WORK STUDY — WHAT IS IT?

BY

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As a result of a tour of various establishments, it has become apparent that the question asked in the title can be answered in many ways. Analysis shows that these answers can be headed under the following five R.s—Realistic, Reasonable, Ridiculous, Ribald and Rabelaisian.

Much of the variation in approach to the subject is founded on a lack of knowledge of what ' Work Study ' really is, and how it might be used in the Service. Most people associate it with its Time and Motion origin, and conjure up a picture of Charlie Chaplin in *Modern Times*, or of a gay fantastic light pattern drawn by lamps on a worker's moving hands in a micro-motion film. The mind picture is, of course, governed by the vintage of the mind, the older generation think of Charlie Chaplin the younger of the pretty light curves.

This association of ideas is caused by the unfortunate errors in application of Time and Motion techniques in the early years of this century. The results of some of the early trials were indeed comic, but even the early efforts threw light into many dark corners and led to improvement in efficiency. Nevertheless, in this country, by resting on the laurels of the industrial achievements of Queen Victoria's reign, we failed perhaps to be as critical of our efforts as we might have been, with the result that our rate of output of work has not advanced as quickly as that of other nations.

This self-satisfied lethargy has been pricked by the technological advances of this century, stirred by two world wars, and finally overcome by the need to export or die. Self-criticism of our own effort has become necessary, and Work Study (which is a logical system of self-criticism) has become a household word in engineering.

The very name ' Work Study ' is regarded by some with resentment, if not repugnance, and presumably this is because the two nouns name two unpopular forms of human endeavour, but the name is only a tally on a very useful box of tools.

Means of Improving Efficiency

In naval engineering, as in anything else, there are two basic methods of improving efficiency :—

(i) *Capital Expenditure* on design, new materials, new processes and new sources of power. This method has unlimited possibilities.

(ii) *Improvement of Utilization of Present Resources*, of men, machinery and materials. This method has limited possibilities.

Work Study is concerned mainly with utilization of present resources. By finding facts of the present situation and by improving present methods of doing work, it can feed back information in the form of facts which are an aid to the making of policy for the future.

Efficiency Factors

Efficiency in engineering is a compound of many things but a common formula is :—

Efficiency (E) = Organization (K) + Technical Facilities (T) + Utilization of Resources (U).

The formula being used as :—

$$E = aK + bT + cU$$

where a, b and c are the respective percentage efficiencies of the factors named above. The relation in value of these factors (i.e. their value out of 100 with respect to each other) is variable according to the task being assessed.

For example, in an aircraft carrier the values allowed might be :—

$$E = 50 + 30 + 20$$

but in a smaller ship they might change to :—

$$E = 35 + 20 + 45$$

because, in the large ship, organization towards co-ordination of effort is more important than in a small ship and its better facilities and mechanization make the large vessel less dependent on utilization, which is mainly a human factor. In short, the old saying : ' The smaller the ship, the less room for passengers '.

Work Study can help to improve all of these factors, and thus improve efficiency.

Organization

From the very earliest times, man has used organization, and original efforts to create team-work towards a common goal were almost entirely concerned with men, but the troubled history of technological advance has demanded successive alterations in organization. As more and more machines did the erstwhile manual labour, various A.s and A.s were introduced into organization. Originally applied to men, then to men and machines, we are now on the threshold of automation, where organization may have to be mostly directed to machines.

This shows that organization should be kept dynamic and not allowed to become static, by the application of a judicious ' re-hashing ' at intervals dictated by circumstances. In the culinary art of Mrs. Beeton, ' re-hashing ' implies a reduction to even smaller parts, then a re-mixing into a new whole, followed by further cooking, before the old dish is served up in its new form.

Technical Facilities

Technical facilities include tools, spares, stores, maintenance instructions, skill of men, and methods used. The detailed investigation into how work is done at present, which is the first step in Method Study (one of the branches of Work Study), soon shows the delay, frustration and inefficiency that result from :—

(*a*) The wrong tools
(*b*) Tools in a bad state
(*c*) Lack of spares
(*d*) Lack of stores
(*e*) Stores incorrectly supplied or stowed
(*f*) Inadequate instructions
(*g*) Inadequate skill
(*h*) Bad habits of work
(*i*) Insufficient co-ordination of men's efforts
(*j*) Lack of method leading to unnecessary work.

The facts discovered can be assembled and acted upon, and are most revealing when measured in time lost and the money value of that time.

Utilization

This factor is the one that measures the efficient use of men and machinery, and while we do much to measure our machinery, we do little to measure the more important factor, our men.

This lack of knowledge of how long it takes one man, two men, or a dozen, to do a set task is the more illogical because we always work under a certain notice for steam. It is by no means easy to measure human performance as, although mass-produced, man is the product of many intangible influences as far as his work is concerned. However, during the last seventy years, great strides have been made along the path towards attaining a means of giving sufficient accuracy in measurement of a man's effort on a set task. Obviously, the effort, even of a single man, will alter according to the work and his interest in getting it done. Both the work and the interest can cause infinite variations in the time required, and this is the province of that part of Work Study known as Work Measurement. For instance, a $\frac{5}{8}$-inch nut may be in a bilge, in an oil tank, in a hot corner of the engine room, on a removable piece of machinery ; it may be ' seized ' in any of these positions. If the time taken, by an average workman working at an average speed to remove it in these various conditions, is known, it will be that much easier for an engineer officer to assess the time for a job in which such work plays a part. Standard data of this kind can be produced by Work Study and it is of great help in planning any work.

The Field of Work Study

As the name implies it is a study of work, of work in the widest sense of what has to be done, and not merely in the special and more restricted sense used in the physical sciences. It is primarily concerned with human work and such a study must begin with :—

(i) The factual recording of what is done at present, or what it is proposed to do
(ii) The examination and analysis of records
(iii) The identification and elimination of unnecessary work
(iv) The re-examination of the ' remaining ' essential work to determine the ' one best way ' of doing it.

The final result of these studies of any job is to increase the productivity of those who work by :—

(*a*) Elimination of unnecessary effort
(*b*) Better manning, planning and control of their work.

In theory, these techniques are applicable to all work, but in practice it is important that they are applied :—

(*a*) At the right time
(*b*) In no more than sufficient detail
(*c*) With priority to those operations which promise to give the most substantial savings by their study.

Choosing the subjects, deciding the order in which they need be tackled, and selecting the appropriate techniques to be used, are therefore essential preliminaries to the use of Work Study. Moreover, the continuous technological advance, reflected in new materials, new machines and new men (in the sense of new skills) means that the Work Study attack must be continuous on the widest possible front if the maximum benefits are to be secured.

Work Study Division

Work Study may be conveniently divided into two main subjects :—

(i) Method Study
(ii) Work Measurement.

Both subjects use similar techniques and though for discussion the two may be divorced, in practice they are very happily married in a close and intimate union.

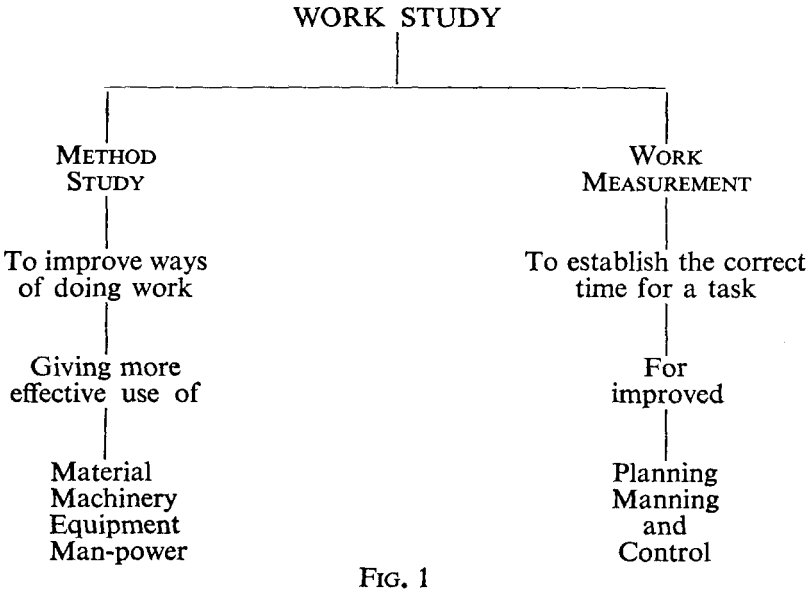

FIG. 1

Method Study

Method Study may be defined as ' the study of the ways of doing things ' or more elaborately as ' the critical examination of existing or proposed methods with a view to their improvement '. Its aim is eliminating waste in man-power, machinery, materials and time, and the improvement of working conditions and the tools for the job. Briefly the general procedure is :—

(i) Make an exact record of what is being done at present, preferably in chart form, so that the whole picture of the job can be seen.

PICTURE	SYMBOL	MEANING	
A wheel rolling	○	**OPERATION**	When something towards completing the job is done
An arrow	⇨	**TRANSPORT**	When the man or part of the job is moved
A mirror	□	**INSPECTION**	When man or job is counted, inspected or checked
Going 'round the bend' is longer than going straight	D	**DELAY**	When nothing happens towards completing the job
Something put down	▽	**STORAGE**	When man or part of the job is put aside, or is held still

TABLE I

(ii) Challenge every item on this record by the following questions :—
- (*a*) What is done, and why ?
- (*b*) Where is it done, and why ?
- (*c*) Who does it, and why ?
- (*d*) When is it done, and why ?
- (*e*) How is it done, and why ?

(iii) Then see what can be :—
- (*a*) Eliminated
- (*b*) Combined
- (*c*) Changed in order of doing
- (*d*) Simplified.

OPERATION CHART	
Chart begins: when in bed Chart ends : when fully dressed	
1	Getting out of bed
2	Cleaning teeth
3	Washing
1	Looking in mirror
4	Shaving
2	Looking in mirror
5	Dressing
3	Looking in mirror

CHART I

(iv) A new method of doing the job is then produced and compiled on Job Cards. These show the order of doing the job, tools required, material, spares and skill required and recommends the best number of men.

(v) The new method is instituted, and the method of its operation is explained to the men conscerned.

(vi) Periodic checks are made to ensure that the job is still being done in the new improved method. These steps can be summarized as :—
- (i) Record
- (ii) Examine
- (iii) Develop
- (iv) Install
- (v) Maintain.

Method Study Techniques

If anyone has to describe an event of any sort, it is usually a long-winded effort, except for experienced writers. Even when the narrative is finished, it takes time for the reader to find any particular fact somewhere in the record. That is a waste of time for the reader, and of course, the writer took even longer to write that fact.

This is the main reason for the lack of detailed knowledge of exactly what we do when we work—the time it takes to write it down. To overcome this a type of shorthand has been adopted in Method Study, involving the use of symbols for different events in a job. These symbols are meant to convey instant visual appreciation of what is happening in a job and, as such, they are like Egyptian hieroglyphs of old, pictures of what is happening.

Those in common use in this country are shown in Table 1.

Operation Chart

This is the chart that gives a bird's-eye view of the whole job.

Consider getting up in the morning (Chart I)

In an operation chart only two symbols are used, the ○ and the □, for Operation and Inspection respectively, and in Chart I there are 5 operations and 3 inspections, which gives due regard to human vanity.

This picture is meant to represent the ' do ' events only, and does not show the various transports we must make, or the delays we may experience, so it may show the ' do ' events but does not show the ' make ready ' and ' clear away ' events associated with each one of these ' do ' events.

Flow Process Charts

This is the next technique used, and it is applied to each one of the ' do ' events in the operation chart.

For instance consider shaving (Chart II) :—

The simple act of shaving now has 20 operations, 5 transports, and 2 inspections, and this is by no means a full record of every event. If this record is studied it is obvious that only 8, 9 and 10 are actual shaving or ' do ' operations, and the rest are ' make ready ' and ' clear away ' events, and they represent the longest part of the job.

This is often so in engineering work ; getting ready or clearing away often takes longer than the actual job, especially when the tools, etc., required are not known beforehand.

To return to shaving, critical examination and applying the questions—What ?, When ?, Where ?, How ? and Who ? and even Why ?—to each of the events in the Flow Process Chart is bound to lead, by elimination, combination, changing the sequence or simplifying, to the use of an electric razor. It is not, however, the only solution, there are others such as :—

(*a*) Put bed in bathroom to reduce transports
(*b*) Employ cheaper labour to ' make ready ' and ' clear away '—(if married and at home, perhaps wife could do this ?—consider results on working relations.)
(*c*) Grow a beard.

However, improvement can be effected by :—

(i) Using an electric razor
(ii) Hanging electric razor already plugged in, alongside mirror
(iii) Reduce transports by having bathroom adjacent to bedroom, and light in centre of mirror.

FLOW PROCESS CHART	*MAN TYPE*	*SHAVING*

Chart begins : on completion of inspection after washing to determine need for shaving
Chart ends : when shaving gear returned to storage

(1)	Remove razor, soap and brush from locker
⇨1	Take razor, Soap and brush to wash bowl
(2)	Fill bowl with hot water
(3)	Remove soap from container
(4)	Wet face
(5)	Apply soap to face
(6)	Work up lather with brush
[1]	Inspect lather
(7)	Remove razor from case and assemble
(8)	Shave R.H. side of face
⇨2	Move body or face to suit light
(9)	Shave L.H. side of face
[2]	Inspect shaved areas
(10)	Repeat shaving of areas where standard low
(11)	Put razor on shelf
(12)	Wash off lather
⇨3	Fetch towel
(13)	Dry face
(14)	Strip down razor
(15)	Dry razor parts
(16)	Re-assemble razor
⇨4	Replace towel
(17)	Wash and shake brush
(18)	Replace soap in container
(19)	Collect razor, soap and brush
(20)	Empty and wash down wash-bowl
⇨5	Return shaving gear to storage

CHART II

FLOW PROCESS CHART	MAN TYPE	SHAVING	PROPOSED METHOD
Chart Begins : As Before Chart Ends . As Before			
⇨1	Remove razor from hook		
○1	Shave R.H side of face		
○2	Shave L.H side of face		
□1	Inspect shaved areas		
○3	Repeat shaving where standard low		
○4	Strip down razor		
○5	Clean razor		
○6	Re-assemble razor		
⇨2	Replace razor		

CHART III

The flow process is then as shown in Chart III.

A much simpler, easier, and quicker method.

There are several other techniques used in Method Study for quick visualization of the relative importance of events in a job.

Gang Process or Multiple Activity Charts

These are used to accentuate the 'do' operations, and to show the relative use of tools or men in a combined job. The multiple activity chart of the previous shaving chart is, assuming shaving takes 10 minutes, as shown in Chart IV.

Flow Diagrams and String Diagrams

These show parts of a job movement or men's movements in a combined operation (e.g. closing up for action stations), and they help to determine where bottle-necks occur, and the best way to carry out combined movements of men or material. These charts consist of scale-drawing plans or three-dimensional drawings with the movements shown by lines or strings.

The chief virtue of all of these techniques (involving as they do an analytical approach to work) are that they make possible the application of very old principles in a more ordered and forceful way, and Method Study has often been called ' ordered common sense '.

Work Measurement

This section of Work Study can be defined as ' the determination of the proper time to allow for the effective performance of a specified task '.

Human work is a complex combination of both manual and mental effort under a wide variety of conditions, thus it cannot be expressed as the engineer expresses work, by the product of force and distance. Furthermore, the degree of accuracy required for the measurement of human work is purely an economic question dependent on the type of work and the frequency of that work.

Whatever means of measurement are adopted, the probable error, inherent in the result, must be found and minimized as much as possible. All measurement of human work is done by observation and timing, and there must follow a basic procedure by fully trained observers if practical assessment of the rates of working are to be achieved. By using statistical methods of checking these results, errors can be found and minimized. This involves finding reliable averages after many observations, and an error correction factor for particular observers. It is then possible to arrive at a ' standard rate of working ' for the average man, in average conditions. This standard rate of working is defined as ' the rate which an average man, suited and accustomed to his task, can maintain throughout his normal working period apart from the necessary time taken for rest, without at the end of that period being more than normally, healthily, tired'. Work done at this rate, with the necessary rest periods, is said

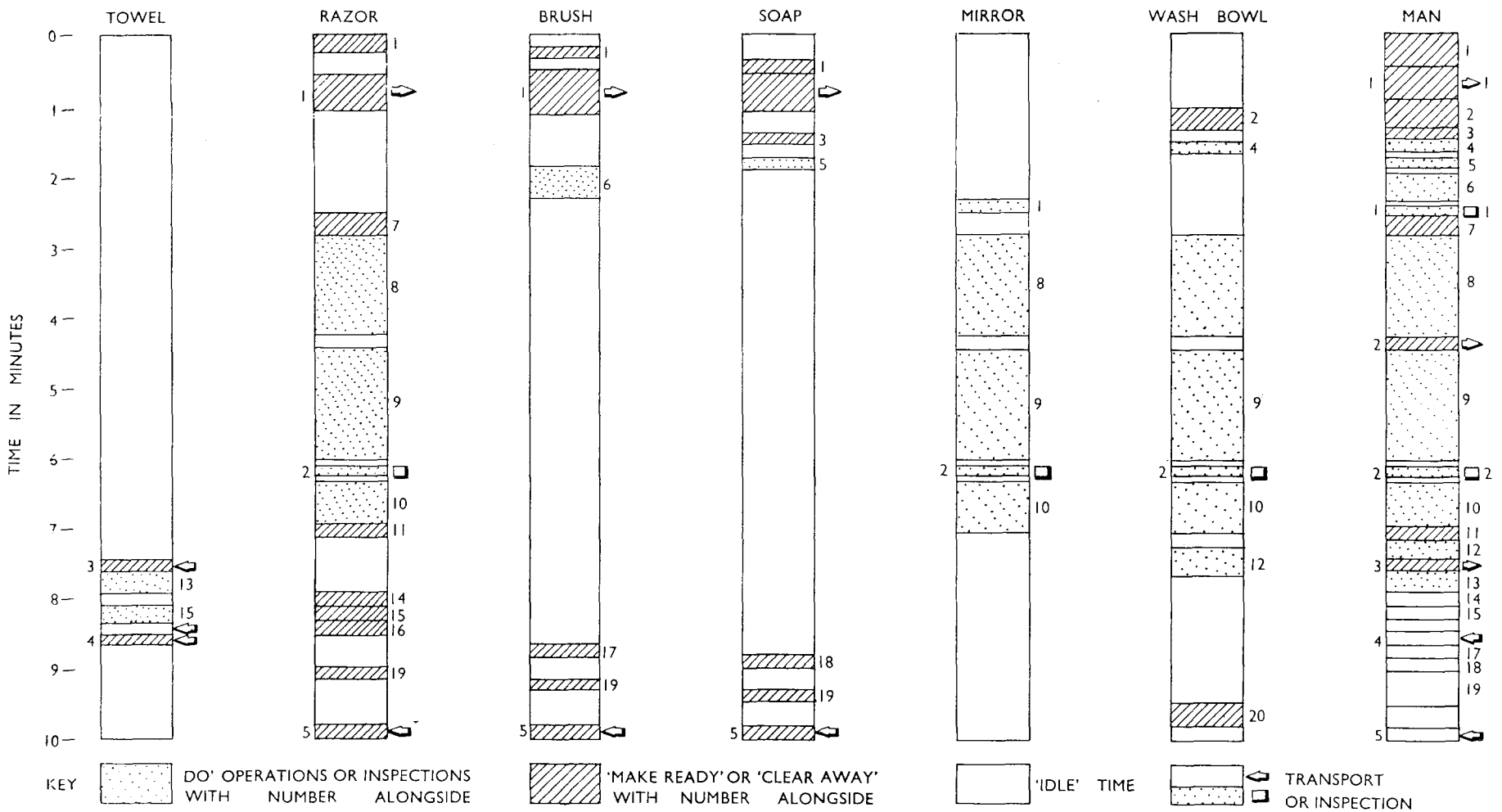

CHART IV—MULTIPLE ACTIVITY CHART—SHAVING

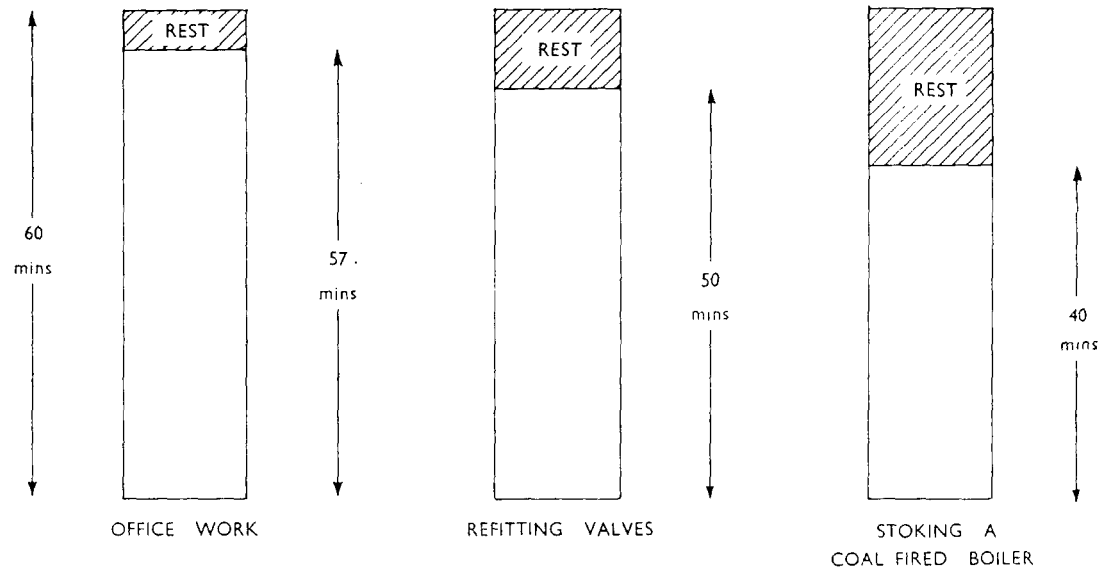

FIG. 2

to be performed at a defined number of work units per hour (usually 80), and this is called ' standard performance '. For example, 2,400 work units would take 30 men 1 hour, or 6 men 5 hours, always assuming that the work could be suitably shared.

Work Units

A work unit varies with the type of work and the conditions under which it is done. For instance, the work unit for 3 different tasks is shown in FIG. 2, and each task must be considered to establish the various rest periods appropriate to the manual and mental effort.

Time Study

Time study by direct comparison with a watch can be used to find average times and the procedure is as shown in Table II.

This procedure can be used for particular jobs such as refitting a running down valve, and it not only supplies the time for that particular job, but also provides the element times for removing $\frac{1}{2}$-in. nuts from studs, etc., which can be classified into lists of standard data. These standard data times can be used in the procedure known as ' synthesis '.

Synthesis

Our maintenance work is not repetitive in the full industrial meaning of the word, and standard data, and synthesis using that data is most useful in the non-repetitive work normal in the Service. For instance, in using a typewriter there are only a limited number of different elements of work, such as striking keys, adjusting the paper, etc., but from task to task the number and sequence of these varies enormously. This is true for practically all naval work. How useful it would be to know how long it takes to remove nuts of various sizes ! Hence, non-repetitive work such as maintenance and repair could be estimated by synthesis using standard data (Table III).

Analytical Estimating

The use of synthesis is limited to the amount of standard data available and it is not feasible in many repair jobs to establish data for every possible element.

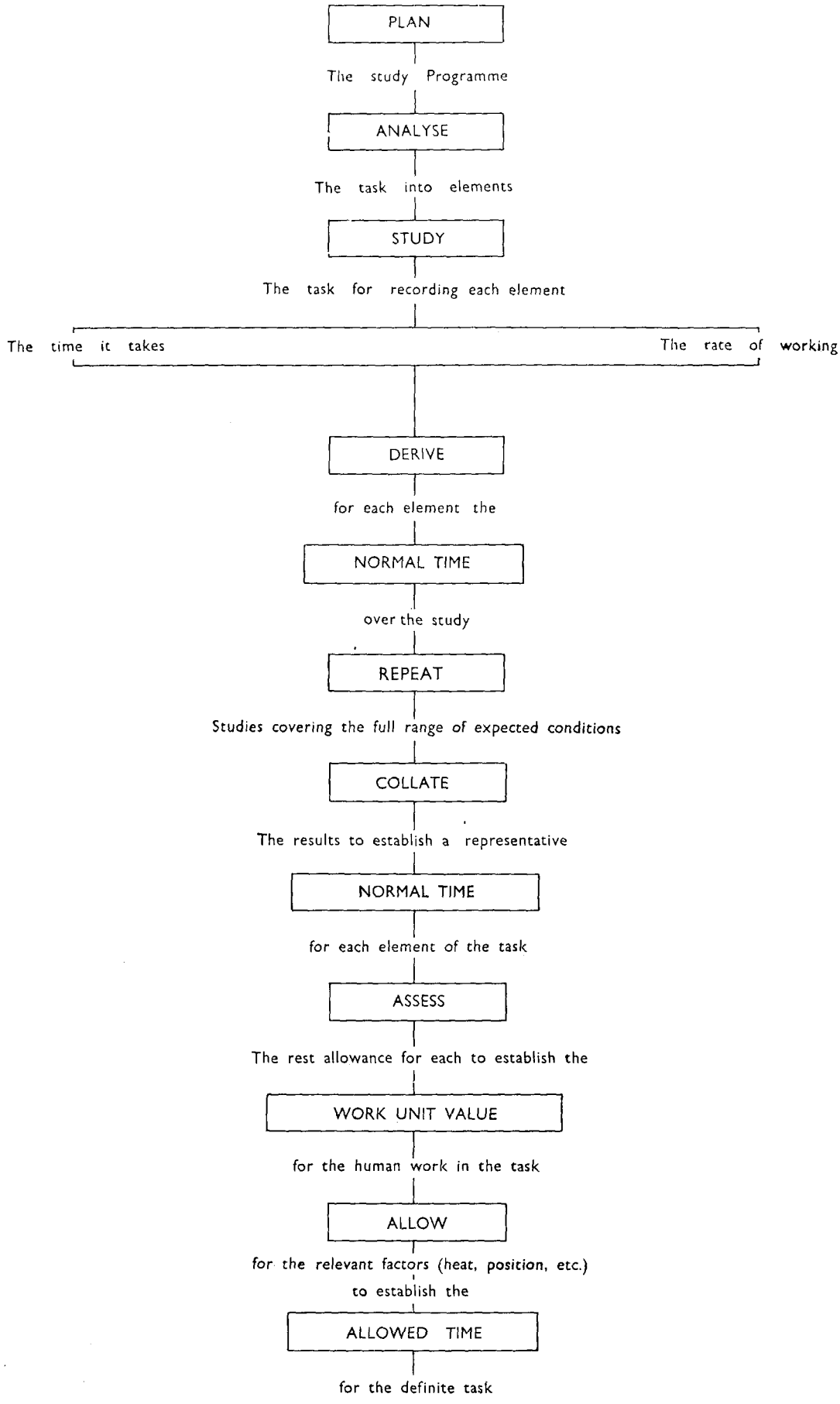
PLAN
The study Programme
ANALYSE
The task into elements
STUDY
The task for recording each element
The time it takes
The rate of working
DERIVE
for each element the
NORMAL TIME
over the study
REPEAT
Studies covering the full range of expected conditions
COLLATE
The results to establish a representative
NORMAL TIME
for each element of the task
ASSESS
The rest allowance for each to establish the
WORK UNIT VALUE
for the human work in the task
ALLOW
for the relevant factors (heat, position, etc.)
to establish the
ALLOWED TIME
for the definite task

TABLE II

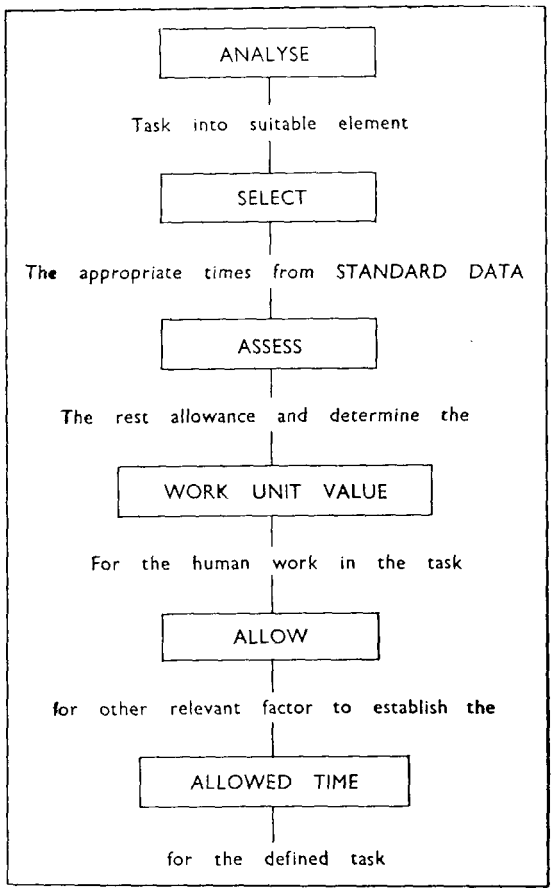

TABLE III

The procedure used is to analyse part of the job for which no standard data is available into suitable elements and then to use one of the common predetermined Time-Motion systems.

These systems are the result of extensive laboratory study of human muscular action in doing work and by reproducing the actions that are expected to be required, and reading off the time required for those human actions from the tables provided, it is possible to estimate with sufficient accuracy how long the job will take.

These outlines of the main features of Work Measurement show the systematic approach and objective attitude behind them. There is ample evidence in industry of the reliability of the results, but sound techniques are one thing, the way they are used is another. Work measurement is founded on complete honesty and, properly used, it can provide a vital contribution to higher efficiency.

In one article, one cannot hope to cover all aspects of what has become a profession, but it is hoped that the techniques described may be of help in understanding what Work Study is, and what it sets out to do.

When work is going on in the Navy, the ' drips ' about a job arise from all sorts of causes, but they can be generally classified into :—

(i) Criticism of how things are organized
(ii) Wrong directions to do a job
(iii) Incomplete directions on how to do a job
(iv) Wrong tools, or no tools available
(v) Tools in bad condition, or not enough tools
(vi) Working conditions (heat, light, sound, polluted atmosphere)
(vii) Not enough time to do a good job
(viii) Not enough warning of work to be done
(ix) Waiting for others to do their part of a combined job
(x) Opinion of the rate of working of others on the job.

Each of these can be translated into some time-honoured remark, which is explicit of a feeling of frustration, confusion and delay, and which leads to a ' slight blue haze '. Each of these ' drips ' can be lessened, and sometimes completely removed, by applying Work Study.