

cient, some dissolved oxygen usually remains and scavengers such as sodium sulphite, iron compounds and certain organic substances must be used to remove the last traces. If not removed, the inhibitors—nitrate, chromates, etc.—may be used to prevent corrosion.

Carbon Dioxide. As with dissolved oxygen, free carbon dioxide can be picked up from air. In addition, waters containing carbonates and bicarbonates may break down when heated and give off this gas. Well waters normally contain more than surface waters. Solubility of carbon dioxide is greatly influenced by pH of the solution, the solubility decreasing with temperature increase and increasing as pressure goes up. The same method, namely desaturation, is used for its removal. Because of its greater solubility, carbon dioxide

is more difficult to remove than dissolved oxygen.

In feedwater systems and boilers, preventing corrosion from free carbon dioxide, carbonates and bicarbonates is simple. Adding an alkali or a complex phosphate is quite effective. But breakdown of carbonates and bicarbonates in the boiler liberates carbon dioxide, which renders the steam and condensate corrosive. Introducing a volatile alkali to the boiler or steam eliminates such corrosion. The amines have been used, and recently organic ammonia compounds were found practical.

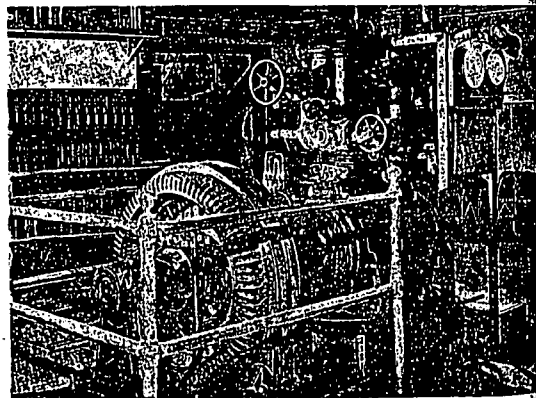
Ammonia. Encountered rarely unless water is contaminated with sewage, ammonia is very soluble and cannot be removed by ordinary desaturation; in fact, multiple or fractional distillation is required to get rid of it. Corrosion

from ammonia is confined to non-ferrous metals. Fortunately, ammonia itself does not usually cause the difficulty. (In this respect there is considerable controversy regarding the role of ammonia in corrosion.) It is the high pH resulting from ammonia presence that causes corrosion. Consequently, enough is present to raise the pH to corrosive value, usually over 8.5, acid treatment can be resorted to or ammonia can be removed with a deammoniator.

Hydrogen Sulphide. This gas rarely causes trouble. As with ammonia it is commonly found in sewage-contaminated waters, although some well waters contain appreciable amounts. Desaturation will usually remove most of it. An alkali to neutralize the acidic hydrogen sulphide may also be added under some conditions.

How to Spot Refrigerating Troubles

Trouble-shooting hints from George Holman tell how to interpret warning signs before a failure causes a shutdown



SPOTTING UNUSUAL NOISES in a machine and identifying their cause before damage occurs is one qualification of a good operator. Any one can stop a wrecked machine.

► **FAILURES** in refrigerating equipment normally warn of impending danger if you know how to read the signs. (These pointers on compressor behavior give distress signals in italics and list causes alphabetically.)

1. *Uneven vibration jars floor and pipes.* Compressor bearing begins to seize shaft or pin. Do not stop machine, but slow it down at once. Keep it turning slowly a few minutes, if possible. If bearing is exposed, spray with oil.
2. *Uneven pulsations of compressor.* A: If compressor is double-acting, valves at one end of cylinder are out of order. B: Worn or loose bearing, crank, crank pin, etc.
3. *Pistons pound as compressor starts.*

A: Oil pump has lost its prime. Bearings are uncushioned by oil. Prime by pressure adjustment, or by pouring oil into pump.

B: Oil filter is stopped up. Clean it thoroughly.

C: Wristpins, crankpins, bearings, etc. are out of order.

4. *Quick snapping sound under head of enclosed crankcase of single-acting compressor when starting at low compression ratio.*

A: Poppet-type suction valve strikes safety head. Clean valves and oil system.

B: Weak or broken closing spring poppet-type suction valve. Inspect and place with stronger spring.

C: Worn stem and dampening piston poppet-type suction valve. Replace with precise-machined suction-valve cage.

D: Suction-valve cage does not get. Inspect, clean and repair oil system.

5. *Rapid rise-and-fall of poppet-valves in compressor.*

A: Evaporator floods and liquid carries over into compressor. Stop machine once. Close expansion valve. Close (Continued on page 138)

ELECTRONICS FOR THE POWER ENGINEER

By F. A. ANNETT, Associate Editor

5—Photoelectric Tubes

► **LAST MONTH** we learned how electrons in tubes are freed by heating the cathode, a process known as thermionic emission. Here we will study how light or photoelectric emission releases electrons from a metal surface. Tubes for this purpose are popularly known as electric eyes, photocells, photo tubes and photoelectric tubes. The latter is the name by which these tubes are most commonly known, and will be used in this article.

These tubes are applied widely for smoke- and flame-indicating, opening and closing doors, liquid-level control, counting, weighing, and many other purposes. They have an anode and a light-sensitive cathode in a high-vacuum or gas-filled bulb.

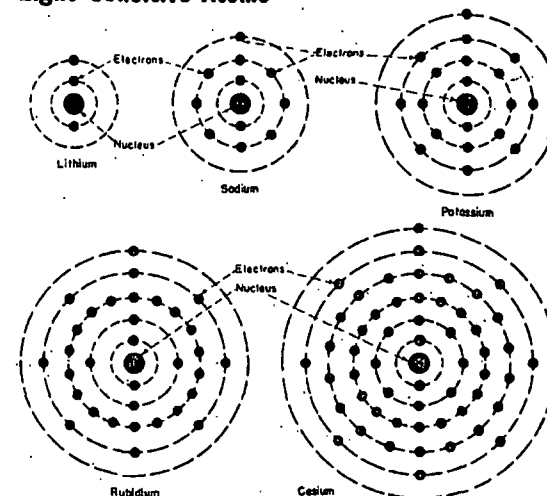
Their cathode is usually semicylindrical, Fig. 2, coated with a light-sensitive material such as oxides of cesium, barium, sodium or potassium. Their anode is usually a straight vertical wire, supported in the tube's base. It is partly surrounded by the cathode and made as small as permitted mechanically so as to cast the least possible shadow on the cathode. A light beam is focused on the cathode, as in Fig. 3, which causes electrons to flow to this anode, when a potential is applied across the two.

Light-Sensitive Metals. At this point we will consider why some metals are light-sensitive. They are for the same reason that certain metals are good conductors. In May 1948 *POWER*, p. 105, we learned that the atoms of the best conductors, copper and silver, have each a single electron in their outer orbit, located well away from the nucleus.

The single electron of each atom is assumed to be held loosely and is influenced by adjacent atoms. In this way it is free to move about at random until brought under the influence of a voltage, when it drifts slowly from the negative to the positive terminal of the circuit.

Among the most light-sensitive materials are the alkali metals, lithium,

Light-Sensitive Atoms



Among the most light-sensitive materials are the alkali metals—lithium, sodium, potassium, rubidium and cesium. Light sensitivity increases in order named.

sodium, potassium, rubidium and cesium. Electron arrangement of each is shown in Fig. 1. As would be expected, lithium is the least light-sensitive, the single electron in its outer orbit being the closest to the nucleus of all five elements. On the other hand, cesium, which has the single electron in its outer orbit farthest from the nucleus, is the most light-sensitive.

Unless there is some reason for doing otherwise, cesium and its oxides are most generally used for the cathode coating of photoelectric tubes. Such a cathode may have a silver-plated copper base covered by a thin layer of

cesium oxide over which is an exceedingly thin deposit of cesium. Such a construction improves the light sensitivity of the cathode.

Photoelectric tubes with such a cathode are particularly suitable for use with incandescent lamps, as they are 10 to 100 times more light-sensitive than those with other practical cathodes. Such tubes are sensitive to the same light as the human eye and are used in color matching. They are also used in most industrial relays that operate on the interruption, diffusion, deflection, reflection or refraction of a light beam. Alkaline earths—barium, strontium,