for the roofs of greenhouses to keep the plants warm inside. At lofty elevations, like the great plateaus of Central Asia, the dry air allows the heat received by the soil during the day to escape so rapidly that a freezing temperature is felt before the night is ended; and this in turn is followed by torrid heat in the early afternoon.

**4. Absorption and Reflection.**—A good absorber is also a good radiator, but a good reflector can be neither. Snow is a good reflector, but a poor absorber or radiator. Light colors often absorb solar heat less and reflect more than dark colors.* White is generally considered the best reflector, and black the best absorber and radiator. But the nature of the material is of more importance than its tint. If on a bright summer day three thermometers are exposed to the sun, one held up in mid-air, another resting on a bed of black silk, and the third on a bed of white sand, it will be found in a short time that the temperatures indicated will be very different. The thermometer on the sand will have its bulb more warmed than that on the bed of black silk; and both of these will be warmer than the one in mid-air.

vapor to check the radiation back into space. See "American Journal of Science," March, 1883.

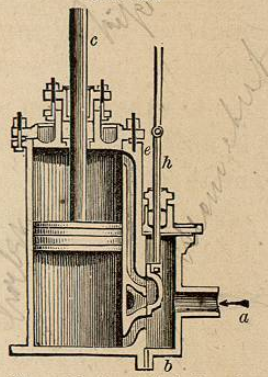
* Experiments show that with artificial heat the molecular condition of the surface varies radiation as well as reflection. In fact, white lead is as good a radiator as lamp-black.—On one side of a sheet of paper paste letters of gold-leaf. Spread over the opposite side a thin coating of scarlet iodide of mercury—a salt which turns yellow on the application of heat. Turn the scarlet side down. Hold over the paper a red-hot iron. The gold-leaf will reflect the heat, but the paper spaces between the letters will absorb it, and on turning the paper over, the gilt letters will be found traced in scarlet on a yellow background.



## IV. THE STEAM-ENGINE.

When steam rises from water at a temperature of 212°, it has an elastic force of nearly 15 lbs. per square inch. If the steam be confined and the temperature raised, the elastic force will be rapidly increased.

Fig. 186.



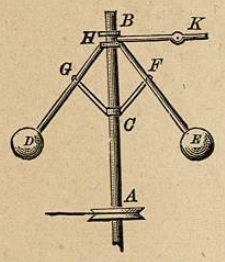

Steam-chest and Cylinder of an Engine.

**1. The Steam-engine** is a machine for using the elastic force of steam as a motive power. There are two classes, *high-pressure* and *low-pressure*. In the former, the steam, after it has done its work, is forced out into the air; in the latter, it is condensed in a separate chamber by a spray of cold water. As the steam is condensed in the low-pressure engine, a vacuum is formed behind the piston; while the piston of the high-pressure engine acts against the pressure of the air. The elastic force of the steam must be 15 lbs. per square inch greater in the latter case. The figure represents the piston and connecting pipes of an engine. The steam from the boiler passes through the pipe, *a*, into the steam-chest, *b*, as indicated by the arrow. The sliding-valve worked by the rod *h* lets the steam into the cylinder, alternately above and below the piston, which is thus made to play up and down by the expansive force. This valve is so arranged that at the moment fresh

steam is let in on one side of the piston, the spent steam on the other side is released into the outer air, or into the condensing chamber.

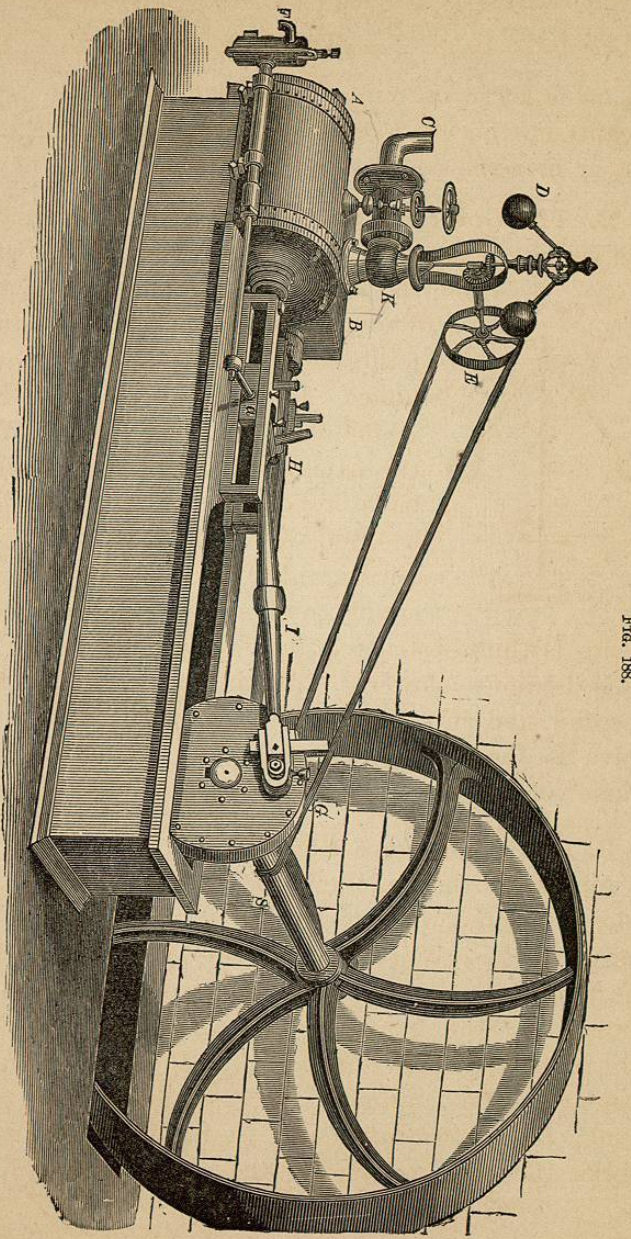
**2. The Governor** is an apparatus for regulating the supply of steam. $AB$ is the axis around which the heavy balls $E$ and $D$ revolve. They are so connected by hinge-joints that the ring at $B$ may be pulled down or lifted by them, while that at $C$ is fixed. When the machine is going too fast, the balls fly out and thus pull down the rod, $K$, which is in connection with a valve that controls the pipe supplying steam. A portion of the steam is thus obstructed, and the revolution of the balls becomes slower. This in turn makes them descend, and in so doing they lift the rod, $K$. The valve is thereby opened and more steam supplied, whenever the speed of revolution becomes too small.

Fig. 187.




The Governor.

**3. A High-pressure Engine** is shown in Fig. 188. $A$ represents the cylinder; $B$, the steam-chest at its side, connected with it on the interior by the sliding-valve already shown; $C$, the throttle-valve in the pipe through which steam is admitted from the boiler; $D$, the governor; $E$, the band-wheel by which the governor is driven; $F$, the pump; $G$, the crank; $I$, the conductor attached to $a$, the cross-head; $H$, the eccentric rod ($h$ in Fig. 186) which works the sliding-valve in the steam-chest; $K$, the




High-pressure Steam-engine.

Fig. 188.

governor-valve; *S*, the shaft by which the power is conveyed to the machinery. The cross-head, *a*, slides to and fro in a groove, and is fastened to the rod which works the piston in the cylinder *A*. The expansive force of the steam is thus communicated to *a*, thence to *I*, by which the crank is turned. The heavy fly-wheel renders the motion uniform (p. 23).

## V. METEOROLOGY.

**1. General Principles.**—(1.) The air always contains moisture. The amount it can receive depends upon the temperature; warm air absorbing more, and cold air less. At 100° F., a cubic foot of air can hold nearly 20 grains of invisible water vapor; a reduction of 70° will cause nine tenths of that quantity to be condensed into visible droplets. When the air at any temperature contains all the vapor it can hold in an invisible state, it is said to be saturated; *any fall of temperature will then condense a part of the vapor.*

(2.) When air expands against pressure (*i. e.*, doing work in the expansion), its energy, being thus expended, ceases to be manifested as temperature. The warm air from the earth ascending into the upper regions, is thus rarefied and cooled. Its vapor is then condensed into clouds, and often falls as rain. Owing to this expansion of the atmosphere and the greater radiation of heat in the dry air of the upper regions, there is a gradual diminution of the temperature as the altitude increases, the mean rate in the north temperate zone being about 1° for 300 feet.



**2. Dew.***—The grass at night, becoming cooled by radiation, condenses the vapor of the adjacent air upon its surface. Dew will gather most freely upon the best radiators, as they will the soonest become cool. Thus grass, leaves, etc., receive the largest deposits. It will not form on windy nights, nor when there are clouds in the sky to reflect the heat radiated from the ground. In tropical regions the nocturnal radiation on clear nights is often so great as to render the formation of ice possible. In Bengal, water is exposed for this purpose in shallow earthen dishes resting on rice straw. In parts of Chili, Arabia, etc., by its abundance, dew feebly supplies the place of rain. When the temperature of plants falls below 32°, the vapor is frozen upon them directly, and is called *white*, or *hoar-frost.*

**3. Fogs** are formed when the temperature of the air falls below the *dew-point*, *i. e.*, the temperature at which dew is deposited for a given degree of humidity. They are characteristic of low lands, rivers, etc., where the air is saturated with moisture.

* Dew was anciently thought to possess wonderful properties. Baths in this precious liquid were said greatly to conduce to beauty. It was collected for this purpose, and for the use of the alchemists in their weird experiments, by spreading fleeces of wool upon the ground. Laurens, a philosopher of the middle ages, claimed that dew is ethereal, so that if we should fill a lark's egg with it and lay it out in the sun, immediately on the rising of that luminary, the egg would fly off into the air!