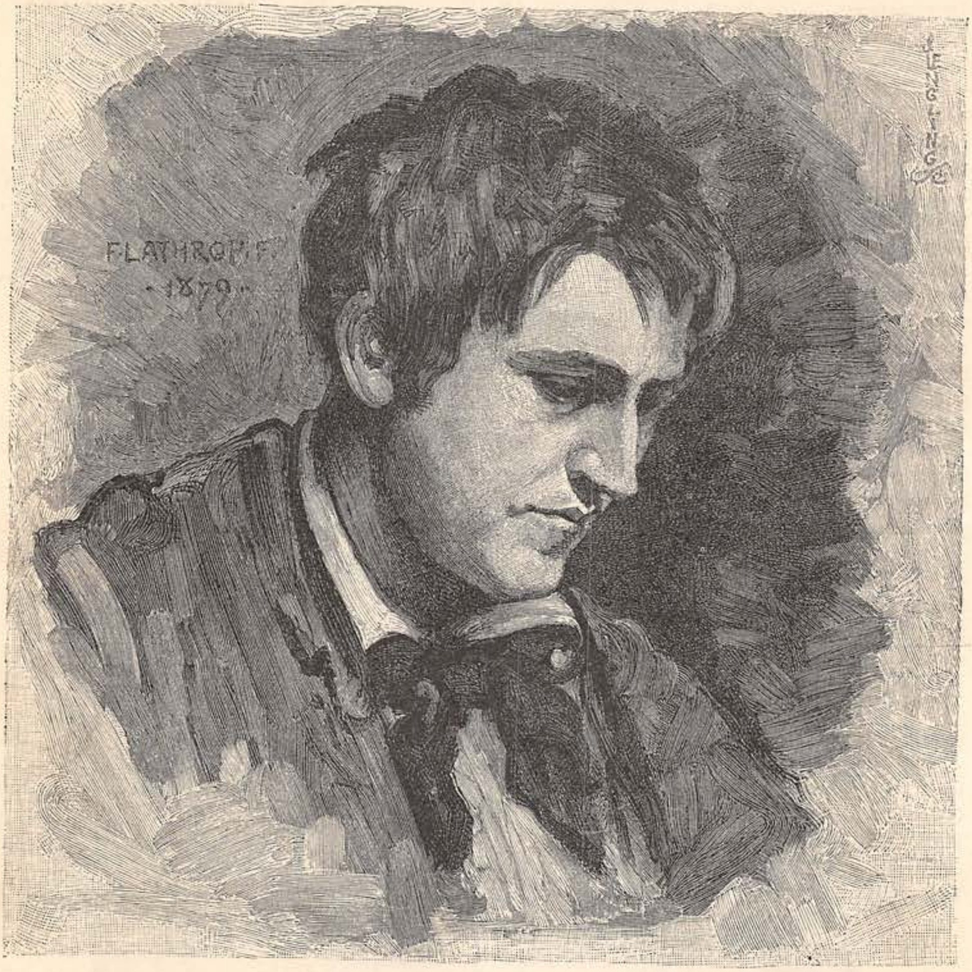
EDISON'S SYSTEM OF FAST TELEGRAPHY.



THOMAS ALVA EDISON. (DRAWN BY FRANCIS LATHROP; ENGRAVED BY F. JUENGLING.)

WITH a view to obtain a system of electric telegraphy that should combine the advantages of a greater speed with less expense than had been attained by the systems then in operation, Mr. Edison in 1869 began a series of experiments which culminated after four years' labor in his automatic telegraph, by which was made feasible the transmission over a single wire of several thousand words per minute at a cost not much greater than that previously entailed by the transmission of a single short message. This increase of speed over the Morse system, which at its best transmits, on an average, not more than twenty-five words per minute, promised a speedy supremacy for the new system, which was quickly inaugurated on a line between New York and Washington. During the first year it transmitted more than three millions of messages; but at the end of that time, owing to litigation and complications between the rival telegraph companies, its use was suspended. Since then it has not been employed, and probably it will not be until after the courts have passed upon the various questions involved. We believe no detailed description of the invention as a whole or as improved by Mr. Edison has ever been published.

The subject of fast telegraphy by automatic means is one that has occupied the attention of inventors ever since the inception of the electric telegraph. The first automatic system was devised as early as 1846. Its inventor was Alexander G. Bain, of Edinburgh, Scotland, and the main principle of his invention underlies all that have since been made. Since the invention of Bain, numerous automatic systems have been tried; but, up to the one devised by Mr. Edison, none had attained such perfection as to offer serious rivalry to the Morse system. And it is little wonder, when we consider the many difficulties in the way; for among the requirements for perfecting an automatic system are: 1st. Some mechanism which shall be able, without liability to derangement, to perforate paper rapidly; 2d. Means to neutralize or obviate the retarding effects of the electricity held in the wire known as the static charge, and common to all telegraph lines. 3d. A chemical solution, appropriately sensitive to the electric current, at the receiving end of the line. There are also minor incidental difficulties.

Before entering into the details of Mr. Edison's work in overcoming these difficulties, let us consider the main principle, common to all automatic systems of electric telegraphy, viz.: the transmission of signals by groups of holes punched in paper, and their reproduction at the distant end of the line on chemically prepared paper. In Fig. 2, at the transmitting end of a telegraph line is a strip of paper, A, having holes punched through it to represent telegraphic characters of dots and dashes. The paper is interpolated between the metal rollers, C, Fig. 2, connected with the line, and a metal cylinder connected with the battery, B. Being a non-conductor of electricity, the paper, when thus interpolated, breaks the circuit, and no electricity passes over the line. If, now, we move the paper forward between the metal rollers and the cylinder, by hand or clock-work, as the case may be, the rollers and cylinder will touch each other through such holes in the paper as present themselves. Thus the circuit is closed at each hole, and a current of electricity is sent over the line. At the receiving end of the line we have simply a strip of paper prepared with certain chemicals that are sensitive to electricity, the paper forming a part of the electric circuit. The current of electricity passing through such chemically prepared paper decomposes the chemicals and produces marks on the paper. In D, Fig. 3, is

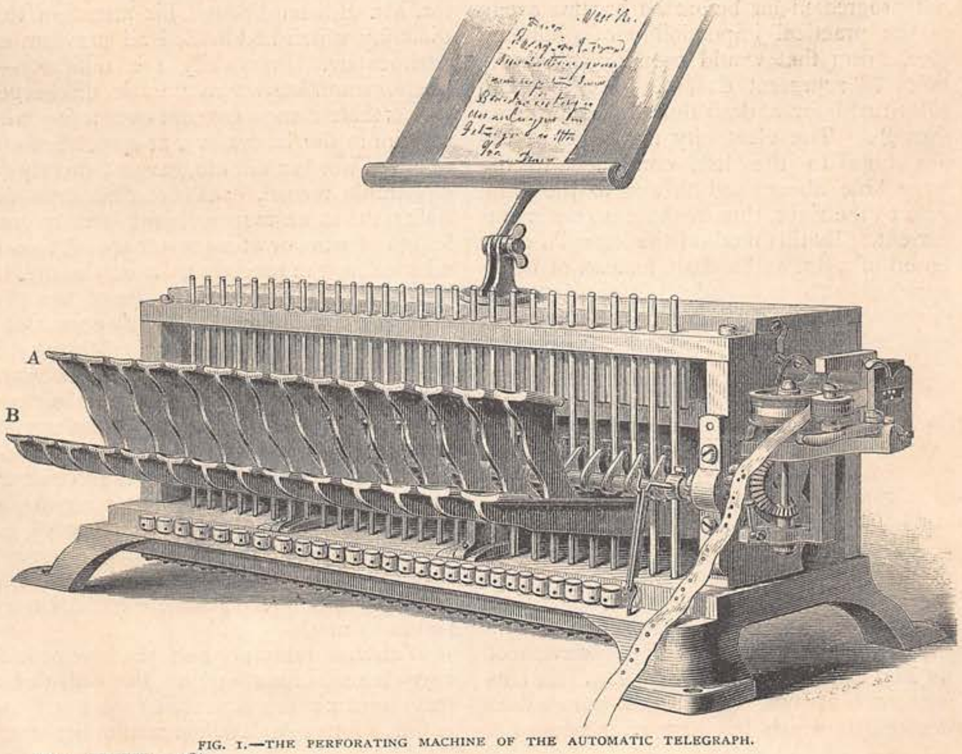


FIG. 1.—THE PERFORATING MACHINE OF THE AUTOMATIC TELEGRAPH.

shown more clearly the perforated holes in the transmitting paper, and in E, the corresponding records made on the receiving paper.

Devoting first his attention to the apparatus for perforating the telegraphic charac-

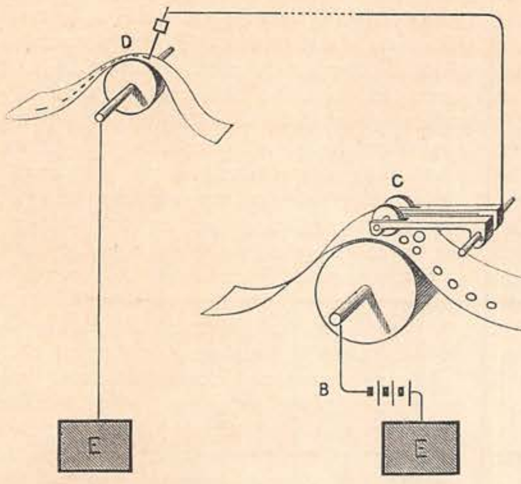


FIG. 2.—PRINCIPLE OF AUTOMATIC TELEGRAPHY.

ters, Mr. Edison constructed several machines for the purpose, as none of those previously invented came up to his requirement for speed and reliability. But his labors had not progressed far before he became aware of the practical impossibility of obtaining mechanism that would properly punch the holes to represent dashes. He therefore substituted for a dash three holes arranged thus o°o. The electricity first entered the dot hole to the left, continued to the large hole above, and thence to the little hole to the right, thus making a continuous current. By this method the letter A, composed of a dot and a dash, instead of being punched o ▭ was made o o°o, the letter B, composed of a dash and three dots, was punched o°o ooo, and so on. At the receiv-

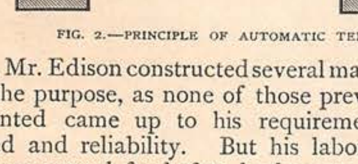


FIG. 3.—AUTOMATIC AND MORSE CHARACTERS FOR THE WORD "THIS."

ing end of the line, the marks would be for A, · — for B, — · · · A perspective view of the perforating machine, as finally developed by Mr. Edison, is shown in Fig. 1. It consists of various well-known mechanical devices, by which keys are connected with punches in such a manner that a depression of the key forces the punch through paper appropriately placed. For instance, a depression of the A key would perforate the characters o o°o, and so on. It would exceed the limits of this article to describe the mechanical devices making up the perforating machine, but the cut conveys the general idea. A and B are the banks of keys corresponding with the letters of the alphabet and connected with punches made to perforate dots and dashes.

The paper found best adapted for perforation was thick wood-paper with very short fiber, as it left no fiber projecting from the holes to interfere with the contacts. The paper is unrolled loosely in a large box from which it is taken up by the machine. The speed with which characters are punched by the machine averages about thirty or thirty-five words per minute, depending upon the skill of the person perforating. In one instance the incredible speed of one hundred and ten words averaging five letters each was attained in one minute by an exceptionally skilled operator.

Having obtained a satisfactory perforator, Mr. Edison directed his attention to a difficulty which had baffled all previous experimenters. Practically the difficulty—a phenomenon known as "static discharge"—was this: a message sent over a few miles of wire in the laboratory, at a speed of one hundred words a minute, gave a perfectly decipherable record, each dot and dash distinct; the same message, sent over a great length of wire, or at a greater speed, recorded itself at the receiver as a single straight line (Fig. 4). The explanation of this phenomenon may be made clear by an analogy.

Let us suppose a system of telegraphy, in which the signals are made by means of water passing through an inclined pipe. A vessel containing water will constitute the sending instrument, while a strip of cloth moved under the lower end of the pipe will serve as the receiver. Water here takes the place of electricity, and the pipe the place of the wire. The moving strip of cloth is exactly analogous to the chemically prepared strip of paper upon which the electric current leaves its mark.

With a short pipe, such a system, however clumsy, might be used, but with a great length, since the pipe must be filled and emptied for each signal, it would be utterly impracticable. It will readily be seen that if the signals follow each other too rapidly, the result will be a continuous stream from the lower orifice of the pipe. So long as the sender is pouring water into the tube, the flow at the receiving end will be of a uniform or increasing rate of velocity. When he stops, the flow will continue to diminish till it ceases. If, at the moment it begins to dribble, a sponge, large and porous enough to absorb all the water remaining in the pipe, were applied, the pipe would at once be emptied and ready for another signal. This is the sort of remedy used by Mr. Edison to empty his wire of the surplus or static electricity remaining in it after the recorded signal is complete.

Fig. 5 represents the apparatus. C is the receiving-paper, E the earth, A the magnet, which is introduced into the circuit by a branch wire or shunt, and which is to act as the sponge. The direction of the electrical current, and, of course, the static current as well, is represented by the unfeathered arrow at B: where it reaches the branch wire, this current divides, one portion passing through the chemically prepared paper at C to the earth. The other portion passes around the magnet, A. When the current which passes around the magnet weakens in the least degree, a current is generated by the magnet, a part of which, represented by the feathered arrows, tends to flow around the small circuit formed by the shunt, and the portion of the main wire containing the receiver, C, while the remainder escapes to the earth. It will be seen by looking at the figure that through the line in which the prepared paper, C, is placed, the two currents flow in opposite directions. The moment the flow of electricity decreases, in consequence of the completion of the signal, this antagonistic magnetic discharge begins and neutralizes the static discharge through the prepared paper. The magnet thus serves to take all the electricity out of the line and send it to the earth and answers as the sponge which soaks up the surplus water.

By altering the supposed water-telegraph, another method may be used for overcoming the difficulty due to the static discharge. Let us suppose the pipe, A C, in Fig. 6, to be perfectly level. Signals may be transmitted by forcing water into the pipe. The moment the pressure, by which the water is injected into the pipe, is removed, let us suppose that both ends of the pipe are opened wide, and the remaining water allowed to flow from both alike. Since the water flows toward either end as soon as the pressure ceases,—as is shown by the lower feathered arrows,—there must be one point, B, in the pipe where there is no flow. At the corresponding neutral point in a telegraphic wire the static discharge is null; and if at this point the receiving instrument be placed, an almost incredible speed may be obtained. The recording instrument, be it remembered,

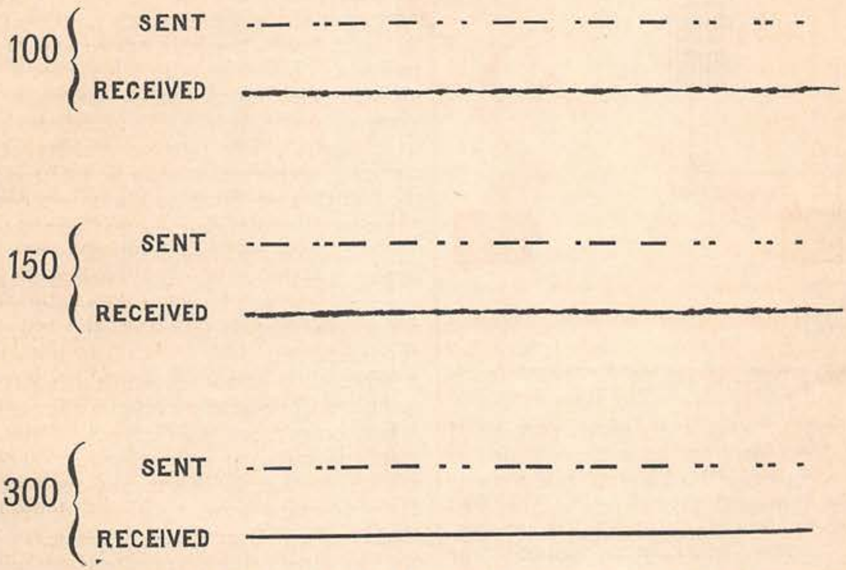


FIG. 4.—THE EFFECT OF STATIC DISCHARGE UPON SIGNALS AT DIFFERENT RATES OF SPEED PER MINUTE.

is sensitive only to the passage of electricity, and not to its mere presence. In order to secure a neutral point wherever he pleases, Mr. Edison constructs an artificial line, which resembles, for all practical purposes, miles of ordinary suspended telegraphic wire. He thus imitates, by proper devices under the table on which his instruments

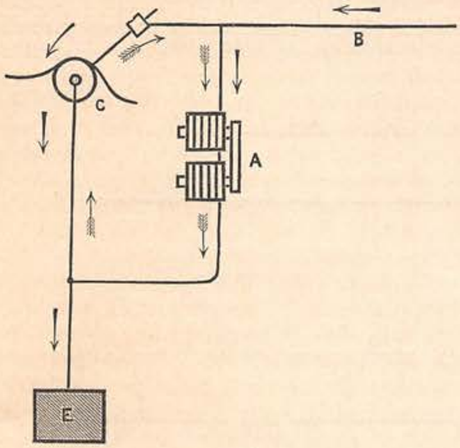


FIG. 5.—DIAGRAM SHOWING OPERATION OF CURRENTS AT RECEIVING END OF LINE.

are placed, a line of any desired number of miles. New York has thus been made the neutral point from Washington, and a speed of three thousand words per minute obtained. Mr. Edison claims that with sufficient expenditure for artificial line he could make either end of the Atlantic cable the neutral point, and enormously increase its speed.

With such enormous speed a new difficulty presented itself. The trouble now was to find a chemical solution sensitive enough to record clearly and quickly the signals sent.

The principle of chemical recording by electricity is this: If a current be passed from an iron wire through a piece of paper moistened with water (which moistening makes the paper a conductor), the water is decomposed into its constituent elements of oxygen and hydrogen. The oxygen thus set free instantly attacks the metal point resting on the paper and forms an oxide on such point; in other words, rusts it. This minute rusting or oxidization can be detected by certain chemicals. For instance, if the chemical ferro-cyanide of potassium be mixed with the water, and the metal conveying the electricity to the paper be iron, the ferro-cyanide of potassium will unite with the particle of rust on the iron and form Prussian blue. If the conducting metal be tin, another chemical is employed and another color results from the combination. Previous experimenters had given solutions based only on empirical rules. Mr. Edison found the law, by means of which he was enabled to make many hundreds of working solutions. In all cases it is the proto-salt of the metal which is formed, that is, the salt with the least oxygen in its composition. Knowing this, one has only to moisten the paper with a chemical that gives a coloration with this oxide, and called its re-agent. The extreme rapidity of this chemical combination may be inferred from the fact that in order to obtain a record of 3,000 words per minute,—each word averaging five letters,and each letter three electrical impulses,—the metal point must rust 45,000 times and the rust be taken off and enter into a new combination 45,000 times in the space of one minute.

When three thousand words a minute are mentioned, one hardly realizes what is meant. A few comparisons may help us; a fast telegraph operator can only write forty words a minute, so that by this means one wire can carry as many words as eighty skilled men could copy. A man talks at a rate of about one hundred and sixty words a minute, therefore the wire would take every word that twenty men could say, all speaking at once.

In all the solutions where the metal point takes part in the chemical combination, considerable pressure is necessary in order that the new compound may be deposited upon the paper, as well as to prevent a mechanical dragging-out of the telegraphic characters.

The necessity for a uniform yet delicate adjustment of this pressure presented another barrier. When the metal used does not take part in the chemical combination, as is the case when the metal is platinum, and the chemical is iodide of potassium, this heavy and uniform pressure is not necessary, but there are attending drawbacks to the employment of this combination. Many

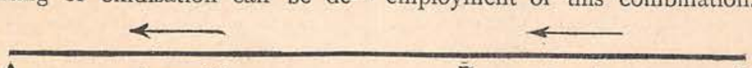


FIG. 6.—ILLUSTRATION OF THE PRINCIPLE OF THE NEUTRAL POINT.

months were spent by Mr. Edison in the search for both the proper metal and chemical. Such combination was finally found by him in the metal tellurium used on paper moistened with salt water, but the discovery involved another change of front. Previously, it was the oxygen set free by the electricity that acted upon the metal. In the use of tellurium the hydrogen was the active agent. The union was productive of the most happy results; the signals made were perfect in every respect. Tellurium also has the property of cutting the signals off very sharply. This serves as another device for overcoming the static discharge from the line. A curious scientific measurement occurs in connection with this. The hydrogen set free by the current forms with the tellurium a yellow compound, which on exposure to air blackens very quickly. If the paper be passed very rapidly under the tellurium a yellow mark can be seen near the point of contact, which in a short distance turns black. If this distance is measured and the speed of the paper be known, one can easily reckon how much time it requires for telluretted hydrogen to oxidize. In the small space of an inch, the inventor more than once succeeded in recording the Lord's prayer in telegraphic characters, all of which were perfectly distinct under the microscope. The paper found to give the clearest and sharpest signals was thick, well-washed bibulous cotton-paper, moistened with water, in which a little salt had been dissolved,—the purpose of the salt being to make the moist paper a better conductor of the electricity, thereby augmenting the amount of decomposition.

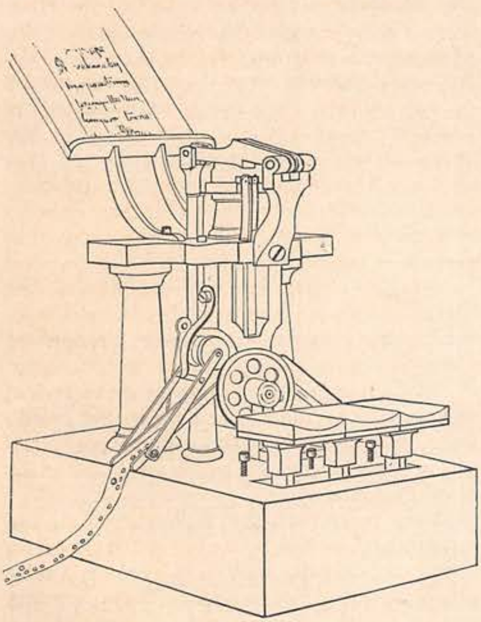


FIG. 7.—SMALL PERFORATING MACHINE FOR GENERAL USE.

The new system had been in practical operation some three months, when Mr. Edison conceived the idea of so transmitting messages that they should appear on the distant strip of paper in the form of Roman letters. The accomplishment of such a result would render the employment of skilled persons at the receiving end of the line entirely unnecessary, thus effecting not only a great saving of money, but what is more valuable in telegraphy, a great saving of time, in that the messages could be taken direct from the wire and delivered at once to the person addressed.

To effect this, many radical changes were necessary. The perforating machine, especially, had to be completely altered. In the new perforator, Mr. Edison dispensed entirely with the dash holes previously explained, employing only the small dot holes, which were so arranged as to form the Roman letters. For instance, instead of the A punch perforating the holes thus ∘°∘∘ as in the old machine, he constructed it to perforate holes forming that letter so ⁘ and at the distant end the signals would appear in little dots appropriately grouped. A would appear on the chemical receiving paper thus ∴ and so through the alphabet. All this seemed to promise very well, but when signals were sent with great rapidity, the characters on the receiving paper came out, it is true, in the manner explained, but with them came numerous other characters which completely obscured them. To get rid of these unnecessary records, Mr. Edison, after many experiments, arranged an apparatus so constructed that it would blot out all signals between the true letters. The only drawback to this system was a reduction in the speed of transmission, as in practice it was found difficult to send at a higher rate than two hundred and fifty words per minute on a line three hundred miles long, and proportionally less as the length of the line increased. On account of litigation and from lack of funds this portion of the invention was never perfected.

A novel idea, and one that bade fair at the time to reduce very greatly the cost of telegraphing, was just about to be inaugurated when the litigation before mentioned put a stop to the entire system. It was as follows: A small perforating machine (a perspective view of which is shown in Fig. 7), having three keys, could be purchased from the company at a small cost. With this instrument any person might, after a few hours' practice, punch the dots and dashes of his message in a strip of paper. When thus perforated he could send the paper to the telegraph office for transmission. At the telegraph office the strip would merely have to run between the contact rollers of the wire, and in a twinkling the message was at the distant end of the line. For thus transmitting, the company proposed to charge not as is now the custom, so much per word, but so much per yard, the sender being at liberty to crowd a volume, if he could, within that space.

Whether this new system of telegraphy will supplant the old or not, time alone can tell. During the brief period of its practical operation it gained many warm advocates, not the least among whom was the then postmaster-general, who strongly urged its adoption by Congress as a national system of telegraphy. Sir William Thomson called the attention of the British Association, in words of high praise, to the system as one of the wonders of the Centennial Exhibition.

JOURNALISM AS EXEMPLIFIED BY THE LATE MR. BAGEHOT.

I HAVE recently read the "Literary Studies" of Mr. Walter Bagehot, published since his death. I was curious to see this book, not so much on account of what I should learn about the subjects which it discusses, as of what I should learn about the author. One is interested to observe the steps by which a man, attracted by many and diverse subjects, at last finds his way to the kind of work which he can do best. The essays are pleasant and amusing reading, but somewhat disappointing. The fault of them is that they are too theoretical and not sufficiently immediate. Instead of looking directly at his subject and describing it as he perceives it to be, he argues, infers, etc. The true critic, having looked intently at the matter, asserts that the poet A possesses the quality x. Mr. Bagehot's way is to prove the truth of this proposition by showing that all persons of the class A possess the quality x; he is thus compelled to start backward and devote three or four pages to analogies. But he is not always theoretical; the best things which occur in his far more valuable political works and his writings in the "Economist" are the results of a profound and subtle intuition. He had a singularly exact apprehension of sentiments shared by masses of men. In his books on the British Constitution, he makes this remark, that the reason why the press in the United States at ordinary times is able to attack the government with so little effect is that the government must be in power till the end of its term of four years, and cannot at any time be turned out, as in England. This remark shows how clearly he had the state of our public sentiment before his eyes. The fact that Mr. Bagehot had never been in this country makes all the more remarkable his direct apprehension of our ways of thinking.

But it is as a journalist that Mr. Bagehot seems to me to have been particularly admirable and worthy of imitation. Among the admirable qualities of his writings in the "Economist" that which ought especially to be imitated was his respect for business and public action. He seemed always to be saying with reference to any great public question, "What should I myself do, had I the matter to decide?" His manner was that of a man who sits down among a number of friends, as honorable and intelligent as himself, to discuss *things* and not to make a vain and ineffectual display of *words*. His especial title to praise and imitation is that he looked upon journalism as action rather than literature, and upon himself as a partaker in the public business of the day, rather than as a man of letters.

Literature and journalism are not only very distinct, they are very far apart; they are in some particulars almost irreconcilable. The one point which they have in common is that the professors of both express ideas by means of alphabetic writing. Authors usually write short articles before they write books, and these are printed in newspapers. It thus happens that there are few men of letters, particularly in this country, who