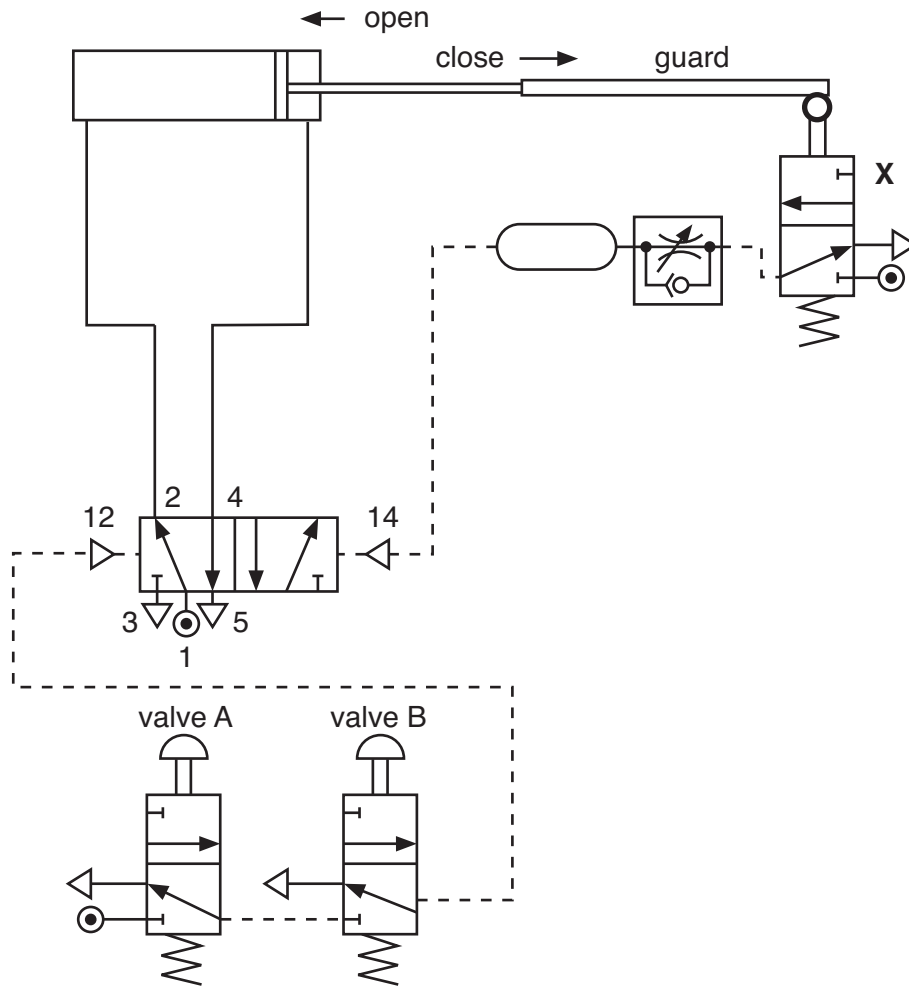


Fig. 10

- (a) The two valves in Fig. 10 form part of a safety system to protect the operator.
- (i) Name the configuration of the two valves. [1]
 - (ii) Using the two valves, draw an alternative method of providing the same outcome. [2]
 - (iii) State a health and safety reason for the combination of the valves. [1]

- (b) (i) State the name used for valve type **X** in Fig. 10. [1]
- (ii) In Fig. 10 valve **X** initiates the cylinder return cycle. Using notes and sketches, show an alternative method of achieving the automatic return of the cylinder that does not involve physical contact between the guard and a valve. [4]

- (c) The system shown in Fig. 10 has:
- a cylinder with a $\varnothing 50\text{ mm}$ bore;
 - main air supplied at a pressure of 0.8 N/mm^2 ;
 - a 90% efficiency.
- Using the formula: $F = P \times A$,
 where F is force, P is pressure and A is cross sectional area
- $$A = \frac{\pi D^2}{4}$$

Calculate the force applied by the cylinder on its outward stroke. [3]

- (d) To further improve safety the start circuit was altered as shown in Fig. 11.

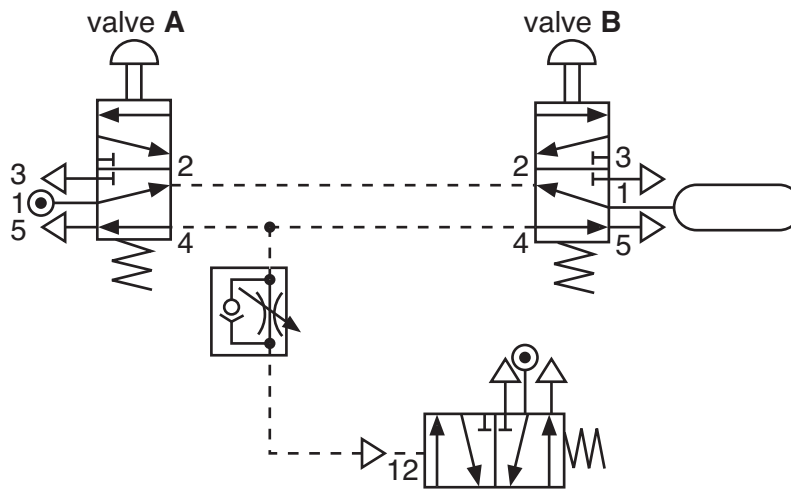


Fig. 11

Explain how the new circuit operates. [4]

- (e) Discuss the implications of changing to 'just-in-time' (JIT) manufacture. [8]

[Total: 24]

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