Fig. 14, they will tend to remain in that position because of their mutual attractions. In other words, when a substance is once magnetized it tends to remain magnetized.

While the conclusion reached above affords a satisfactory explanation of the observed behaviour of magnetic substances, it does not give any solution of the real question, "What is magnetism?" It merely shifts the question from the magnetic substance to the molecule of that substance. Up to the present time nothing really definite is known of the cause or nature of molecular magnetism.

Ewing's Theory of Magnetism.—Consider the condition of a bar of iron fresh from the foundry or forge. If the molecules are not magnets and do not exert a force one upon the other, they will have no definite order or arrangement. If, however, they have positive and negative poles, it is obvious that they will tend to arrange themselves into more or less stable groups in which all the like poles point in one direction, or nearly so. Such an arrangement of groups is shown in Fig. 15. The arrangement in each group will be such that the poles will neutralize each other as far as possible. If such a bar of iron is placed in a weak magnetic field, the magnetic force may not be sufficient to overcome the forces which hold the groups of molecules together; i.e., to break up the groups of molecules which have formed under the influence of their own forces. If the strength of the magnetic field, which may now be referred to as a "magnetizing force," is increased until it is strong enough to overcome the forces which hold the molecules in groups, the molecules will turn around and form new groups in which the axes of the molecules will be very nearly, if not exactly, in line with the magnetizing force. If the magnetizing force is still further increased, the few molecules which still remain in their original groups, and those which are not in alignment will be forced to point in the same direction as the others. Beyond this the magnetizing force may be increased indefinitely without appreciably increasing the magnetism of the bar. The process of magnetizing a substance thus consists in forcing its molecules to point in one direction, and it is obvious that when they are all in line the limit of magnetization has been reached. In this condition the substance is said to be "saturated," since it cannot be further magnetized. From the above it follows that if a magnetizing force is gradually applied to a piece of magnetic substance the latter will become magnetized slowly at first, then very rapidly, then slowly again until it reaches a maximum.

Consider now how far this theory is supported by experiment. Suppose that means are available for producing a uniform magnetic field in which the lines of force are parallel, and that the strength of this field can be varied at will. If a bar of iron is placed in this field, with its axis parallel to the lines of force, and the strength of its magnetism is measured as the strength of the magnetizing force is increased from zero value, it will be found that there is practically no evidence of the bar being magnetized until the magnetizing force reaches a certain value; then the magnetism increases very rapidly up to a certain point, and beyond this point it increases very little. The relation between the magnetism and the magnetizing force is shown by the graph (Fig. 16). The experimental result thus obtained is in complete harmony with the theory stated above.

RAILWAY SIGNALLING.*

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"In the event of a wire failure occurring between two telegraph offices trains will simply flag across. When trouble of that kind occurs, dispatchers (in other districts) on the side of the break opposite from the dispatcher in whose territory the break occurs, will be advised by the operator closest to the break, and will move trains over the detached territory until repairs to the wire have been made."

This method of moving trains was installed on 63 miles of the Northern Pacific, single track, early in 1908, and on over 500 miles in October, 1908.

The results obtained under this method is given in the Railway Age Gazette, of February 19th, 1909, as follows:

"In the table below, the tonnage and time of the freight trains over this line for the first 15 days in November, 1908, are given, together with the average time of all freight trains for each day; and alongside of these figures are shown those for the corresponding days in 1907. The weather conditions were the same in 1908 as in 1907. At the earlier date the manual block system was in use, with standard code dispatching rules, but permissive blocking was freely used; while at the later date there was no permissive signalling. As will be seen by the summary at the bottom, the average running time was reduced 9¾%, though the number of trains run was 20% greater. Besides this increase in trains, the operation of the division was complicated in 1908 by the presence of four work trains each day, traversing a territory of 20 miles, making usually four trips a day, or 16 trips for the four trains. The number of through passenger trains is four each way daily." I have not copied the table given, but the summary of results are:

Average running time, 1907, 10 hours, 52 minutes.
Average running time, 1908, 9 hours, 49 minutes.
Saving per train over 1907, 1 hour, 3 minutes.
Increased efficiency over 1907, 9.66%.
Total trains run, 1907, 226; 1908, 270.
Increase in number of trains over 1907, 20%.

"A similar satement for the 11 days, October 21-23, being the first eleven days of the operation of the new system, shows that the time of the trains was reduced 15.5%, while the number of trains run was increased 23.7%. The saving averaged two hours and four minutes to each train. In this Otober reord the tonnage was slightly less than in the previous October, but the whole of the falling-off was in the west-bound movement.

"The discription of the operation of this system is as follows: Assuming that engine 1376, an east-bound freight train, is ready to leave A. When the operator at A reports the departure of the train to the operator at B the latter immediately consults his block record sheet to see the condition of the block between B and C. If found clear, the operator at B calls the dispatcher on the train wire and says, 'B 1376 to C.' The dispatcher consults the train slips on his desk relative to the condition of the block between B and C. If he finds it clear, he responds to the operator at B, 'BC No. — to 1376 to C, O.K.' with signature. The operator at B copies this on a block card, making two carbon copies. He then calls the operator at C on the block wire and says to him, 'B 1376 to C.' The operator at C consults his block record to see if the block between B and C is clear.