The Mechanization of Letter Mail Sorting

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WHY mechanize the storing of letter mail? After all, billions of letters are mailed and delivered every month for just a few cents each.

The answer lies in the rapid increase of the volume of mail. Fig. 1 shows how rapidly this volume is increasing. Note that the ordinate is logarithmic and the curve is almost a straight line. Fig. 2 shows that the mail volume is increasing even more rapidly than the population. From 6 pieces of mail per person per year in 1847, it has climbed to 350 pieces of mail per person as of 1955, and we can expect this number to be doubled by 1980. About 150,000 people are involved already in the sorting of letter mail. At the present rate of increase, it will soon be difficult to find enough suitable people in the country to sort mail manually.

Thus the Post Office Department is forced to mechanize, simply to be able to accommodate the exponentially increasing volume of mail. However, it also can expect other advantages, such as speed, accuracy, reliability, and economy of operation, and all of this with no increase in personnel. The personnel now employed in the sorting of letter mail need not fear layoffs, because it is the publicly expressed policy of the Department that no one will be laid off as the result of the adoption of sorting equipment.

So much for policy matters. Now to get down to engineering.

At the National Bureau of Standards Post Office Project, we started with these basic assumptions:

1) The manual system of sorting letter mail has been in use and under study for many years. It is very unlikely that it can be improved appreciably. Therefore, any major improvement must be the result of introducing mechanization.
2) The U. S. postal system is too large to mechanize all at once. Besides, this would not be a prudent way to proceed even if it were possible. Therefore, mechanization must be introduced progressively.
3) At least initially, the mechanization of a post office should not affect the nature of its output or input. If a post office sorts outgoing mail to 2500 destinations and incoming mail to 600 letter carrier routes before mechanization, it should continue to do so after. This insures that the mechanization of one post office will not force reorganization of the whole postal system.
4) We cannot hope to do more than help the Post Office Department get started in this field of mechanizing letter-mail sorting. That Department will introduce many improvements as a result of operating experience. Hence we must not delay the mechanization of post offices while we strive for perfection in equipment or systems. Rather, we must freeze designs and procedures as soon as practicable to speed the day of actual operation.
5) The greatest improvement potential lies in those operations that take the most man hours per letter. This leads to the conclusion that manual letter-mail sorting is the operation most deserving of attention, because each letter is individually sorted three to eleven or more times. The average must be about six, including the last sort in which the postman arranges the letters in the order of his walk.

Having established this "axiomatic" base, we started our study in three directions simultaneously:

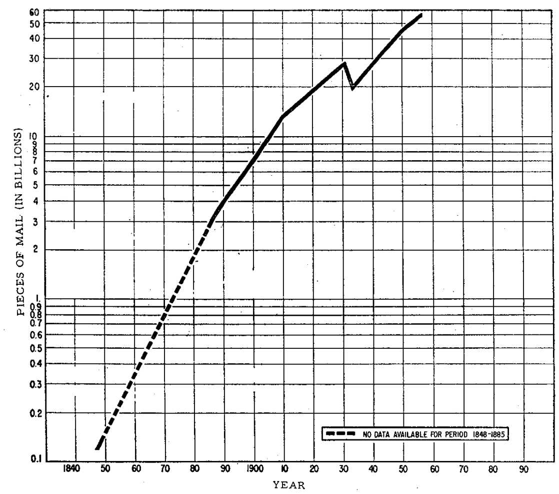

Fig. 1—Mail volume growth per year.

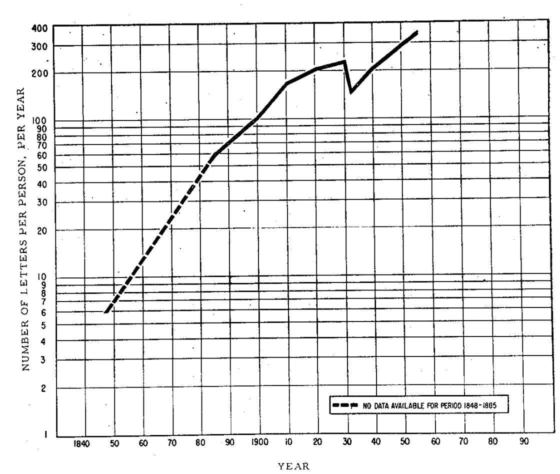

Fig. 2—Ratio of mail volume to population.

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1) An examination of the physical characteristics of letter mail,
2) A study of the mail flow through present sorting offices, and
3) A study of existing equipment for sorting mail.

Here only a brief summary of the third is given.

There are systems in use in other countries in which the human operator reads the mail, interprets the address, and indicates the proper destination in the output of the machine to which each envelope should go. But a machine helps him do the purely mechanical work by bringing letters to him and taking letters from him, each to its designated output bin. Such a machine makes it possible for a human being to sort letters about twice as fast on the average as he can do manually and to sort, not to a maximum of fewer than a hundred output destinations, but to three or four hundred. Such machines have been in use in Holland since about 1935, in Belgium since about 1950, and in England since the Spring of 1956.

However, these machines would not eliminate multiple sorting of mail for large post offices in the U. S., because these post offices sort to more than three or four hundred destinations. Moreover, the operators must be of even higher caliber mentally than manual sorters, since they sort to three times as many destinations at double speed. This is a serious drawback, because it limits severely the fraction of the population capable of doing this work. Finally, these machines are not designed to take advantage of any future standardization of the mail. It was therefore concluded by the National Bureau of Standards personnel that these machines would not constitute a final solution to the mechanization of letter-mail sorting in the United States, although they may find their place in the smaller post offices of this country just as they have in foreign countries.

A more promising system is the one that is being developed in Canada under the leadership of Dr. M. M. Levy. Dr. Levy has proposed that each letter be standardized by having its address converted into a dot code by the first human being who reads the address in the post office. In this way, subsequent readings of that address can be carried out by machines, and no further manual reading of addresses is required until the postman is about to deliver the letter to its final destination. Thus, the number of human readings for sorting is reduced from an average of about six to one. In manual sorting today there are about six sorts on the average, including that of the postman ordering his route. Now although the conversion of the address into the dot code may take longer than the ordinary sorting of a letter manually, it does not take six times as long; the difference represents the savings in manpower achieved by the adoption of this system. The exact saving is not known as of this time, although we hope to have such information in a comparatively short time.

There is a further potential advantage in this type of standardization. A large fraction of the mail has its origin in business houses or firms which specialize in direct mail advertising. Such firms may be induced to imprint the dot code on the envelope themselves. In those cases, the Post Office Department would not have to use any human readers. We have also urged the Post Office Department and firms in the business-machine field to adopt a standardized type font based on a 5×7 mosaic for machine reading. The use of such a font in a standard size for addressing business mail would also eliminate the need for human readers.

Having established our axiomatic base and studied what was available from others, we proceeded to develop our own system using the Canadian idea. We did not adopt the Canadian equipment, because it was not suitable for our post offices. All history is omitted here, and we shall describe our system as we visualize it today.

Fig. 3 is an artist's conception of one section of a mechanized post office. In the foreground are the code-printing stations. Mail that has been cul.ed, faced, and cancelled is brought to these stations. Human operators read the addresses and operate keyboards to rewrite the addresses in a standardized, abbreviated form. These standardized addresses are printed on the back of the envelopes in a dot code not very different from Teletype code. The printing is done with phosphorescent ink to enhance contrast during subsequent mechanical reading.

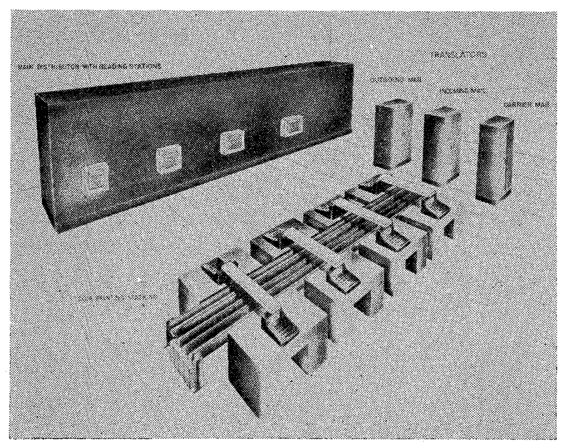

Fig. 3—Artist's conception of one section of a mechanized post office.

Provision is made at this stage for a rough sort of the mail by classes. It may prove operationally advantageous not to code immediately all of the mail that reaches these stations, and therefore provision is made to put some of the mail aside into several categories. For example, since in most large post offices between a third and half of the mail is local, it may be operationally advantageous, in order to speed up the outgoing mail, to put the local mail aside for later detailed address coding. Similarly, it may be advantageous to separate out mail requiring special handling, such as air mail, special delivery, and registered mail.

Also, provision must be made to eliminate from further operations defective mail, *e.g.*, mail which has insufficient postage or an incomplete or improper address.

One of the classes will consist of the mail that has been coded for immediate sorting. This mail is transported bulk-wise to the boxes shown mounted on the large machine in the rear. Each of these boxes represents an automatic code-reader input for the large machine which is the distributor. In each code reader, the dot code on the envelope is illuminated by ultraviolet light and then read in darkness by photocells. The resulting electrical address signals are then fed to one of the three translators represented by vertical rectangles on the right side of the illustration. One of these operates for outgoing mail, another for incoming mail, and the third operates when the mail for each carrier is arranged in the normal order of his walk. The appropriate translator accepts the address signals, and translates them (in terms of its stored scheme of distribution) into electrical signals representing the proper output bin on the distributor. These output signals are sent to the distributor in synchronism with the envelope itself. The distributor then delivers the envelope to the designated output bin.

This, in very broad outline, is the system of mail sorting that the National Bureau of Standards now has under development. What are the problems associated with this system?

The chief problem, of course, is to develop criteria, methods, and data for judging the relative merits of various sorting schemes. To this end, we have investigated the sorting operations of several post offices such as Washington, Baltimore, Philadelphia, Los Angeles, and San Francisco. We may add Chicago and St. Louis to this list later. We study the relative volumes and physical characteristics of the mail from all sources in each of these cities. We study the mail flow pattern through each post office, and we determine the destinations to which it must sort. There is much too much mail in each post office for us to conduct a complete piece count, so we have developed statistical sampling procedures. These data enable us to determine the system parameters for any mechanized scheme of doing the work of each of these post offices. Our comparisons are thus real instead of conjectural.

In addition to the over-all systems problem, there are the many equipment and procedures problems. Some of these will be examined in the order in which they would arise in following an envelope through a mechanized sorting operation. Thus we start with the code printer.

First, what kind of a code shall we use? It must require as little operator time as possible, be easy for operators to learn and to remember, and result in a high speed of operation with a very small error rate. An early report on code development was made to the Post Office Department.

Second, what type of keyboard shall the operator use? We expect to use ordinary typewriter keyboards, initially at least. But we are not sure that these are best; and tests are being run to see whether the direct digital keyboard used by the Canadians or a rather elaborate multichoice keyboard proposed by the Dutch may not be superior. These are human engineering problems and in order to answer them, we have been forced to run tests with human beings. The same test series is being used to determine the human engineering aspects of the codes. These tests are expensive. They take a long time to run. They must be very carefully designed, and the results must be very carefully interpreted so as not to be misleading.

Third, a more straightforward engineering problem, in what form shall the abbreviated address appear on the envelope? Our choice has been to use phosphorescent dots in a code similar to Teletype tape. We arrived at this choice for three reasons:

1) Only optical sensing equipment can be relatively distant from the surface on which the pattern is imprinted and still retain sharp focus;
2) Only in an optical pickup can sensitivity be independent of the distance between the pickup device and the surface from which it is reading; and
3) The use of phosphorescent ink allows us almost complete immunity from anything that may be printed on the envelope in the way of extraneous matter such as advertising, and it gives us a very good signal-to-noise ratio. Phosphorescent dyes are not used today in envelopes nor in the inks used on envelopes. Furthermore, we have proposed that such use be forbidden in the future. There is really no reason for anyone to want to use them, so that this prohibition should not work any hardship on anybody.

Next we come to the translator. It is technically possible to develop an electronic device which is so fast that it can translate address signals into output signals for a whole post office by time-sharing its services to several distributors. The alternative is to develop a device cheap enough to be used with a single distributor, but required to make translations at a correspondingly slower rate. Which shall we use?

One contractor has developed laboratory versions of both kinds of equipment. We believe the future belongs to the more potent equipment, because it will be more compact and economical. However, for the present, we are perfecting the more modest version; so that, in the event of breakdown, only one translator is made idle instead of a whole post office.

The translator under intensive development is somewhat similar, but by no means identical, to the punched metal-card device used by the Bell Telephone System in its long-distance automatic switching. It will be small, cheap, and fast enough. The author hopes that J. Rabinow, the inventor, will prepare a detailed history of the development of this device. It would make a fascinating story.

Finally we come to the distributor. First, there is the question of its general design. There are two ways of dedesigning such equipment. One way is used by the Belgians and the British in their designs. We shall call this an external control system. It makes use of a main distributor frame, which is essentially a mechanical device for pushing envelopes, but which carries no intelligence whatever. The instructions to this device, as to when and how it shall divert envelopes into the proper output bins, come from separate control equipment which must run in strict synchronism with the main distributor. Such devices have been built which work satisfactorily. However, in order to insure strict synchronism between the distributor proper and its control, the construction must be very precise and stable, and the flexibility of layout is limited. We have chosen, therefore, to adopt a modification of another system employed by the Dutch and others. This we call the self-control system. In this, each envelope has associated with it, a mechanized form of the output bin address as it moves through the machine. Each output bin also has a mechanized address associated with it. The two work together like key and lock. There is no auxiliary control unit. Thus, it makes no difference how far this envelope is carried, nor in what direction, because its instructions travel with it.

Another question that arises in connection with the distributor is: For how many output destinations should it be designed? From the point of view of the postmaster who has a job to do, it is desirable to design this equipment to handle the same destinations that he now sorts to manually. This means that the introduction of the equipment would not force any changes in the mail transportation system. So far as other post offices are concerned, they would not know any difference after the equipment was installed. However, this implies, for a place like Chicago, for example, sorting to about 5000 destinations. It may not be feasible, for cost or space reasons, to build so large a distributor.

These problems have been described very briefly and in rather general terms. We are attacking them much more specifically, using, mathematical models, computer simulation, statistical studies, and engineering trials. It is hoped that each of these problems will be the subject of a separate paper at a later date by some member of the project staff. These papers will be prepared for internal use of the project and the Post Office Department. If they prove to be of interest to others, we are sure the Post Office Department will permit distribution.

The National Bureau of Standards Post Office Project staff is not doing all these things by itself. We are getting invaluable help from the Post Office Department in gathering and interpreting postal data. Most of the very ingenious engineering features of the sorting equipment are due to the Rabinow Engineering Company, our sorting equipment contractor. Prof. Harry H. Goode of the University of Michigan, who is chairman of the Technical Program Committee of this Conference, has been our invited critic, and a very conscientious and useful one. It is he who has encouraged us to make earlier and greater use of mathematical models. Many others have also helped in other ways.

This has been a very quick review of the work of the Post Office Project at the National Bureau of Standards. It has run very lightly over a large and complex field. We hope that, in time, ways will be found to cover the ground more thoroughly for the benefit of those who may be interested in greater detail.

Discussion

Question: Do you care to say anything about mechanical facing of mail incidental to mechanical mail sorting?

Mr. Rotkin: Since this is not a mail handling specialist group, I had better explain that facing means arranging the envelopes so they all face the same way. It is done at present for the convenience of the canceling machine as well as that of the sorter. This is not part of the work that the National Bureau of Standards is doing. We pick up the mail after it has been faced and canceled. It is perfectly feasible from a technical point to do this mechanically and the Post Office Department is working on it in conjunction with at least two contractors.

Question: What type of distributor is visualized for the final route sorting of the carrier mail?

Mr. Rotkin: The same kind that would be used for distributing outgoing and incoming mail. It is our objective to have one distributor do the work of all three kinds of sorting, either by time sharing or by just dividing the distributor into sections appropriate to each sort.

It is more likely to be by time sharing because of the way the work comes into the post office. It is quite feasible to do this. The number of sorts involved is comparable. For example, in Washington, we sort to about 2500 or 2600 outgoing destinations. We sort to about 500 or 600 carrier routes and each carrier makes several hundred stops. I don't know the exact number but it is in the neighborhood of 500.

In Chicago, for example, they sort to about 5000 or 6000 outgoing sorts; for incoming mail, they sort to about 5000 or 6000 carrier routes and each carrier also has somewhere in the neighborhood of 500 stops.

Therefore, the same equipment can be used for all of the sorts and the only difference required would be in the kind of instructions the machine gets from what I call a translator.

Question: Will it be necessary to standardize letter sizes to attain optimized mechanization?

Mr. Rotkin: It is not necessary; it certainly would be helpful. We are trying at present to determine what the largest letter will be that we will accept into this mechanization sorting system. This is one of the reasons for measuring physical characteristics of the mail. Letters come in all sizes from very, very small to quite gigantic things called flats. It obviously does not pay to design a machine that will handle anything as large as flats because it doesn't occur in a high enough percenetage of the cases.

We don't know whether this will be the proper cutoff point, but tentatively, we are working on the assumption that $6 \times 12 \times 3/8$ is big enough. I expect that after we have done our statistical work, we will find out this is too big, and then we can afford to make our cutoff for a smaller size of envelope.

Question: Is character reading a part of the system?

Mr. Rotkin: It is not a necessary part. If we could have good character reading, it would be helpful. This is why we would like to have people standardize the style and size and format for addresses for business purposes. It would make the problem of character reading almost child's play compared to what it is today with the wide variety of sizes, type fonts, and general arrangements of addresses.