within itself with any other line in the exchange without the intervention of second selectors and connectors.

Much has been done in the line of automatic telephony that might be described here, but attention has been given to a complete description of the only automatic system that has gone into wide commercial use rather than to several systems which, while promising, have as yet achieved little commercial prominence. It is to be expected that the near future will bring forth many developments in this newly aroused field of telephone activity, and the advent of an effective party line system of working as well as of measured service working in its various branches, is to be confidently expected.

It is difficult at the present time to form an accurate opinion as to the relative merits of the so-called automatic and manual systems. The writer's views on this subject, so far as formulated at the time, are shown in a paper entitled "The Automatic vs. The Manual Telephone Exchange," delivered by him before the International Electrical Congress at St. Louis, September, 1904. The remaining portion of this chapter is quoted from that paper:

"In the manual system in its highest development, the telephone user has only to place his receiver to his ear and make his wants known, the desired connection being made at the central office by operators. This system may be assumed to be highly developed, as it has been almost universally used since the advent of telephony, a period of nearly thirty years. The manual system, in its present form, represents the consecutive work of a large number of men in a field of the most intense and constantly increasing activity, all these men striving for the best possible means of accomplishing a desired result.

"In the automatic system, the central office switches are governed in their movements by the actions of the subscribers or users who desire connections and subsequent disconnections. The subscriber does his own work, manipulating the apparatus before him in such a way as to cause the switches at the central office to select, connect with, and afterwards disconnect from, the line of the subscriber desired.

"Unlike the manual system, the automatic cannot be assumed at the present time to have reached a relatively high development. While the automatic switch-board has been in the minds of inventors since the year 1879, it is not true that it has been put into considerable use until very recently. Instead, therefore, of its development being paramount in the minds of a large number of prac-

tical telephone workers, it has been fostered till lately by but few men, some of whom were unfamiliar broadly with the details of the telephone business. With a courage that must excite the admiration of all, a very few of these men have persisted, and as a result the telephone engineer, the operator of telephone companies, and last, but most important, the general public, are confronted with what I think is the greatest problem that has been recently before the telephone world: The problem of the automatic vs. the manual switch-board.

"It is not the purpose of this paper to attempt to solve this problem. The unequal degree of development of the two systems makes impossible a final satisfactory solution at the present time. It is rather to state some of its phases as they appear to me, and to make comment on them wherever my study of the situation has led to more or less positive convictions that this paper is offered.

"A fundamental question affecting the entire problem is this: is it possible to make a machine serve to effect the electrical connection of any line, in a large or small group, with any other line in the group, for the purpose of telephonic communication, and afterwards to effect a disconnection when required? There can be, even at the present early stage of development, but one answer to this question. That it is. The automatic switch-board at Grand Rapids, Mich., recently selected for me 100 different lines chosen at random from among approximately 5000 lines centering at that office. Some of the subscribers called did not respond, which will occur in any system; and some of the lines were automatically reported busy, which is to be expected; but in no single case was the wrong line chosen, and in but one case was the disconnection improperly effected. The verdict of a large number of subscribers interviewed by me in that city is practically unanimous to the effect that they uniformly secure their connections and disconnections promptly, accurately and satisfactorily.

"I conclude, then, in view of present achievement and of that future progress which this must stimulate men to make, that it is possible for the automatic switch to perform these functions satisfactorily.

"If, then, the automatic switch-board may be made to accomplish the commonplace connection and disconnection of lines, which form the great bulk of the work in a telephone exchange, is not the system so inflexible in its method of operation as to preclude the possibility of its performing the great multitude of special duties

which, while not constituting the bulk of the work, are of constant occurrence and of hardly less importance? I refer to such matters as toll connections, private branch exchange work, and to a number of subordinate but necessary classes of service.

"A prominent telephone engineer has recently remarked to the effect that if some of the people enthusiastic on the subject of automatic switching in telephone exchanges were to visit the school for telephone operators maintained by the New York Telephone Company, they would be discouraged in their efforts, as no machine could ever be made to perform the many and varied functions that it was necessary to teach these young ladies before they became proficient telephone operators. This seems to be a statement that has very little to do with the real automatic problem. It should never be required that the machine shall do the same work that is demanded of the girl, nor do it the same way. That is manifestly impossible, for no machine can ever be endowed with intelligence. (It may be that you will say that there are some telephone girls similarly affected.) Since the very reason for the existence of the automatic exchange is to do away largely with the operator, it follows logically that whatever intelligence is to be applied to the making of the ordinary connection between two lines, it shall be that with which the subscriber desiring to make the connection is endowed. Here is a fundamental difference between the two systems which must always lead to different modes of operation.

"The real functions that the automatic switch-board should be required to do automatically are those relating to the ordinary routine work of connecting and disconnecting subscribers' lines under the control of the calling subscriber. When some act needing intelligence at the central office is required, then let an operator supplement the work of the machine. To condemn the automatic switch because it will not perform all of the special requirements without the aid of human intelligence, is just as unfair as to condemn a linotype machine because it cannot digest one of Steinmetz' equations. My mind has gradually changed upon this point until the doubt now exists as to whether the automatic system, wisely supplemented by operators, is not even more flexible than the manual. It is the ease with which the personality of the operator may be introduced into the automatic system, and also the ease with which certain of the purely automatic functions may be varied by mere changes in the circuit, or in the mechanical relation of the parts, that makes this doubt exist.

"Of course, there are many phases of traffic and service that are yet to be worked out for the automatic system, but apparently the longer one studies the problem the more nearly he becomes convinced that the automatic system is sufficiently flexible, with the interjection of human intelligence when necessary, to make possible the solution of practically all of the problems of service.

"So far as I am aware, selective-signal party line working has never been accomplished commercially with automatic systems. I believe that the reason for this is solely the fact that automatic telephony is yet new. I have recently seen a plan whereby any ordinary number of stations can be selectively operated on a party line with practically no other added complication either at the central office or at the subscribers' stations than that which is added to the apparatus of an individual line manual system to adapt it to the same class of party line work. While the automatic party line is not yet developed to the extent of actual commercial use, it is entirely feasible, and will not be one of the controlling factors in the solution of the problem: automatic vs. manual.

"I have looked into the subject enough to believe that what is true of the party line problem is true of the common battery problem, and also of the measured service problem, whether the measuring of the service is accomplished by collecting coins or tokens at the subscribers' stations or by operating counting devices either at the sub-stations or at the central office. There is undoubtedly a vast amount of work yet necessary before these features are commercially incorporated in working apparatus in an entirely satisfactory manner. I merely say that my study has shown me that no insurmountable obstacles exist that would prevent the successful establishment of party line, common battery and measured service working.

"These statements do not greatly help the man who is to-day casting about in making a choice between the automatic or the manual system for present use. It is not, however, with the present alone that we are concerned. We must plan and build for the future; and the remarks just made are given merely as bits of contributory evidence as to what developments may be expected.

"Having seen that the thing is possible, that it seems from a technical standpoint to be able to do what is wanted, another question is: do the subscribers like it?

"The evidence all seems to point in one direction. They do. At Grand Rapids, Mich., ninety-five per cent. of a large number of

subscribers interviewed by me liked it better than common battery manual service; four per cent. did not care much one way or the other, and one per cent. liked the manual system better. At Fall River, Mass., where the system has been in use for a much longer period, the verdict was quite the same in effect. Evidence from other cities where automatic service is being tried seems to agree. It must be said in fairness, however, that at Grand Rapids the mass of subscribers is leavened by the presence of a large number of stockholders in the local company. Again, there is in that city much civic pride in the system, as telephone people come from all parts of the country to inspect the plant. Still again, the delight of the subscribers may be similar to that of a child with a new toy, but this can hardly be true, because of the fact that the exchange at Grand Rapids has been in service for a period of nearly nine months and is carrying a very large business load, so that if the people were not actually getting satisfaction they would probably know it. The new toy idea is also apparently disproven by the condition at Fall River and New Bedford, where the service has been maintained for several years and seems to be much liked.

"The question also naturally arises: is not the automatic switch-board and necessary subscribers' mechanism too complex to be maintained in proper working order without undue cost? It is perhaps too early to decide this question. There is not enough evidence one way or the other. Judging from the past, however, the tendency of industrial achievement seems to be toward automatic methods. As examples, take the arts of printing, of weaving and the use of machine tools.

"Summing up, therefore, the statements already made, the automatic system is not only a possibility, but is actually here. With the interjection of human intelligence to supplement it in performing certain functions, it seems to be as flexible as the manual. Party line, common battery and measured service working, while not yet achieved commercially, so far as I am aware, seem to be well within the grasp of those who are doing the development work. The public seems to like it, and we do not know whether it is too complex or not.

"It will be noted from the foregoing that the idea of having the central office apparatus perform *all* the phases of telephone service is apparently not tenable. Many of those who have advocated it in the past have abandoned it and are introducing human aid in the performance of some of the functions. This being true, a certain

number of operators are and will be needed in automatic exchanges. This tends to destroy in some degree the primary object of the automatic system—the doing away with operators. We have seen many papers bearing on each side of this question, to the effect that the salaries of the operators were or were not to be eliminated; that retiring rooms, matrons, operators' luncheons, etc., were or were not to be done away with. These items of expense will probably exist to some degree in all large automatic exchanges. That they will be greatly reduced is without question, but whether or not they are reduced to such an extent as to offset other sources of expense introduced by the employment of automatic apparatus, is a problem yet to be solved.

"What are some of these sources of expense that tend to offset the reduction in operators' salaries and expenses coincident therewith? Taking the automatic system as a whole, we find that it is considerably higher in first cost than the manual system, and assuming that interest and depreciation are at the same rate in each case, this shows to considerable disadvantage for the automatic system in the annual charges due to these items alone.

"For an exchange of 5000 lines served by one office, the cost of automatic equipment, including telephones, may be taken at $35 for each individual line. In manually operated exchanges the corresponding cost is not far from $25 per line. The difference becomes greater, that is, more in favor of manual, for smaller offices, and smaller or less favorable to the manual in larger offices.

"Whether or not the depreciation on automatic apparatus should be taken at a higher rate than that on the manual, is a question that we have not at present sufficient data or information to determine. It is true that in the automatic switch-board the flexible cord nuisance found in all present forms of manual switch-board apparatus is largely eliminated. It is also true that the automatic apparatus is more complicated and requires greater care in its maintenance; but whether, if both systems are maintained with reasonable care, the automatic will show a greater rate of depreciation than the manual, I am not at all certain. Much of the depreciation in manual telephone apparatus is due, not to the fact that the apparatus wears out, but rather to the fact that it is rendered obsolete by new inventions. That the same will be true in the case of automatic apparatus cannot be doubted, but it is a good point to bear in mind that if telephonic development should point toward automatic apparatus to the exclusion of manual, and should prove the supe-

riority of automatic, then the highest developed and newest manual apparatus will depreciate greatly in value by that fact alone. It does not seem unreasonable, therefore, to place the rate of depreciation on both manual and automatic apparatus at about the same figure.

"In point of maintenance the advantage must be conceded to the manual. This is certainly true at present with regard to both the central office and the subscriber's station apparatus. No good reason is apparent why it should not always be true. Automatic apparatus is especially at a disadvantage at the subscriber's stations, and it is really at this point that the automatic system seems to involve a poor engineering feature. The tendency of telephone development in regard to sub-station apparatus has been until lately along what seemed to be unquestionably good engineering lines. The sub-station equipment has been gradually simplified, the battery has been removed, as has also the magneto generator, and the instrument has been reduced to the simplest fundamental parts.

"Automatic telephony as at present developed for large work takes a step backward by reintroducing the local battery. That this is disadvantageous no one can deny, but on the other hand, it must be pointed out that the disadvantage is by no means as great as it would have been several years ago because of the fact that dry batteries have recently come into almost universal use for this kind of work, and are far superior, all things considered, to anything heretofore available.

"The disadvantage of local batteries, while mitigated, is still present, and is real; but, taking the automatic system as we have reason to believe it will exist in the future with no local batteries, it will still possess, as far as we are able to see, a more or less complicated impulse transmitting device, by means of which the subscriber will be able to direct the movements of the switches at the central office. Complexity, not only of mechanism, but of function, is thus introduced at the subscriber's instrument, and this seems to be an inherent disadvantage to all present schemes of automatic exchange working. This, of course, is another factor that must be weighed in considering the relative economies of the two proposed methods.

"There is a point that I have not yet seen mentioned in print, which, under certain cases, seems to be of great importance. This is the matter of trunking between two or more automatic offices in such cities or communities as naturally demand, by the distribution of their subscribers, more than one office. It is true that the present

automatic switch-board seems to be capable of properly handling this condition if the requisite number of trunk lines between the offices are provided. At first thought it seems that the number of trunks required between offices for a given amount of traffic might be somewhat less in the case of the automatic than in the case of the manual system, on account of the immediate disconnection and release of the trunks; in the automatic, upon the hanging up of the receiver of the calling subscriber. Further consideration, however, will show that there is very little difference in the time the trunk is held busy in the two systems, the length of actual conversation being assumed to be the same in each case. The reason for this is that, while the automatic gains in this respect in the release, it loses something in the making of the connection, because in the case of the automatic, the trunk is selected with the first movement of the dial by the subscriber, and the length of time that the trunk is held busy, therefore, must include the time during which the subscriber is setting up his own connection; whereas, in manual boards a trunk line begins to be busy at the time when the B operator picks up the incoming trunk plug and designates its number to the A operator.

"So far there seems to be little difference between the systems in this respect.

"The bearing on the trunking problems of the relative efficiencies of different sized groups of trunks between offices does not, however, seem to have been weighed by many in considering the question of automatic vs. manual exchanges. When sufficient trunks are provided between offices to handle business on the so-called 'no delay' basis, it is known that a large group of trunks will handle very much more business per trunk line than a small group. For instance, when there are only ten trunks in a group between offices, it is a well-established fact that slightly less than eighty calls per trunk per day may be handled. If, however, the group be increased to 100 trunks, as many as 145 calls per trunk per day may be handled. This is an increase of considerably over eighty per cent. in actual trunk efficiency. In the present automatic system, group the trunks as you may, it is inherently true that the efficiency of the trunks is reduced to that of a group of ten. I do not mean by this that it is not possible to place as many trunks as desired between any two offices, but that any subscriber has access to ten trunks only in order to secure a connection to any other office. It is true that some other subscriber may have access to another ten, or to the same ten, but no one subscriber can reach more than ten.

This seems to be a grave objection to the use of automatic systems as at present developed, in those communities where several offices must be employed and where traffic is such as to demand a large number of trunks between offices. The remedy to this is obviously that of giving the subscriber the chance to select his trunks from larger groups. This, I take it, is one of the problems that need serious consideration in adapting the automatic system to very large communities. It does not enter seriously in single office work.

"In all that I have said I have attempted to take the very practical view of the engineer, and fundamentally that view must always compare systems with the intent of selecting a means of doing what is required well enough for the smallest price. From the strictly engineering view one does not take into account relative popularities of mere ways of accomplishing results. But this is necessary in such a case, for there are features of the automatic system which may make it so popular as to force upon the owners or prospective owners of telephone industries a serious consideration of the doctrine of expediency. This is by no means the least of the important things to consider.

"I expect to be criticised because I have not solved the problem. It cannot now be solved any more than the question of alternating versus direct-current transmission could be decided when we first were brought to realize that there was an alternating versus direct-current transmission problem. My object has been to state the problem as I see it, and I hope that in doing this something may have been accomplished toward clarifying it."