

passenger train was derailed and nearly all of the cars were overturned and ditched. A number of passengers were injured.

rc, 25th, 8 p. m., Chicago Great Western, Dyersville, Iowa, an eastbound freight train which was switching at the station was run into at the rear by a following freight, damaging the engine of the second train, a pushing engine at the rear of the first train, and the caboose and several cars. A drover and one other man in the caboose and the fireman of the second train were killed and a drover and two trainmen were injured.

rc, 20th, 5 a. m., Southern Railway, Durham, N. C., a freight train which had been unexpectedly stopped was run into at the rear by a following freight, and the engine and five cars were wrecked. Two trainmen were injured.

xc, 25th, Pennsylvania road, Rockville, Pa., a passenger train collided with some freight cars being switched on the main track, and the engine man was killed.

uf, 26th, 2 a. m., Seaboard Air Line, Panasoffke, Fla., passenger train No. 50 broke through a trestle bridge which had been weakened by fire, and one passenger car was overturned. Several passengers were injured.

xc, 27th, Seaboard Air Line, Athens, Ga., collision of freight trains; one engine man killed.

*unx, 27th, Norfolk & Western, Henry, Va., a freight train was derailed and the two engines drawing it together with nine cars, were wrecked. The wreck took fire and was partly burnt up. Two engine men and one fireman were killed and one other trainman was injured.

unx, 27th, Grand Trunk, Helena, N. Y., a passenger train was derailed and 11 passengers were injured.

bc, 28th, Alabama Great Southern, Coaling, Ala., butting collision of freight trains, wrecking both engines and several cars. One of the trains had stopped at the station and the other one approached at uncontrollable speed. A tramp was killed and one engine man was injured.

unf, 20th, Atlantic Coast Line, Alapaha, Ga., a passenger train was derailed at a misplaced switch and three trainmen were injured. It is said that the switch had been maliciously misplaced.

Water Softening.

At a recent meeting of the Engineers' Society of Western Pennsylvania, Mr. James O. Haudy, Chief Chemist of the Pittsburg Testing Laboratory, read a paper on the above subject. The first part of the paper gives a good history of the development of water-softening apparatus, including general descriptions of the prominent types of apparatus now on the market. Mr. Haudy concludes that the essential principles of water softening on which any successful machines must be based are:

In a continuous system the feeding of chemicals must be very precise and capable of easy adjustment and the devices must be simple.

The chemicals and water must be thoroughly mixed for a sufficient length of time under proper conditions so that the softening process is completed before using the water.

The internal construction of a continuous machine should be such that the steady progress of the water through the machine is certain. There must be no eddies and if the supply is delivered intermittently or the rate of pumping is variable, it is essential that the uneven flow be counteracted.

In order to reduce the trouble and expense of operation the apparatus should be designed so that clarification is very complete, thus leaving little work for the filters.

A continuous apparatus should hold four times the maximum hourly output. In an intermittent type of apparatus the time for filling and emptying tanks must be added to the four hours standing. This makes the tank area in the intermittent system usually about twice that in the continuous system.

The softened water should be entirely clarified when discharged.

Labor and superintendence must be cut down to the minimum and high class labor should be employed.

The continuous system has the advantages of simplicity and compactness and is cheaper to operate, because it requires less power and less labor and there are fewer valves to get out of order. The maintenance charges are also less if steel construction is used.

Mr. Haudy also calls attention to the lack of uniformity in the methods of obtaining and expressing the analytical results on which water softening calculations are based. The method used by the Pittsburg Testing Laboratory is as follows: Evaporation to dryness on the water bath. Treatment with the boiling distilled water free from carbon dioxide. Filtration and washing with boiling water. The residue is thoroughly rubbed up with a rubber-coated rod. If the water is high in sulphates, use plenty of hot water. Dissolve the insoluble part in dilute hydrochloric acid. Determine iron, lime and magnesia volumetrically in both soluble and insoluble portions. Express results as soluble and insoluble lime and magnesia. Determine silica in separate portion. Determine chlorine and sulphuric anhydride by usual methods. Determine alkalinity or acidity by adding a measured excess of standard d.n. sulphuric acid to 100 c.c. of water, boiling 20 minutes in platinum or porcelain, and titrating back with deci-normal sodium hydrate, using phenolphthalein indicator. Calculate acidity to sulphuric acid or alkalinity to calcium carbonate. Determine nitric anhydride by the phenol-sulphuric method, using silver sulphate to remove chlorine before evaporation, and adding a little sodium carbonate to prevent loss in evaporation.

Free carbon dioxide is determined if the sample has been sent in a sealed condition, so that the gas has not escaped. This is determined by titrating 50 c.c. in a nessler tube, with 1/50 N. sodium carbonate.

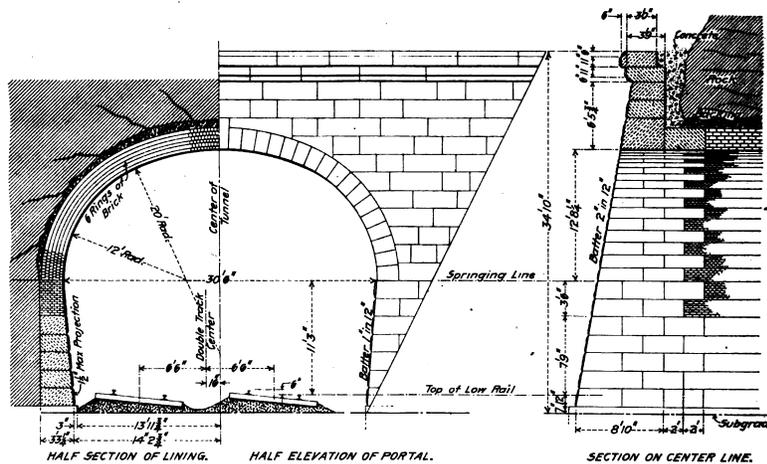
The calculation of chemical treatment required for softening hard water or neutralization of acid water is

based entirely on the amounts of free carbon dioxide, soluble and insoluble lime and magnesia, free acid and iron. It is in the less important matter of arbitrarily disposing the acids among the bases that chemists differ. Proper practice is to calculate insoluble lime and magnesia to carbonates. The residual alkalinity is figured to sodium carbonate. When, however, we have to decide how much of the soluble lime is combined with sulphuric anhydride or other acids, and the same for the soluble magnesia, we realize that we can no longer proceed logically, but must follow an arbitrary practice. It is possible by using dilute alcohol for extraction of the original solid residue to leave calcium sulphate behind with the carbonates of lime and magnesia. This, however, seems of questionable advantage, as the separation of all sulphate of soda is difficult, and sulphuric acid has to be determined twice. This method is not used, but if used it would be best to make the separation by water first, then evaporate to dryness and extract with alcohol. An arbitrary method of calculating is to give the soluble lime first sulphuric anhydride, then chlorine, then nitric anhydride until satisfied. Satisfy soluble magnesia in the same way with what remains, calculate residual acid radicals to soda, unless both soda and potash has been determined. In that case satisfy soda first. The question is whether to recommend the introduction of the alcohol method into ordinary practice for the sake of actually determining sulphate of lime, or to figure all soluble lime to sulphate, if there is enough sulphuric acid present.

It may be supposed that calcium chloride and nitrate, and the corresponding salts of magnesia, including also the sulphate, do not form scale, and, therefore, need not be removed. In reply to this it may be said that it is doubtful whether any magnesium salts are stable under boiler conditions, and they should all be removed to prevent corrosion. It is difficult, if not impossible, to partially treat a water so as to leave calcium chloride and nitrate undisturbed. They are objectionable, as they change to sulphate if magnesium sulphate is present. They should, therefore, be removed.

Standard Tunnel Section, Norfolk & Western.

A description of some of the most interesting features of the Norfolk and Western was published in the *Railroad Gazette* July 3 and 24 and Sept. 25, 1903. Supplementing these articles, what may be considered as a standard tunnel section on that road is now presented. The drawing shows the portal and section of tunnel No. 3 on the double track line between Elliston and Christiansburg. Modifications are, of course, made to suit the local conditions where such work is done; but, in the main, an attempt is made to adhere to the general standard form



Standard Tunnel Section on the Norfolk & Western.

shown. As much of the rockwork along the line is soft shale and sandstone associated with the coal formations, lining is a necessary element of the tunnel construction. The lining is formed by an arch, six bricks deep with a concrete grouting between it and the overlying rock, so that the latter is evenly supported and the danger of caving is prevented. These rocks need such a support, else pieces of greater or smaller size are apt to fall down and impose a local overload on the brickwork.

The springing line of the arch is 11 ft. 3 in. above the top of the rail and the latter is 1 ft. 7 in. above the subgrade. The width of the arch at the springing line is 30 ft. 6 in. and it is turned on radii of 12 ft. and 20 ft. for the sides and crown respectively. The sides are of stone with a brick cap, and rise with a batter of 1 in 12. The portals are of cut stone with the front face carried up to a sufficient height to serve as a retaining wall and prevent the sliding of earth or rock down upon the track. In the case illustrated it is 34 ft. 10 in. above the subgrade line. This stonework is laid in cement with 3-16 in. joints, and a face batter of 2 in 12. The track is laid on broken stone ballast, well tamped beneath the ties.

This section is now being substituted in a number of

tunnels where the roof was either left unsupported or where timbering was put in in order to save on first cost, and the work will probably be extended to other tunnels on the line until they all conform to the standard. Improvements of this character have brought the road up to its present state of efficiency.

Performance of Automatic Block Signals Under Unfavorable Conditions.

BY H. S. BALLEET,
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I.—FROST.

[The interest shown by readers in Mr. Balleet's article of Feb. 26 has been so general that we have asked him to discuss automatic signals and the problems of their maintenance and operation more at length, and the first of a series of articles is given below.—EDITOR.]

Interruptions to the regular operation of automatic block signals occur mostly during the winter months, and principally on account of sudden changes in temperature. Failures peculiar to the summer months are those due to heavy thunderstorms.

The winter of 1903-04 has proved to be the most severe in many years, and signal apparatus has been affected by weather throughout a large territory. A few railroads have for several winters suffered the inconveniences of these weather conditions, but it remained for the present season to determine what kinds and how many signals and how large a territory are susceptible. But few railroads were prepared to anticipate the extreme conditions.

Tests made during the past eight years have developed many peculiarities or "freaks" in the causes of failures of signal apparatus, the most interesting of these being those due to frost. Frost and ice are responsible for many failures noted in daily practice as "cause unknown." The mechanism and controlling parts of signals in boxes and other enclosures are subject to conditions comparable with those attending the formation of dew and afterwards frost on grass, fences and board walks. Frost forms within some enclosures more readily than in others. Dew is formed at night, frost occurs in the morning.

The air always contains moisture. The amount it can hold depends upon the temperature; warm air more, cold air less. A cubic yard of air, at 75 deg. F. will hold half an ounce of water. A reduction of 27 deg. will cause half that quantity to be deposited. When the air is saturated with moisture, or, more properly, vapor, any fall of temperature will condense a part of the vapor. Grass, at night, becoming cooled by radiation, condenses upon its surface, the vapor of the air. Dew will gather most freely upon the best radiators, as they will the soonest

become cool. It will not form on windy nights even if the wind is light, because the air is constantly changing and does not become cool enough to deposit its moisture. When the temperature of the grass falls below 32 deg. F., the vapor or moisture is frozen into hoar-frost.

The precipitation of moisture within enclosures is diametrically opposite to that just described, except that the condition is noted in the morning when the sun is above the horizon (the sky need not be cloudless). The heat of the sun strikes the earth, and this heat is radiated back as obscure heat in long slow waves. The heat from the sun is transmitted to the earth in straight lines and does not heat the surrounding air. Space is not warmed by the sunbeam, neither do rays of heat always elevate the temperature of the medium through which they pass; but the heat that is in the earth tends to diffuse itself equally among surrounding bodies; and it is this latter condition which plays so much havoc with metallic surfaces. The air surrounding iron cases taking heat from the earth causes the temperature of the metal to rise and the heat contained in the metal is transmitted to the air within the enclosure. Where wood is used to protect the apparatus, the warm air on the outside

affects the wood very slowly. In consequence of this obstruction or insulator, the air within is heated gradually, thereby allowing the metal parts of the apparatus to warm at the same rate. It is evident, therefore, that it is not, as is generally supposed, the fault of the cold wave that frost interrupts signal operations; it is the sudden rise in temperature. The temperature of the metallic parts within the case is considerably below 32 deg. F., and the air within the enclosures as well as that surrounding them rises rapidly.

The mechanisms being separated from the sides of the cases by bodies of air, remain at the lower temperature until the air can warm them. The moisture is precipitated because the heat of the air is abstracted and transmitted to the metal, and when it touches the metals, it is frozen and sticks there. If the rise in temperature continues, this frost is reconverted into water, and not infrequently large drops are seen to have been formed on all metals within the enclosure. The metals most affected are copper, steel and cast iron. Platinum, German silver and composition metals will be considered in connection with relays.

Where these sudden rises in temperature are followed by rapid declines, say, 30 deg. to 40 deg. within a few hours, the warm air, having already absorbed some moisture from the outer atmosphere, seems to be incapable of collecting all the moisture from the various metal parts, and as soon as the decline sets in, a portion of the moisture contained in the air, within the enclosure, is precipitated and deposited on the same parts. The entire quantity, seemingly so very little, freezes into ice and not infrequently causes important moving parts of the mechanism to be frozen together, making them immovable. It usually requires three to five hours for the metals to heat so that their temperature will correspond with that of the air. This is readily demonstrated by opening the enclosure and noting how quickly the frost is dissipated by air rushing in. If the deposit is light, it will disappear almost instantly; now restore the original condition by intercepting the means of ventilation and wait about thirty minutes; and, unless the temperatures are alike, in the air and the metal, frost will again be formed.

Interruptions due to this frosty condition have been found, from close observation, to be confined principally to the months of November, December and January. Slight frost conditions are noted at a few scattered signals during October and February. Most of the trouble, as already shown, is experienced with signals in regions where the air is heavily charged with vapor.

Again, it is found that the location of the sun enters largely into these frost conditions. It is an interesting fact that frost troubles are only heard of during the winter solstice. This is due to the shorter time that the sun is above the horizon during that season, which means but little heat radiated to the earth.

Though the conditions here enumerated appear to be beyond check or control, many efforts have been made to anticipate the accumulation of frost and ice, and with more or less success. The first practical design of an enclosure for protecting automatic block signal mechanism from interruption by the elements was put in service as early as 1866. This design is the pioneer of the enclosed disk, or "banjo" signal case of to-day. There are now two distinct designs of these cases: The one is built up each side, of two thicknesses of narrow boards with an iron frame surrounding them; the other is of sheet iron exclusively. Ten years' practice substantiates the claim that both are storm-proof.

The operating and controlling electro-magnets and the disk are contained in these cases; in a number of installations, the lightning arrester and also the track relay are located therein. This is done to simplify the installation and facilitate inspection.

Where but one case is used to give the required indication, it is usually placed on top of a hollow iron mast; where two cases are required, as for a home and a distant signal at the same point, they are placed on brackets which are bolted to the sides of wood or iron masts.

There are but few moving parts to the mechanisms contained within these cases, and it is due to the simplicity of construction and control, that there is so little interruption to their perfect operation. Instances are, however, on record where ice has formed between the revolving armature and its pole pieces, causing the disk to remain in the position occupied at the time of freezing. The excess of moisture in these cases is small for several reasons. First: The case is always situated some distance above the surface of the ground, which gives it the benefit of air freely circulating around it. Second: The small amount of metal surface and the presence of a large quantity of air reduces the amount of precipitation. Third: Where the case is of wood, a poor conductor of heat, the temperature within is raised slowly.

The exposed or "clock work" disk signal is designed so as to require the use of a hollow iron post, the mechanism, case and disks being located on the top of same. The gears, armatures and controlling electro-magnets, as well as the contacts for controlling the circuits, are placed within a square cast iron enclosure just below the disk. This signal, as the name implies, is operated by means of a weight, which is suspended within the hollow post.

Frost causes serious interruptions to the proper operation of these mechanisms. In addition to clogging the gear, the accumulation of ice will prevent the revolving of the disk by freezing the main vertical shaft to the bearing. Most of the trouble from frost is caused by the

mechanism being set directly over the hollow post which allows communication with the earth.

In the electro-pneumatic semaphore signals, as originally designed, the only apparatus which are protected from interference by the elements are the electro-magnet and the valve which controls the supply of air used to set the semaphore arms in the proceed position. In more recent installations, the balance levers and vertical rods which work the arms have been placed within cast iron enclosures. Frost does not appear to interfere with this mechanism, but the condensed moisture in the valve sometimes freezes and prevents its prompt operation.

The earlier types of the electric semaphore were worked by outside connections. There are still in use many of this type. The motor and mechanism are in a box on a bracket sufficiently far down from the top of the post to allow the convenient operation of the balance lever. Although set high above the surface of the ground, these motors and their mechanism are frequently interrupted by frost. They are enclosed in a metallic case fairly well ventilated. This mechanism usually consists of a motor driving a drum to wind—a cable to raise the balance lever. The frost makes trouble by accumulating on the motor commutator enough to insulate the brushes; it also forms in such quantities as to clog the gear.

In the Union and the Hall electric semaphores all of the apparatus, including motor, gears, slots, clutches, relays and lightning arresters, are contained within an iron box fixed at the base of an iron mast, which contains the vertical rods. There are several important details to be considered in connection with these installations; one of the most important being the design of the mechanism case.

The latest design of a cast iron mechanism case now in use is so arranged as to allow no room for a battery, the base of the case being bolted directly to a concrete foundation. In this arrangement, the dash pots are also set on the concrete, the motor, its mechanism and the controlling electrical parts being mounted on a wooden or cast iron shelf some distance above the dash pots. The dash pots are frequently frosted and the return of the arm to the stop position is somewhat delayed. The mechanisms gather large quantities of frost and sometimes ice; there is one case on record where there was sufficient of the latter to prevent its operation. The part most susceptible to frost is the motor commutator. It is subject to most interruption when it has no covering of any kind to prevent the air coming directly in contact with it; the frost will insulate the brushes, thereby preventing rotation. The precipitation of moisture on unprotected commutators is sometimes anticipated by applying a coating of oil. This is partially effective; it will act as a preventive in the milder cases. A better way to anticipate this interruption is to cover the commutator with flannel or felt; this overcomes many petty interferences from frost; but extreme cases arise and this also fails.

These iron cases are ventilated on two sides. The air is allowed to circulate through these two openings (about 1½ in. in diameter, suitably protected outside to prevent storms from beating in), and if there is enough wind to keep the air within in circulation, the accumulation of frost will not be troublesome. This means of preventing the moisture in the air from precipitating is satisfactory until the draft ceases and then the difficulty reappears. A number of plans to successfully ventilate several hundred of this design of mechanism cases by means of a draft have thus far failed.

The later designs of iron posts have a mechanism case and a battery case bolted together. These cases are built up from cast iron frames, and are covered with sheet iron. The battery case is bolted directly to the concrete base. These cases have no ventilating openings. Mechanisms in them do not show any less accumulation of frost than in cast iron. Most of the motors in these have their commutators covered either by glass or a combination of celluloid and brass. In ordinary circumstances this is quite effective, but extraordinary frosts still cause interruption. Scientifically there is but one sure relief; that is to keep the air circulating. There is a second remedy if it could be carried out; that is to keep the air dry. Of the first solution, it may be said that a number of plans to create a draft have been tried and appear to be hopeless failures. If one deems the expense justifiable, well-made fan motors within the enclosure, operated from a battery, would be effective. If a fan is kept in proper working order, it will prove an absolute success; this has been demonstrated. As to keeping the air free from moisture, many things have been tried, some of the most interesting being sulphuric acid, ordinary burnt rock lime, and chloride of lime. Heat, provided by hot water apparatus, thermal coils and kerosene oil lamps, has also failed. In several cases the lamps increased the trouble by promoting the formation of ice. At one time, the experiment was carried so far as to build large fires on the ground near the case in an effort to dry the air, but it proved fruitless. Lining these iron cases with white pine boards appears to have given some relief. Lining with hair insulator also assists very materially in the reduction of the interference.

The gas signals, operated by liquid carbonic gas, are placed in iron mechanism cases to which is bolted a sub-case for the battery, both cases being surrounded by the iron signal mast, the design corresponding with the one built of sheet iron and previously described. In some localities frost is deposited on these mechanisms; it takes, however, an extreme case to interrupt its operation. The properties of this gas are such as to insure perfect free-

dom from freezing. If, however, there is moisture in the gas, there is likely to be freezing at the valve, thereby causing failures in operation. The gas (if perfectly dry) exhausting from the cylinder, after the signal has been set to the proceed position, absorbs whatever moisture there may be in the enclosure, thereby decreasing the chance that frost will accumulate.

Electric Railroads in Ohio.

The Street Railway Journal reviews the progress made by the street railroads in Ohio. Ten syndicates operate about 1,700 of the 2,917 miles of electric road within the State. These syndicates and the mileage they work, classified according to whether it is interurban or city, are as follows:

Name.	Interurban.	City.	Total.
Everett-Moore	272	195	414
Elkins-Widener	141	226	387
Pomeroy-Mandelbaum	250	...	250
Andrews-Stanley	220
Tucker-Anthony	163	20	183
Appleyard	142	16	158
Winters-Clegg	80	40	120
Allen-Stone	110	...	110
Columbus Railway & Light	8	98	106
Scrugham	101	...	101

The gross earnings of electric roads for the year ending April 30, 1903, according to reports filed with the Auditor of State, these being the latest figures obtainable, were \$18,927,250. Of course, this is on a considerably smaller mileage than is in operation at the present, since a number of roads were placed in operation last year, and their earnings did not figure at all in this total. It should also be considered that several roads were placed in operation late in 1902, hence, did not figure for an entire year, neither were they up to their full earning power, on account of only partial operation in many cases. But it is safe to say that Ohio roads earned \$20,000,000 in 1903.

It is manifestly impossible to separate the earnings of the city roads from those of the interurbans, because a number of companies operate and figure both together, but it is interesting to note that as, indicated by the following table, the city roads of the five leading cities of the State, with less than one-fourth the total mileage, earned over one-half the total gross receipts:

City.	Earnings.	Mileage.
Cleveland	\$4,500,000	220
Cincinnati	3,500,000	210
Toledo	1,500,000	102
Columbus	1,200,000	106
Dayton	785,000	63
Total	\$10,985,000	701

The handling of freight and express is beginning to prove quite an important item in the earnings of some of the electric roads of Ohio, but as a general proposition it can only be considered as being in its infancy. Forty-one companies engaged in either one branch or the other during the year ending April 30, 1903, and the total receipts from both sources were \$343,735. The largest earnings were made by those companies that handled freight at freight rates, rather than express, which tends to refute the growing impression that the earnings are larger where goods are handled as express at express rates. The showings of some of the best of the freight and express handling roads are shown in the accompanying table:

Name.	Gross Freight.	Expr's.	Both.
Fairfield Tr. Co. (Lancaster)	\$10,800	\$3,200	...
Eastern Ohio Traction	197,000	44,000	...
Toledo & Western	122,000	23,000	...
Cincinnati, Dayton & Toledo	482,000	2,700	\$11,000
Cleve., Painesville & East.	231,000	...	10,000
Cin., Georgetown & Pittsmonth	130,600	37,500	10,200
Cleve. & South'n Tr. Co.	382,700	10,000	7,200
Col., Buckeye Lake & Newark	130,500	...	3,800
Col., London & Springfield	119,900	...	3,200
Col., New Albany & Johnst'n	21,600	1,900	...
Dayton, Covington & Piqua	54,200	2,300	...
Dayton & Northern	96,900	9,300	...
Dayton, Spring'd & Urbana	105,600	...	11,350
Dayton & Troy	117,700	4,700	...
Dayton & Western	80,200	7,400	...
Dayton & Xenia	98,900	3,500	...
Lake Shore Electric	494,000	26,200	4,700
Mahoning Valley Ry. Co.	411,000	12,200	...
Maumee Val. Ry. & Light Co.	75,300	3,800	...
Newark & Granville Ry.	63,500	1,300	...
Northern Ohio Tr. & Lt. Co.	727,000	...	\$15,800
Ohio Central Tr. Co.	60,700	1,500	...
Ohio River El. Ry. & P. Co.	45,400	...	2,900
Canton-Akron Railway	293,000	...	2,900
Pennsylvania & Ohio Ry.	73,000	...	2,200
Flint, Fostoria & Eastern	47,400	...	3,100
Toledo, Fostoria & Findlay	59,000	...	2,064
Tuscarawas Tr. Co.	56,800	2,500	...
Western Ohio Railway	121,000	...	3,800
Youngstown & Sharon	112,200	...	3,700

The Swiss State Railroads earned in 1903 about 1½ per cent. more gross, but 9 per cent. less net than in 1902. The various claims for improved service and better treatment of employees which the companies did but the State did not resist, have naturally resulted in a considerable increase in expenses. The Gotthard Railroad, the only important Swiss line still worked by a company, earned net 5 per cent. more in 1903 than in 1902.