42066

STEAM TURBINE

PROTECTIVE SYSTEM

GENERAL

The purpose of the Protective System is to detect undesirable or dangerous operating conditions of the turbine-generator, take appropriate trip actions, and provide information to the operator about the detected conditions and the consequent actions. In addition, means are provided for testing all testable equipment and circuits.

The Protective System consists of two major subsystems:

1. The Mechanical-Hydraulic Trip System – described in detail in the Turbine Section of the Instruction Book.

2. The Electrical Trip and Monitoring System (T&M) – described in detail in the Electro-hydraulic Section of the Instruction Book.

This instruction describes in summary both subsystems and their relationships.

A simplified signal flow diagram of the Protective System is shown in Figure 1.

PRINCIPLE OF OPERATION

The Emergency Trip System (ETS) is the high-pressure fluid system that, when in the Reset or pressurized state, permits all steam valves to open in the presence of opening signals from the EHC. When in the tripped or depressurized state, it overrides all opening signals, and trips the Main and Reheat Stop Valves, the Control Valves, and the Intercept Valves directly by way of their disc-dump valves, and trips the Extraction Check Valves through the Air Relay Dump Valve. The principal output function of the Protective System is to control the state of the ETS.

I. MECHANICAL-HYDRAULIC TRIP SYSTEM

The ETS is pressurized from the high-pressure hydraulic fluid supply, through the following chain of devices, all components of the Mechanical-Hydraulic Trip System:

a. Mechanical Shut-Off Valve (MSOV)

b. Mechanical Trip Valve (MTV)

c. Mechanical Lockout Solenoid Valve (MLV)

d. Electrical Trip Valve (ETV)

e. Electrical Lockout Solenoid Valve (ELV)

The MSOV and MTV are controlled hydraulically by the Mechanical Trip Pilot Valve (MTPV), and when their pilot lines are depressurized, these valves shut off their input line and drain their output line, tripping the ETS.

The MLV is controlled electrically by the T&M, and when energized, it bypasses the MSOV and MTV, permitting these two valves and two of the three signal paths that actuate them to be tested without tripping the ETS.

The ETV is controlled hydraulically by the Electrical Trip Solenoid Valve (ETSV), and when its pilot line is depressurized, this valve shuts off its input line and drains its output line, tripping the ETS.

The ELV is controlled electrically by the T&M, and, when energized, bypasses the ETV permitting this valve and the signal path that actuates it to be tested without tripping the ETS.

In order to trip the ETS, any tripping signal has to actuate one or both of the MTPV or the ETSV. Each of these two cases will be examined separately.

1. MTPV ACTUATION

This valve is operated mechanically by the Trip Latch Rod, which is tripped (*i.e.*, allowed to move under the influence of a charged spring to a position where the MTPV is tripped) by the Trip Finger.

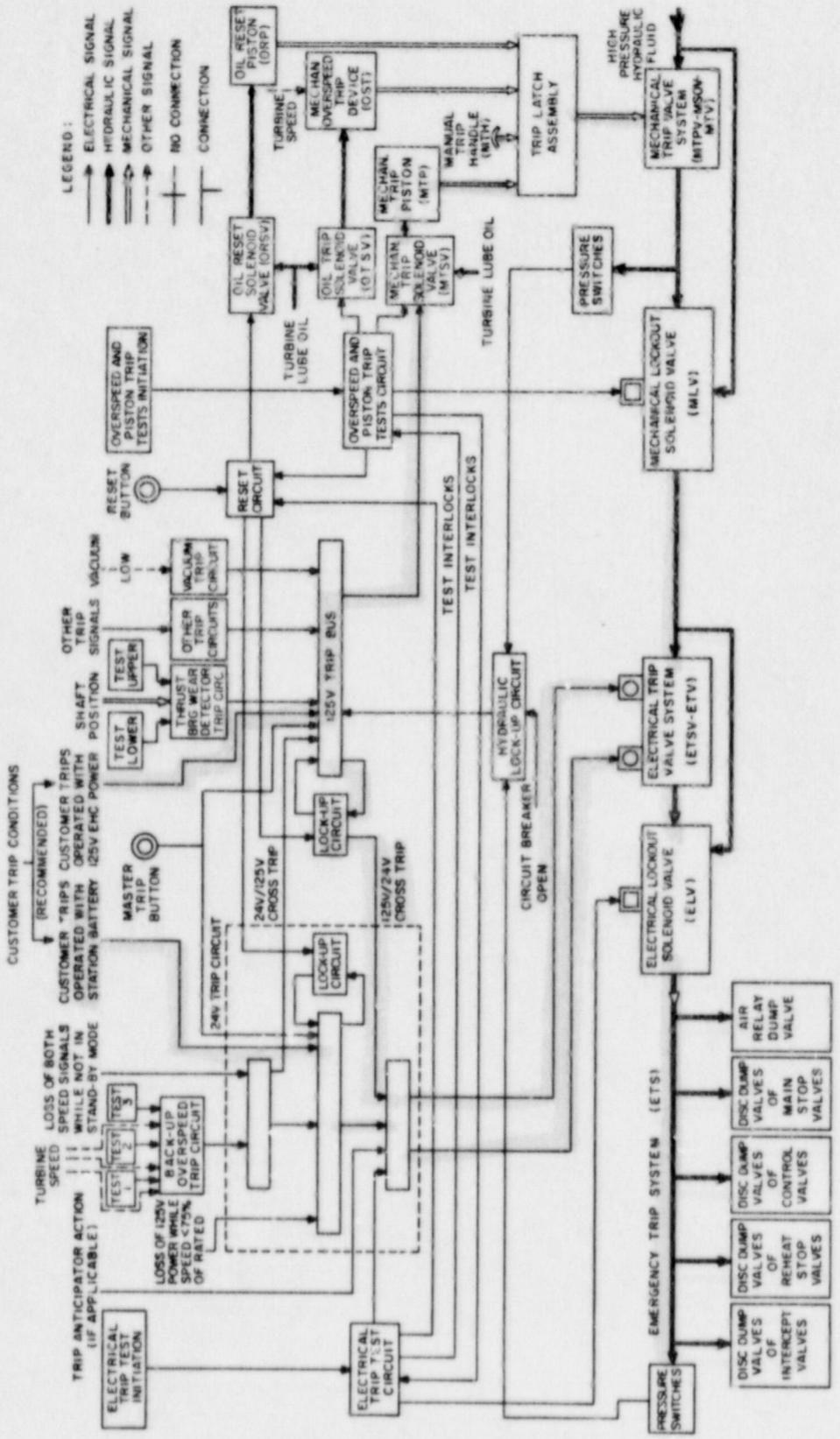

Fig. 1. Signal Flow Diagram – Protective Systems

The Trip Finger is operated by:

a. The Mechanical Overspeed Trip Device (OST)

This is actuated during an overspeed of the turbine exceeding the OST setting, or at rated speed during a Mechanical Overspeed Trip Test. During this test the T&M energizes the Oil Trip Solenoid Valve (OTSV) which admits lubrication oil to the OST causing it to trip. A coordinated actuation of the MLV prevents the ETS from tripping.

b. The Mechanical Trip Piston (MTP)

This is held in the reset position by turbine lube oil pressure. The piston is allowed to trip by action of a spring when the oil pressure is lost or when the oil is shut off by the Mechanical Trip Solenoid Valve (MTSV). This valve is energized by the T&M during a 125V trip as it will be defined later, or during a MTP Test. In the latter case a coordinated actuation of the MLV prevents the ETS from tripping.

c. The Manual Trip Handle (MTH)

There is no provision for testing the MTH under lockout conditions. An MTH test will result in an actual trip.

The Trip Latch Rod, once tripped, latches mechanically, and remains in the tripped position even after the condition that caused it to trip (a, b, or c) has been cleared. It is reset by the Reset Mechanism, consisting of:

a. The Oil Reset Solenoid Valve (ORSV) – when energized by the T&M actuates the Oil Reset Piston.

b. The Oil Reset Piston (ORP) – resets the Trip Latch Rod and the MTPV, which in turn resets the MSOV and MTV.

2. ETSV ACTUATION

This valve has two 24 VDC solenoids which are normally energized when the ETSV is in the reset state. The valve trips when both solenoids are de-energized. Failure of one solenoid will not cause a spurious trip. The solenoids are connected to the T&M and are de-energized during a 24V trip as will be defined later, during a Trip Anticipator action (if applicable), or during an Electrical Trip Test. In the latter case, a co-ordinated actuation of the ELV prevents the ETS from tripping.

The Mechanical-Hydraulic Trip System includes a number of pressure switches and limit switches which are connected to the T&M and provide information about the state of the various components (valves, piston, Trip Latch Rod, MTH, etc.).

II. ELECTRICAL TRIP AND MONITORING SYSTEM (T&M)

The principal function of this part of the Protective System is to connect all external trip signals (except the tripping signals from the OST and MTH, which act directly on the Mechanical-Hydraulic Trip System) to one or both of the MTSV and ETSV after suitable modifications by logic circuits. Each of these valves is independently capable of tripping the ETS.

The incoming trip signals are arranged into two groups:

1. Signals External to the EHC Cabinet:

These cause 125V Trips; i.e., they activate the 125V Trip Bus and energize the MTSV directly.

In addition, the 24V trip circuit is indirectly operated through a set of relays (crosstrip), and the 125V Trip Bus is locked up after a short time delay.

When the generator circuit breaker is open, and the MTV and ETS are tripped, an additional lock-up circuit is established through pressure switch contacts.

During a MTP Test the MTSV is energized without activating the 125V Trip Bus, the cross trip circuit and the lock-up circuits.

2. Signals internal to the EHC Cabinet:

These cause a 24V trip, i.e., they de-energize the ETSV solenoids through a set of relays contacts, and lock-up the 24V trip circuit through another set of relays contacts.

The first set of relays is also operated during a Trip Anticipator action (if applicable) or during an Electrical Trip Test; in these two cases the lock-up circuit is not activated and the situation is cleared once the cause producing it is removed, without necessitating any positive resetting action.

Of the signals internal to the EHC Cabinet, the Loss of Both Speed Signal and the Back-Up Overspeed Trip Signal energize, in addition to the tripping and the locking relays, a third set of relays which cross trip the 125V Trip Bus. The other three signals that cause a 24V trip do not energize these cross trip relays; however of these, the Master Trip Button causes

a 125V Trip through a separate contract. The Customer, at his option, can do the same for Customer Trips energized by the 125V Station Battery. Only the loss of 125 VDC when speed is below 75% of rated inevitably produces a 24V Trip alone.

A loss of 24 VDC de-energizes the ETSV solenoids, causing a 24V Trip and cross trips the 125V Trip Bus.

In summary, all trip signals to the T&M, except the loss of 125 VDC, and – if the customer so chooses – the customer trips operated with station battery, activate two independent paths throughout the T&M and the Mechanical-Hydraulic Trip System, and redundantly trip the ETS.

When the condition that caused a trip has cleared, the EHC can be reset by depressing the Reset Button on the Turbine panel. This will:

a. Break the lock-up circuits.

b. Reset the MTV through the Reset Mechanism.

The Reset button must be held down until the "RESET" light comes on to assure the ETS pressure has been re-established.

The T&M also contains the logic for testing the trip devices. (Mechanical Overspeed, Mechanical Trip Piston and Electrical Trip tests.) When one of these tests is initiated, the T&M logic provides a sequence of signals to the appropriate lockout, trip, and reset valve solenoids and receives feedback signals that allow it to sense the status of the Mechanical-Hydraulic Trip System after each step and whether the test was successful.

Each of the three Back-Up Overspeed Trip Circuits can be separately tested without causing an actual trip. These circuits, as well as many other trip circuits of the T&M, are arranged in a two-out-of-three logic system.

The Thrust Bearing Wear Detector is tested via an automatic system from the control panel.

Finally, the T&M System contains logic for the display of the status of the ETS, Mechanical-Hydraulic System, and T&M itself, logic for annunciation and First Hit Detection of tripping and other abnormal conditions, and provides switching signals for control functions to other sections of the EHC and for customer use.