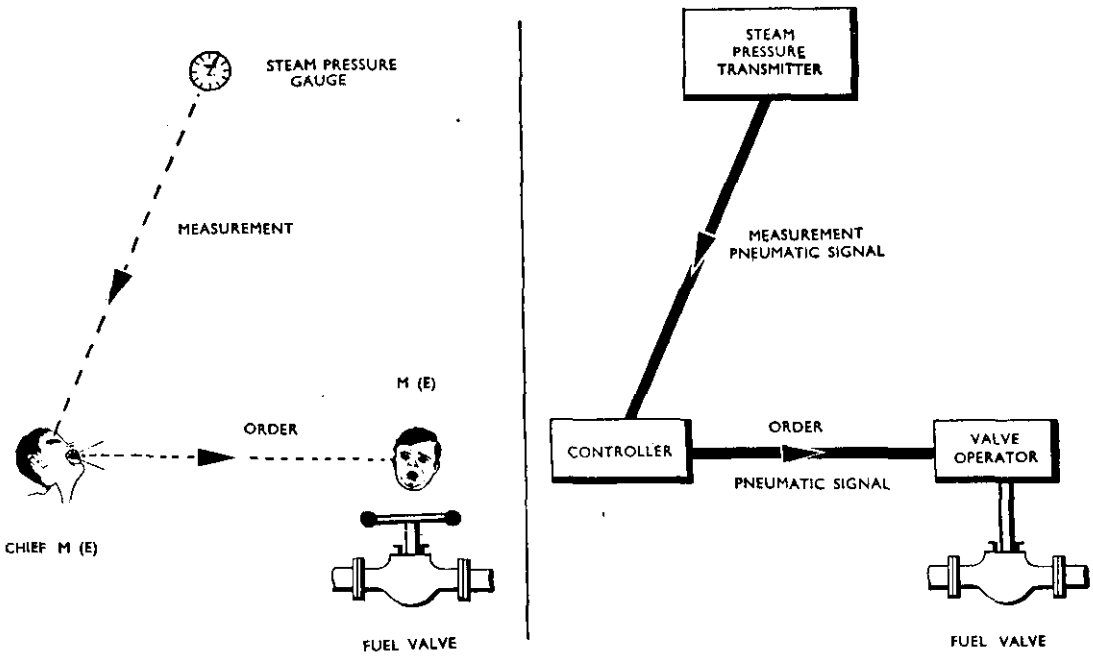

FIG. 1—ILLUSTRATION OF CONTROL PRINCIPLES

PRINCIPLES OF AUTOMATIC BOILER CONTROL

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STEAM PRESSURE CONTROL

Purpose

The object is to maintain a constant steam pressure, regardless of the steam output.

Whether the control be automatic or manual, three main functions are involved, namely measurement, interpretation and action. FIG. 1 illustrates the sequence of events for both manual and automatic control. Automatic control differs from manual control mainly in the method of sending signals and orders. Measurement of steam pressure is conveyed to the controller by a pneumatic signal, instead of by eye. Action is ordered by the controller using a pneumatic signal instead of word of mouth. The pneumatic signal is an air pressure system which varies between 3 and 27 lb/sq in., although some systems use a 3 to 15 lb/sq. in. range.

The following TABLE compares the elements used in automatic manual control :—

Function	*Element*	
	Manual	*Automatic*
Measurement	Pressure gauge	Pressure transmitter
Interpretation	Chief M(E)	Pressure controller
Action	M(E)	Valve operator

ELEMENTS OF AN AUTOMATIC CONTROL SYSTEM

Measurement

Steam pressure in the drum is converted to a pneumatic signal by a steam pressure transmitter. This instrument is basically an ordinary Bourdon tube pressure gauge. Instead of rotating a pointer, the Bourdon tube varies the pneumatic signal between 3 and 27 lb/sq in. as the steam pressure moves over the range of the instrument. For example, a 0–600 lb/sq in. transmitter will produce pneumatic signals of 3 lb/sq in. at zero steam pressure, 15 lb/sq in. at 300 lb/sq in. steam pressure, 27 lb/sq in. at 600 lb/sq in. steam pressure.

Interpretation

The steam pressure controller receives information as pneumatic signals and issues orders to valve operators, again in the form of pneumatic signals. The two signals received by the controller are :

(*a*) The steam pressure desired in the boiler

(*b*) The actual steam pressure in the boiler.

The desired steam pressure is fed into the controller as a pneumatic signal from an adjustable pressure reducing valve in the 3–27 lb/sq in. range. The actual steam pressure signal is obtained from the steam pressure transmitter. The two signals are compared and their difference is magnified and passed to the valve operators as an order to increase or decrease fuel flow and air flow. The order continues until the actual value of steam pressure becomes equal to the desired value.

Action

Valve operators move the controlled valve stem to a position ordered by the controller. If the order is a pneumatic signal of 3 lb/sq in. the valve will be closed ; if 15 lb/sq in. the valve will be half open ; if 27 lb/sq in. the valve will be fully open. The pneumatic signal moves a pilot valve admitting compressed air to air motors which drive the controlled valve in either direction. When the correct movement has taken place a mechanical linkage between the controlled and pilot valves restores the pilot valve to its null position.

A common defect in valve design is that equal steps in valve movement do not produce equal changes in the quantity that is being controlled. For example, the first turn on a fan steam valve may bring the speed from zero to 1,000 r.p.m. while a further six turns may be necessary to increase the speed to 2,000 r.p.m. To counteract this effect some types of valve operators incorporate a cam which may be shaped to correct the relationship between pneumatic signal and the quantity which is being controlled.

INSTALLATIONS

Messrs. Sunvic's Automatic Steam Pressure Control

H.M.S. *Tiger* and H.M.S. *Hermes* are fitted with a simple steam pressure control which works on the lines described above. FIG. 2 illustrates the arrangement. Fuel and air are controlled by the same order from the controller. To maintain correct matching between fuel and air flow, cam correction is used in the operators for both the Lucas spill control valves and for the fan steam control valve. Rotary piston-type air motors drive the valves. A 3 to 15 lb/sq in. range of pneumatic signals is used.

If steam demand is varying rapidly, as for example when the ship is manœuvring, the inertia of the fan will prevent air flow keeping pace with changes in fuel flow. To avoid making black smoke, when manœuvring, excess air may be blown continuously by adding a fixed bias to the signal to the fan steam valve.

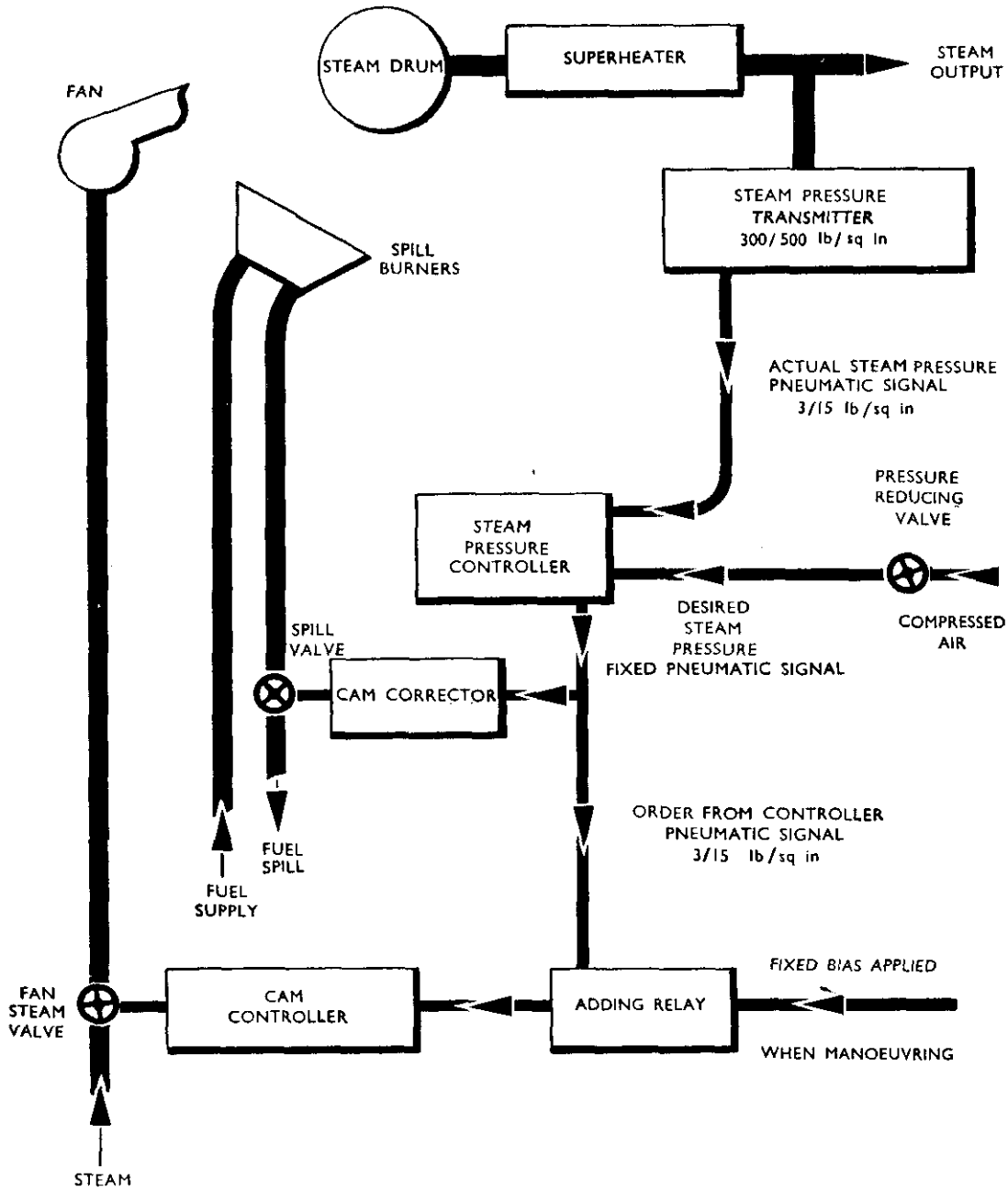

FIG. 2—BASIC AUTOMATIC STEAM PRESSURE CONTROL IN H.M.S. 'TIGER'

Advantages

Wide range spill burners are used, therefore no interference with the pneumatic control is necessary by putting burners on and off. (See following article).

The control system is simple, only three active instruments being required.

A trunked air supply eliminates one time lag on air flow which occurs when a closed stokehold requires filling with air.

Disadvantages

Correct matching of fuel and air flows depends on the accuracy of cutting cams and upon the consistency of machinery characteristics. Matching will be impaired by such changes as coking of burners, wear of valves and changes in fuel temperature.

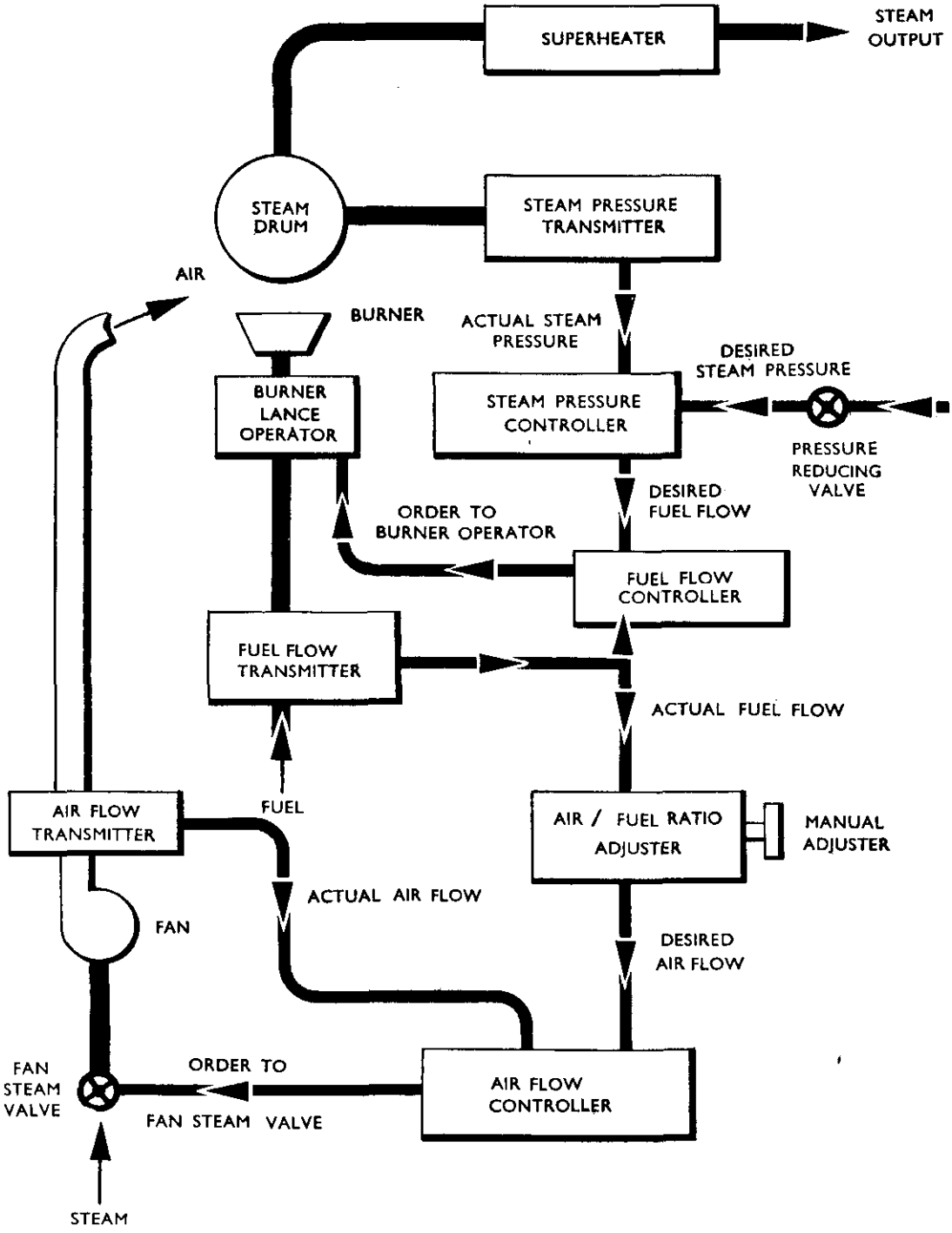

FIG. 3—BASIC STEAM PRESSURE AND COMBUSTION CONTROL IN H.M.S. 'BELFAST'

No attempt is made, in the control system, to speed up air flow changes to keep them more nearly in step with fuel flow changes. There will be a tendency to blow excess air, particularly when manœuvring.

Messrs. Bailey Meter's Steam Pressure and Combustion Control

H.M.S. *Belfast* is fitted with a more sophisticated control system which was developed in H.M.S. *Centaur*. Instead of the steam pressure controller changing fuel flow and air flow directly, the closed loop principle is used. FIG. 3 shows