He did not point out, however, that there was no way in which his capabilities could be predetermined.

I should like to give one example to bring out my point that there are important variations in the fundamentals of machine operations, as well as in the fundamentals of individual operations.

The Fellows Gear Shaper is a machine used in the automotive industry for producing transmission gears. Many of you are familiar with its operation. There are three feeds on the machine—fine, medium and coarse. The factor for figuring machine time is 700 strokes per revolution for the coarse feed, 1000 for the medium and 1400 for the fine. Let us assume that we are going to cut a twenty-four tooth gear, using a three inch pitch diameter cutter of six pitch, and using a speed of 200 strokes per minute. A six pitch three inch diameter cutter would have eighteen teeth. We will now figure the machine for one revolution of the blank. Using the fine feed, we get

$$\frac{24 \times 1400}{18 \times 200} = 9.33 \text{ minutes}$$

The time is 9.33 minutes for this set up.

Now let us assume that we are going to cut the same gear using the same speed and the same feed, but using a four inch pitch diameter cutter. We then get

$$\frac{24 \times 1400}{24 \times 200} = 7.00 \text{ minutes}$$

The time in this case is seven minutes.

This is a typical example of a fundamental which must be reckoned with in machine operations. We used the same feed and the same speed in both instances. The only difference was that a larger cutter was used in the one case. This, however, produced a twenty-five per cent difference in time.

The variations in the fundamentals of individual operations are not so easily determined. The application of good common sense to both machine and individual operations, however, brings out useful information. Theories must not be carried too far in dealing with these problems.

Allan H. Mogensen.[5] First, I want to congratulate Mr. Lowry on his excellent paper and to express agreement with his general propositions. I feel, however, that his statement, "When time study was first introduced into industry, a separate study was taken on each job as it came along," does not give proper credit to the man for whom this Society is named. It will be found that the establishment of synthetic times was the very aim Mr. Taylor had in mind in breaking down an operation into its simple elementary movements.

At a meeting of the American Society of Mechanical Engineers in Detroit in 1895, Frederick W. Taylor stated, "Practically the greatest need felt in an establishment wishing to start a rate fixing department is the lack of data as to the proper rate of speed at which work should be done. There are hundreds of operations which are common to most large establishments, yet each concern studies the speed problem for itself, and days of labor are wasted in what should be settled once for all, and recorded in a form which is available to all manufacturers. What is needed is a handbook on the speed with which work can be done, similar to the elementary engineering handbooks. And the writer ventures to predict that such a book will not be long in forthcoming."

As brought out by Mr. Merrick, again in 1912 Mr. Taylor stated that time study consisted of two broad divisions, first, analytical work, and second, constructive work. He defined the latter as follows: "Add together into various groups such combinations of elementary movements as are frequently used in the same sequence in the trade, and record and index these groups so that they can readily be found. From these records, it is comparatively easy to select the proper series of motions which should be used by a workman in making any particular article, and by summing the times of these movements, and adding the proper percentage of allowances, to find the proper time for doing almost any class of work."

It may be seen from this that from the start Taylor had in mind, and put into practice, the very principles that we are discussing here.

The manufacture, or processing, of any article may be divided into two classes, namely, (1) that for which the exact method of procedure is known in advance; (2) that for which the exact method of procedure is not known. Therefore, in using the fundamental operations of a machine as a basis for synthetically building up the standard times for an operation, these two classes must be considered separately.

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To illustrate the first method, I have formulated an example showing how the operation times would be computed in the case of a concern manufacturing gears to order. Assume that a request has been received for a price quotation for 250 gears as shown on the drawing in Figure 1. All bevel gears can be placed in one of seven classes, or types, and reference is then made to the chart illustrating

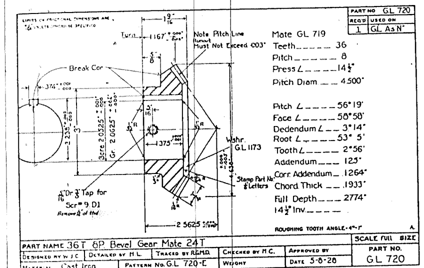

Figure 1

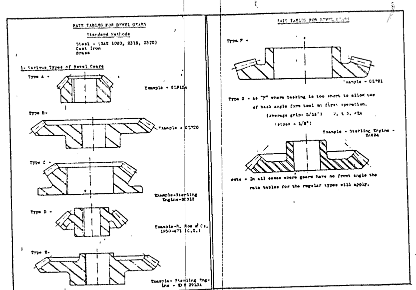

Figure 2

these (Figure 2). It will be seen that the gear falls in the second group, Type B. Reference is then made to the operation sequence chart (Figure 3), for gears of Type B, cast iron, and to be made in a quantity of over twenty-five pieces. The chart gives the operation numbers, operation names and classes of machines upon which the operations are to be performed. Take the first operation, 5 B O—bore, turn hub, face end of hub and shoulder. It is performed on Machine Class 58, a Jones and Lamson Machine Company Double Spindle Hartness Flat Turret Lathe (Figure 4).

For this machine, studies of the type discussed by Mr. Schulz and Mr. Lowry have been made, giving all the fundamental operations for the lathe, and the unit times. Listed here are the handling, tool setting and machine setting and starting times (Figure 5).

RATE TABLE FOR BEVEL GEARS

E- Cast Iron-

2- Orders of 25 pieces or over.

Type B

Oper. No.	Operations	Mach. Class	Rate Table
5 BO	Bore, turn hub, face end of hub & shoulder	58	This Column refers to Pages in Rate Table Books
6 RE	Hand ream		
10 KS	Keyway	64	
15 RE	Hand ream		
20 TR	Face end of hub & shoulder	60	
25 TR	Rough face & back angles	60	
30 TR	Finish face & back angles	60	
35 TR	Rough & finish front & front angle	60	

Figure 3

MACHINE RATE TABLE

Jones and Lamson Machine Co.
Double Spindle Hartness Flat Turret Lathe.

2. Handling Time.
A. Chucking and Removing

1. Air Chuck
a. Small and medium size change gears.

	Forgings	Cut off or 1/2 turned
1. Chuck 2 pieces.	.22	.12
2. Remove 2 pieces.	.10	.10

b. Small and medium size bevel gears.

	Air chuck	Wrench chuck
1. Chuck 2 pieces.	.12	.22
2. Remove 2 pieces.	.10	.16

2. Stud Arbor
a. Small and Medium bevel gears.

1. Place 2 pieces on arbor and tighten.	.35
2. Remove 2 pieces.	.25

3. Draw Arbor
a. Small and medium bevel gears.

1. Place 2 pieces on arbor and tighten.	.19
2. Remove 2 pieces.	.13

B. Setting Tools

1. Index turret for 1/4 turn-Each additional 1/4 turn requires .02.	.05
2. Advance turret	.03
3. Back turret	.03
4. Back and Index turret	.07
5. Advance turret and throw in feed	.06
6. Advance turret and throw in headstock feed	.07
7. Advance turret, change and throw in feed	.09
8. Advance turret, change speed and feed, and throw in feed	.11

C. Machine Setting and Starting

1. Start machine	.03
2. Start machine and change speed	.04
3. Change speed	.03
4. Change feed	.03
5. Change speed and feed	.05
6. Set headstock.	.06
7. Set headstock and throw in feed	.08
8. Set headstock, change speed, throw in feed	.09

Figure 4