SEQUENTIAL CONTROL

This study file introduces some of the basic ideas about sequential control.

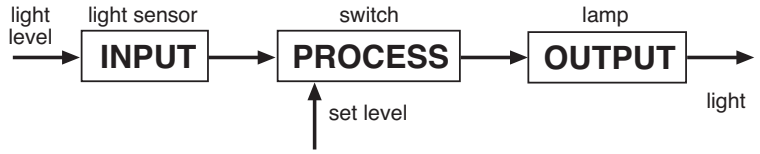
In particular you will need to know the difference between **continuous** and **sequential** control, and between **synchronous** and **asynchronous** sequential control systems.

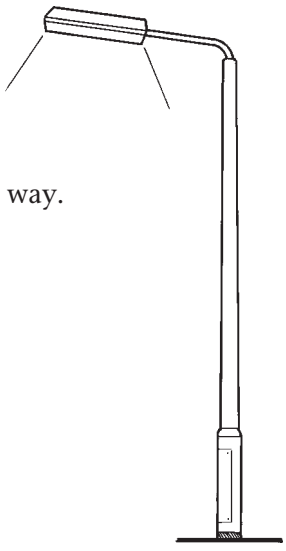
Other general information about control systems is described in Technology Study File 11.

CONTINUOUS AND SEQUENTIAL CONTROL

Continuous Control
In continuous control systems the inputs are sending information into the system all the time and the outputs of the system are being controlled all the time. A change to the input leads directly to a change in the output.

An example of this kind of system is a security floodlight that comes on in the dark; the level of light reaching the light sensor is continually controlling whether or not the lamp is on.



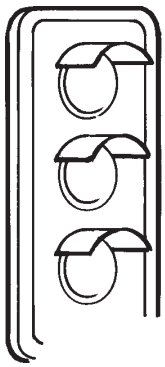


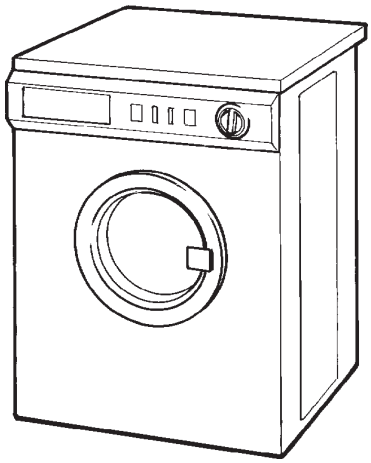
Street lights are often controlled in the same way.

SEQUENTIAL CONTROL

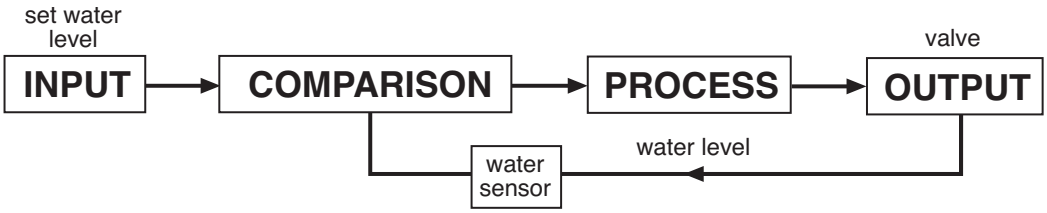
In a sequential control system a series of different events takes place one after the other. The finishing of one event in the sequence provides the signal for the next event to start. Examples of sequential systems are;

- the timers that control central heating systems,
- washing machines,
- traffic lights,
- lifts in buildings.

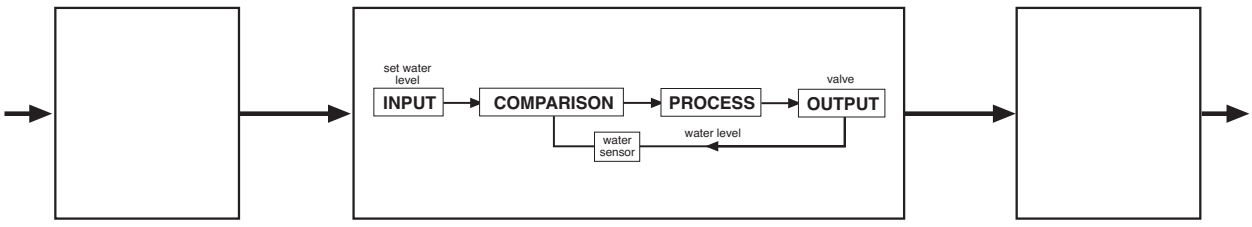




Sometimes one of the events in the sequence is itself a **continuous** control system. For example, filling a washing machine with water uses a continuous control system that monitors the water level and controls the water input valves;



However this is only one event in the series of events that makes up the complete **sequential** control system for the washing machine;



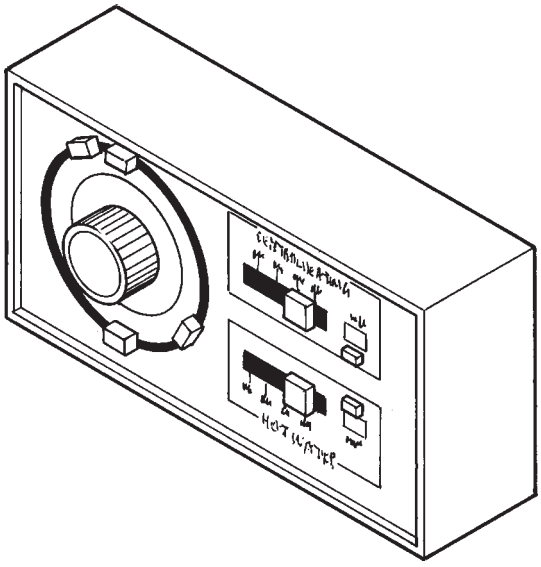
It will be started by the event that comes before it and, when the machine is full, it will start the next event off.

SYNCHRONOUS AND ASYNCHRONOUS CONTROL

Synchronous Control
In a fully synchronous control system all of the events in the sequence take place at ***set points in time***, regardless of any external change.

Synchronous control systems are used where the control of a sequence of events must take place at pre-set time intervals. Such a system doesn't take any account of events outside it, only the time between events is important. Therefore it doesn't need any sensors; it is an open loop control system.

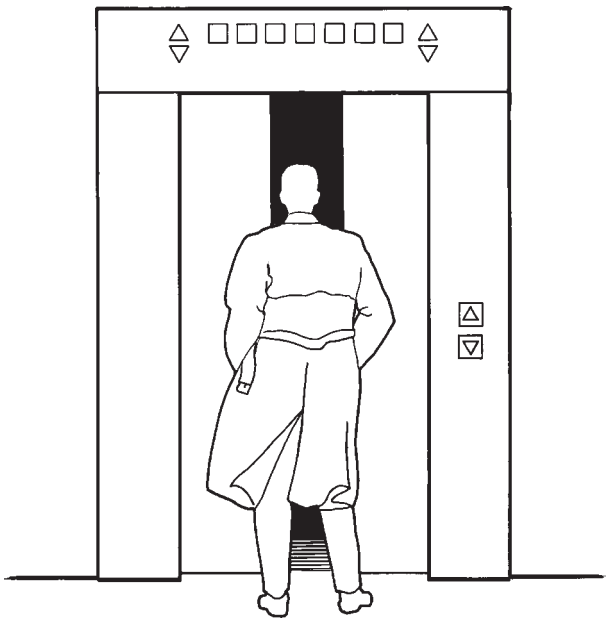
Central heating timers are synchronous controllers; the points at which the heating and hot water systems are turned on and off are fixed in time. (Notice though that once the heating or hot water is turned on, that part of the sequence is usually a continuous system; temperature is continuously monitored to control the heating system.)



Asynchronous Control
In an asynchronous control system all of the events in the sequence take place as a result either ***due to an external event*** or ***because the previous event has finished***, regardless of the time taken.

Asynchronous control systems are used where the time taken for a sequence to occur is unimportant. Each event happens as soon as the previous event is finished or when something outside the system happens; such systems require sensors to detect the completion of an event or an outside event and so must be closed loop.

The control system for a lift is asynchronous; the sequence of events depends entirely on external events (people pressing the call buttons outside the lift, and the floor buttons inside it) or the completion of lift movements (the lift stops moving, and the doors are opened, when a switch detects that a floor has been reached).



MIXED SYNCHRONOUS / ASYNCHRONOUS CONTROL SYSTEMS

In most real sequential control systems there is a mixture of synchronous and asynchronous control;

- Many modern traffic light sets have pedestrian crossing lights or sensors in the road to detect the presence of cars. These affect the timing of the sequence of lights making the mainly synchronous system mixed.
- In a lift automatic doors often stay open for a fixed time. This makes a mainly asynchronous system mixed.

The following is a list of some devices that use sequential control systems.

1. A car burglar alarm.
2. An automatic car park barrier.
3. A microwave oven.
4. A dishwasher
5. A time lock on a bank's safe.
6. A robot arm welding parts of a car together

For each system;

- Draw a block diagram showing the sequence of events in the system.
- Write down whether you think it is synchronous, asynchronous or mixed.
- Explain your answer.
- If you think a system is asynchronous, explain how you think each step in the sequence is triggered.
- If you think it is a mixed system, describe which parts you think are synchronous and which asynchronous.

Copy and complete the following sentences using words from the list at the end;

In a _____ control system the outputs are controlled in a series of steps that happen one after the after. In a _____ control system the outputs are being constantly controlled by the system.

A _____ system is a sequential system where each step takes place at a fixed time.

In _____ systems each step takes place when the step before it finishes.

_____ systems require sensors to detect when one step has finished and to start the next step.

Many sequential systems are partly synchronous and partly asynchronous. These are called _____ systems.

sequential, sensors, synchronous, mixed, outputs, asynchronous, inputs, continuous, step, control system.

(In a sequential control system the outputs are controlled in a series of steps that happen one after the after. In a continuous control system the outputs are being constantly controlled by the system.

A synchronous system is a sequential system where each step takes place at a fixed time.

In asynchronous systems each step takes place when the step before it finishes.

Asynchronous systems require sensors to detect when one step has finished and to start the next step.

Many sequential systems are partly synchronous and partly asynchronous.)

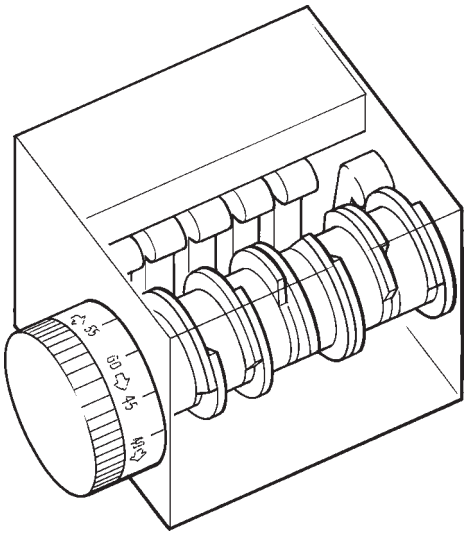
IMPLEMENTATION OF SYNCHRONOUS CONTROL SYSTEMS

The heart of a synchronous control system is some kind of **timer**. This can be mechanical or electronic. The timer also needs:

- A **sequencing element**; this sets the times that outputs are switched on and off. Remember that there are no external inputs into a synchronous timer.
- An **output** stage that provides the start and stop signals.

MECHANICAL SYSTEMS

All mechanical timers are different kinds of **cam timer**. Here a motor turning at a constant speed is used to turn lots of cams. As the cams turn they push on switches to turn them on or off.



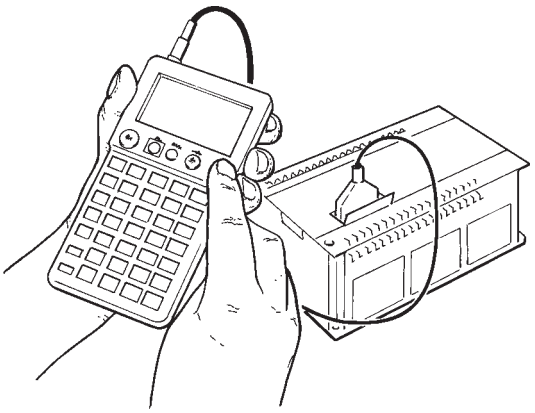
Central heating and washing machine timers always used to be made from cam timers. In industry too, cam timers have been used widely - though they are being rapidly replaced by electronic timers these days.

ELECTRONIC SYSTEMS

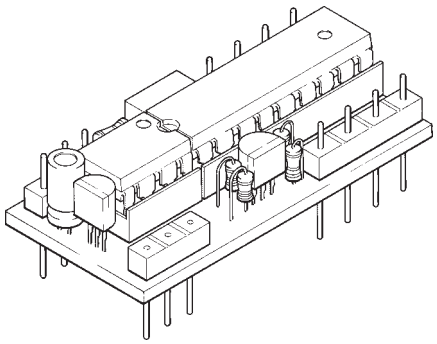
There are a number of different electronic systems that can be used.

A **dedicated circuit** uses an oscillator to give electronic clock pulses. Further circuitry, often involving the use of logic gates, is then used to control a sequence of switching.

Programmable Logic Controllers (PLCs) are commonly used in industry. A PLC contains the same kind of microprocessor as a computer. However it is designed to be used in an industrial setting so is very robust. The timing sequence can be programmed either through a computer or with a small, hand held, programmer. PLCs are replacing cam timers in most places in industry.



A **microcontroller** is a computer on a chip; an integrated circuit that has all of the main bits of a computer system in it. The timing sequence is usually programmed from a computer before the microcontroller is placed in the device it is to control. Microcontrollers are used in mass production goods because they are very cheap, the timers in modern washing machines and central heating systems very often use them.



An important thing to note about these electronic systems is that they all use low voltages and currents. They also need to be able switch powerful outputs. So they will need some kind of output interface that protects the circuit and provides power. Relays are very often used for this.