

reduction in tractive effort during the change. A smooth transition between all points, both rheostatic and transitional, insures motor operation close to the slipping point of the wheels and a steady, gradual acceleration at all times.

The motors have sufficient capacity to slip the wheels, the slipping point serving as a current limit to prevent overloading. Either pair of motors may be cut out, in case of emergency, by means of a special handle on the change-over switch.

Controllers.—The master controllers receive their energizing current at a potential of 125 volts from the motor generator set and provide for operating the contactors so that they close the motor circuits under different combinations and regulate the external motor resistances to give 10 points series and 9 points parallel. The controller is of the non-automatic type and has two handles: one regulating the applied voltage at the motors and the other for controlling the direction of rotation of the motors. Each of the above handles control a single cylinder.

Pantograph Trolleys.—The overhead trolleys are of the pantograph type, mounted on insulated bases and pneumatically operated. A hand pump is provided for raising the trolley in case a locomotive has been standing some time and has no air supply.

Automatic Stops.—Provision is made for automatically opening the control circuit and cutting off all power from the locomotive, in case the engineer over-runs a signal set against him. At the same time a special valve is opened which will set the emergency air brake.

The huge scheme, undertaken at a cost of £3,500,000 sterling, of the provision of a water supply for the gold fields of Western Australia, is a wonderful piece of hydraulic engineering work, and is now well advanced. The primary purpose of the work was not to insure the subsistence of a large community of people, but to maintain and develop a staple industry established in a practically waterless district 400 miles from the western coast of the state. A daily supply of 5,600,000 gallons was to be provided, of which 5,000,000 were for use in the gold fields. The source of supply is an artificial reservoir, from which the water is pumped through a steel conduit 80 inches in diameter by means of eight pumping installations to the main distributing reservoir at Bulla Bulling. This reservoir is 308 miles from the main reservoir and is 1,200 feet above the lowest outlet level of the latter. The water then gravitates a distance of 44½ miles to the Coolgardie service reservoir and the Kalgoorlie service reservoir. The details of all the ironwork used in the construction of the weir were drawn out in the state and all the ironwork used was obtained from Great Britain, and it says much for the accuracy displayed in the drawings that on being grouped together as the work progressed all parts fitted correctly into their proper places. An interesting feature of the work at Kalgoorlie was the use of camels for excavation purposes. According to figures supplied for the use of the Christian Science Monitor by Neil McQueen, the district engineer, 86 camels were used for the excavation work, which was in stiff clay, in connection with the Kalgoorlie reservoir. This reservoir will be lined with a bitumen asphalt compound invented by P. V. O'Brien, the chief engineer in charge, and will be roofed with corrugated iron to keep dust out of the water and prevent evaporation. The reservoir, which is circular, has a diameter of 378 feet and a depth of 22 feet at the deepest part. Its capacity is 10,000,000 gallons.

THE CORROSION OF PIPES BY RAW AND TREATED WATERS.

THE lengthy series of investigations based upon the corrosion of iron pipes by water supply was carried on during 1912 by the Department of Water Supply, Gas and Electricity of New York City. The results of these experiments are contained in a paper read recently before the American Public Health Association by Mr. Frank E. Hale, from whose paper the following information is deduced:—

The presence of carbonic acid is the most potent factor in connection with the presence of dissolved oxygen. The action of these two agents is modified by the presence of other salts, increased by nitrates which furnish oxygen by reduction, and decreased by carbonates which help to form protective coatings upon the pipe. The chemical action takes place in the following order:

The first reaction is the solution of iron as bicarbonate by carbonic acid with the formation of hydrogen. The dissolved oxygen in the water which is near the iron surface oxidizes some of the hydrogen back to water. After the oxygen near the iron is used up the hydrogen remains as a gas. In the cold reaction of the experiments the amount of hydrogen oxidized was found to be about 20 per cent. The dissolved oxygen at the same time oxidizes the soluble iron bicarbonate to insoluble red iron, setting free again the carbonic acid. The carbonic acid set free again dissolves more iron, and is again set free, until all of the dissolved oxygen is exhausted. The red iron oxide then acts as oxidizer until it is completely reduced to black magnetic iron oxide, setting free carbonic acid again. Reduction does not take place beyond this stage. After all dissolved oxygen has been used up nitrates are completely reduced to ammonia, serving to supply oxygen. After all possible sources of oxygen are exhausted the carbonic acid dissolves more iron, which is probably thrown out of solution finally as insoluble basic carbonate of iron, since after complete reaction there is only about 0.2 to 0.7 p.p.m. iron in solution, no free carbonic acid, no dissolved oxygen, no nitrate, sometimes no bicarbonic acid, and under some conditions caustic lime is present. The alkalinity of hard waters is reduced to about 25 p.p.m.

The carbonic acid for the solvent action may be derived from three sources—the free carbonic acid, the bicarbonic acid, and the neutral carbonate. In the latter case the carbonate hydrolyzes so that there are in solution neutral carbonate, lime hydrate and carbonic acid. This takes place when the water reaches the stage that only neutral carbonate is present. The carbonic acid set free dissolves the iron. The presence of lime hydrate was proven by titration with phenolphthalein and methyl orange.

The rapidity of corrosive action is affected by the source of carbonic acid in order as given above, and the amount of soluble iron present during the active stages of corrosion varies with the above order of source of carbonic acid.

Another source of carbonic acid is that set free in alum-treated waters. This is really mostly bicarbonic acid set free. The amount set free per grain of alum per gallon is not, as sometimes stated, 6.8 p.p.m., but about 3.5 p.p.m. (determined by analysis).

It must be understood that the facts as given above apply to new pipe with a clean iron surface and to complete reaction.

Attempts to remove dissolved oxygen from water appear to me to be hopeless as well as expensive, because a consideration of the above reaction brings out a fact that