during the present generation, and it made him feel very old when he reflected that the first locomotive was constructed within his own time and memory. He well remembered his first trip from Detroit to Buffalo by steam. At that time there were no railroads beyond Buffalo, but a steamboat made the trip from Detroit to Buffalo in three days, which was considered to be "remarkably fast time."

The first trip by steamboat up the Hudson to Albany was made by the Clermont in 1807, the time being twenty-five hours. Four years later the Comet, a vessel 40 feet long, was built in England for the navigation of the Clyde. At that time the railroad and the locomotive were as much beyond human conjecture as any unknown achievement of the future was beyond our thoughts to-day. It seemed almost impossible that in those recent times tallow candles and whale oil furnished our lights, and that waterworks and other sanitary aids were unknown luxuries. The carpenter, the millwright, the stonemason, and the government surveyor were the engineers of the day. Steam navigation on the ocean was a problem of the future. The changes which had taken place during the past thirty-five years had been as rapid as they were marvelous. In 1830 there were only 23 miles of railway in the United States. In 1874, 69,273 miles had been completed, and including the two continents of Europe and America there had been built, in the same short interval, 125,000 miles of road.

Forty years ago the ocean steamship, with its side lever engines, its jet condenser, and its inefficient boiler, could scarcely carry coal enough for a voyage across the Atlantic. Now the iron hull, the screw propeller, the compound engine, the surface condensers, the high pressure boiler, the steam hoisting engines for loading and unloading freight, had converted the Atlantic navigation from the Eastern to the Western Continent into an extended ferry so far as the certainty and regularity of trips were concerned. Old merchants who began business forty years ago found it almost impossible to keep up with the age and adapt themselves to the wonderful changes which succeeded each other so rapidly. Twenty-five years ago, when Prof. Trowbridge was in California, the people there calculated that by the year 1880 they would have a railroad across the continent. Ten years later one road had been completed and two more were under way, both of which would soon be completed.

A gigantic contest had been and still was going on between man and the elements. With the aid of Ericsson's screw propeller, the iron hull, and the magnificent steam machinery of the present day—the work of men still living—the storms and waves of the ocean had been conquered and no steamship ever altered her course even to avoid a hurricane. There had also been a great contest on land. The railroad engineer had fought manfully and achieved great triumphs, although his battles were not yet ended. In piercing tunnels and ascending mountains he had attempted and accomplished feats unknown before to his art. He had brought to his use new explosives, electricity, the diamond and steam drill, and the strength of iron and steel in place of that of wood and stone.

Prof. Trowbridge then described the advances which have been made in military engineering. The result of the improvements in the art of attack and defense was that the wars of to-day were short and sharp, and fewer men were killed. Krupp's monster steel gun, weighing 50 tons and throwing a shot of 1,200 pounds with a charge of 170 pounds of powder, was the last and most formidable advance on the side of attack, but in the torpedo it found a deadly enemy which had come to the rescue of the side of defense.

Young engineers just starting out in the profession might think that there was nothing left for them to do except to copy the works of their predecessors, but if they allowed themselves to be discouraged by such an idea they made a great mistake. The field was as large as ever, perhaps larger. Sanitary engineering was only in its infancy, and there was no doubt that great changes were to be made in the manner of building railroads. It was a well known fact that under the present conditions a dead weight of about two and a half tons had to be drawn over the road for every passenger carried. This was certainly wrong and must be remedied. Four years ago the matter was very fully discussed in England, and the best engineer there concluded that there was no remedy. But the question was, nevertheless, an open one. Perhaps the elevated railroads which had risen like magic in the streets of New York would be the beginning of a solution of the problem. The demands of the future would be for faster travel at cheaper rates.

If any one said that there was no longer much work for educated engineers they had but to go to the top of the building (the School of Mines) and look about them. From that lookout they would see no less than half a dozen great feats in engineering going on before their eyes. He referred to the Brooklyn Bridge, the works at Hell Gate, the elevated railroads, the Harlem River improvement, the tunnel under the Hudson River, and the projected bridge over the East River at Blackwell's Island, with a span the longest in the world.

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New York Steam Fire Engines.

The Fire Department of New York has, in daily use, forty-two steam fire engines, besides the steam fire boat, W. F. Havemeyer. Six of the engines are self propellers. Under favorable circumstances the best steamers can throw a horizontal stream 250 feet. The extreme height to which water has been thrown is 150 feet. The average height to which the stream is thrown on ordinary duty is 60 feet. Each fire company costs about $14,000 a year, which sum includes the pay of officers and men, repairs to building, apparatus, etc. During 1878, the engines were employed 832 hours, each throwing on an average 16,000 gallons an hour, or over 16,000,000 gallons in all. The number of fires during the year was 1655.

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MOLECULAR CHEMISTRY.—NO. III.

From the definition of a molecular volume given in our last paper, it follows directly that the volumes of all gaseous molecules taken at the same temperature and pressure are equal. They must be equally distant from one another, or else they would not expand equally when subjected to the same degree of heat. We may conclude, then, that water vapor is made up of molecules of hydrogen and oxygen, all having the same size.

Now, what happens when this water vapor is condensed to form liquid water, or, still further, to form ice? Are all the molecules condensed equally or unequally? Or does the condensation fall only upon one constituent?

According to Herrmann Kopp, there are temperatures at which liquids and solids are also equally affected by heat, and have therefore the same number of molecules in equal volumes. Calculations are made as follows: Calling the density of a water molecule at 0° C. unity, and its equivalent weight 18, the volume it occupies at that temperature is found by dividing the latter by the former: $\frac{18}{1} = 18$. The weight of a body being the product of its density by its size or volume, or $W = D \times V$, we have also $V = \frac{W.}{D}$ Of course its volume will be greater at a higher temperature; hence the first point to be settled was: at what temperature must we make our comparisons? Kopp believed himself warranted in fixing upon the boiling points of liquids as the proper temperatures at which their densities should be compared, because, in the first place, there appears to be a close connection between the chemical composition of many liquids and the temperatures at which they boil. In numerous organic liquids, for example, whose composition differs by CH_2, the boiling points differ by 19°. Thus: alcohol C_2H_6O boils at 78°, propylic alcohol $C_2H_6O + CH_2$ boils at 78° + 19°, etc.

Again, he argued, regarding alcohol as made up of the elements of ether and of water, the volumes of the latter added together at the proper temperatures should be equal to the volume of alcohol computed from its density and equivalent. Selecting density determinations at random without regard to temperature, the results will be found discordant:

Ether $C_4H_{10}O$,	equivalent 74,	density at 12·5°	= ·724,	volume 102
Water H_2O	" 18,	" 0°	= 1·000	" 1
			Sum	103
Alcohol 2 (C_2H_6O)	" 92,	" 17·8°	= ·792,	" 116

When, however, the densities are all taken at temperatures at which the tension of their vapors is the same—one of which is the boiling point—the results agree exactly:

Ether vapor	has a tension of	·313 m. at 16°,	volume....	108 –
Water	" " "	·313 m. at 77°,	"	19 +
			Sum	127
Alcohol "	" "	·313 m. at 57°,	"	127

As we cannot accurately determine the density of a boiling liquid, Kopp was obliged to study the rate of expansion of liquids some distance below their boiling points, and calculate what their density would be, if they continued to expand at the same rate. The boiling point of a liquid may be regarded as that temperature at which its vapor has acquired sufficient tension to overcome the pressure of the atmosphere; and of course this tension is the same for all liquids boiling under the same barometric pressure. According to this view, temperatures other than the boiling points might also be chosen for a comparison of densities, provided the tension of the vapors is the same.

In the third place, Kopp found that isomeric liquids, *i. e.*, such as have very different properties, but are of the same chemical composition, and belong to the same group of bodies, have, as a rule, equal volumes at their boiling points.

Having thus, as he believed, sufficient reasons for selecting the boiling points of liquids as the proper temperatures at which to compare their densities, the question presented itself: If the specific volume of the water molecule at 0° is 18, as we have seen above, and this figure represents the sum of the volumes that $H_2 + O$ occupy in water, how much of it belongs to H_2, and how much to O? The answer to this question involved the study of an immense number of bodies, and was finally announced as the result of the following reasoning:

1. Two molecules of hydrogen may be replaced in organic liquids by one of oxygen without sensibly changing the volume. For example:

Ether	$C_4H_{10}O$	has a volume of	105·6 — 106·4
Butyric acid	$C_4H_8O_2$	" "	106·4 — 107·8
Ethyl acetate	$C_4H_8O_2$	" "	107·4 — 107·8
Acetic acid anhydrous	$C_4H_6O_3$	" "	109·9 — 110·1

It should be noticed, however, that there is here a slight increase of volume with each substitution.

2. Two molecules of hydrogen may be similarly replaced by one of carbon:

Benzoic acid	$C_7H_6O_2$	has a volume of	126·9
Valerianic acid	$C_5H_{10}O_2$	" "	130·2 — 131·2
Methyl butyrate	$C_5H_{10}O_2$	" "	125·7 — 127·3
Ethyl propionate	$C_5H_{10}O_2$	" "	125·8

3. In series whose composition progresses by increments of CH_2, the volumes increase by about 22:

CH_4O	has a volume of	41·9 — 42·9
C_2H_6O	" "	61·8 — 62·5
$C_5H_{12}O$	" "	123·6 — 124·4

The above are only a few selected out of a large number of examples given by Kopp to illustrate these three fundamental points.

Now, as CH_2 represents an increase in volume of 22, and as $C = H_2$, from the fact that it can replace H_2 without change of volume, it follows that the volume of C is 11, and that of H is 5·5, in the above compounds. $CH_2 = 11 + 2 \times 5{\cdot}5 = 22$.

With this starting point, we can obtain the volume that oxygen occupies in water. The volume of water H_2O at its boiling point is 18·8. Subtracting the volume of the hydrogen, $H_2 = 2 \times 5{\cdot}5 = 11$ from 18·8 we have left for oxygen 7·8.

When, however, oxgen is a constituent of a group of elements that enters into combination as a whole, and resembles an element in its characteristics, the volume just found will not fit. For such groups, or radicals as they are called, other values have to be sought, or else the sum of the volumes of the components will be either greater or less than the volume of the compound. Thus, in the case of aldehyde, the oxygen volume is as high as 12·2.

In 45 organic liquids containing only carbon, hydrogen, and oxygen in various proportions, the volumes computed by Kopp, according to the above figures, did not differ from those found experimentally and reduced to their boiling points by more than 4 per cent, which, he remarks, is within the limits of accuracy for such experiments. Considering these figures established, Kopp extended his investigations to substances, in which elements having ascertained volumes are combined with other elements whose volumes he wished to discover. He found the following figures: chlorine, 22·8; bromine, 27·8; iodine, 37·5; sulphur in a radical, 28·6; without, 22·6. Nitrogen assumes three widely differing values: 2·3 in aniline, etc.; 8·6 in nitrous acid; and 17·0 in ammonia. From this he concludes that the same element does not preserve a fixed volume in all its compounds.

Nearly 100 liquid compounds, containing the above elements in different proportions, have been tabulated by Kopp, in which the molecular volumes, computed by adding up the volumes of the constituents, agree closely with the volumes of the compounds found by dividing the molecular weights of the latter by the densities corresponding to their boiling points.

From this list of substances various groups may be selected, the members of which have molecules whose volumes add up to the same figure, notwithstanding great differences of composition. Hence we have in each group liquids which, when compared at their boiling points, follow the same law as gases, for they have the same number of molecules in equal volumes.

In the case of solids the alums are a noteworthy class of compounds, in which similarity of composition and identity of crystalline form are accompanied by a close agreement in molecular volume; but there are, on the other hand, numerous compounds in which, under like conditions, there is a wide dissimilarity of molecular volume, as, for example, in the case of the chlorides of sodium and potassium.

In our next paper we shall examine what other investigators have accomplished in the field opened by the laborious researches of Kopp. C. F. K.

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The Advantage of Cheap Patents.

The Philadelphia *Public Ledger* remarks that although the patent right system has been in operation for many years, there is still a strong disposition not to recognize the property rights of individuals in ideas embodied in new inventions, and quite recently an attempt has been made to modify the patent laws in the direction of making patents very costly and difficult to obtain. Without entering into the general question as to what changes in the law, if any, are desirable, it is worth while to remark that *The Machinery Market* and other English trade papers ascribe our successful competition in manufacture to the influence of our patent laws in stimulating inventions. Mr. Thomas Brassey, several years ago, warned the British workman that he had "more to fear from the highly paid labor of America, which brought labor saving machinery and mechanical skill to such a degree of perfection, than from the lower wages of the continent of Europe." It costs fully ten times as much for a patent in England as in this country, and therein we have a great advantage. It is true that many patents are issued for useless or valueless inventions, but even the failures stimulate the invention of better devices, and the general result of encouraging inventors and inventions is that machinery is carried to a higher degree of superiority here than in any nation of Europe, and better machinery enables us to compete even where we are under commercial disadvantages as to the cost of raw materials, wages, etc.

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Black Polish on Iron and Steel.

To obtain that beautiful deep black polish on iron or steel which is so much sought after, it is required to boil one part of sulphur in ten parts of oil of turpentine, the product of which is a brown sulphuric oil of disagreeable smell. This should be put on the outside as slightly as possible, and heated over a spirit lamp till the required black polish is obtained.

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"Many Mickles Make a Muckle."

According to the calculation of Mr. G. T. C. Bartley, an ounce of bread wasted daily in each household in England and Wales is equal to 25,000,000 quartern loaves, the produce of 30,000 acres of wheat, and enough to feast annually 100,000 people. An ounce of meat wasted is equal to 300,000 sheep.