

### DON'T DISCLOSE IDENTITIES

From the beginning of these studies, the identities of the persons under study have been kept confidential. We look to you to carry on this trust. Please guard the privacy of the persons involved by substituting fictitious names, or code symbols for real names.

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THE HUMAN FACTOR IN INDUSTRY  
R. D. GROSS

29 pp

July, 1931

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July 6, 1931.

MR. G. A. PENNOCK:

Mr. R. D. Gross, who was with the Nash Motor Company as an industrial engineer and took a leave of absence to study in the Graduate School of Harvard, had some discussions with Dr. Mayo about our work. Dr. Mayo suggested that he come to see us when he came out to Chicago and see first hand our various experiments. He has just finished his visit and has written <sup>at our request</sup> the attached paper which contains a number of interesting items in it. We would like to get it back.

M. L. PUTNAM - 6088.

THE HUMAN FACTOR IN INDUSTRY

R. D. GROSS

I. Mankind at the Crossroads.

II. Miscellaneous Comments on the Western Electric Inquiry.

- A. Motives back of the inquiry.
- B. The test room experiment.
- C. The supervisory training program.
- D. The total situation psychology.
- E. Interviewing program.
- F. General summary.

III. Possible Index of Maladjustment.

Note: While at the Harvard School of Business Administration, Mr. Gross, formerly an industrial engineer with the Nash Motor Company, became acquainted with the research projects being carried on by this division through Prof. Mayo. At the suggestion of the latter he spent several weeks here familiarizing himself with our work. In this paper he puts forth his concept of our objectives and offers his impressions and suggestions.

July 1, 1931.

1. MANKIND AT THE CROSSROADS

A short time ago I had a very elaborate system built up to show the vital, crucial, far-reaching importance of the "human factor in industry" to the very future of civilization itself. After scrutinizing the various chains of reasoning involved in this superstructure I seemed to see a certain top-heaviness, but before placing the remains on the scrap heap, it might be worth while to examine its general features, largely because some rationalization to the general scheme of things is desirable.

For any proposal to make claims for widespread attention it must perforce justify itself in broad terms of human welfare. I have since come to wonder to just how much of widespread attention the "human factor" is entitled and to question whether my conception of "human welfare" was not a little too all-inclusive.

The main steps in the reasoning were roughly as follows:

1. The social-economic setting is dynamic. In the growth of civilizations generally, "the understanding of change does not keep pace with change itself". That is to say, there is an ebb and flow in the course of civilizations and cultures.

2. The cause for this unfortunate state of affairs lies in a lack of balance. More precisely, in the year 1931 at least in the inability of the methods of social control to keep pace with technological advance. In other words, modern industrialism has solved its physical and mechanical problems; left unsolved its social problems. The result: chaos and imminent decay.

3. Therefore, to save mankind from itself, restore the balance. Concentrate on devising new methods of social control.

In elaborating on these propositions I first pointed out that society was really dynamic; moreover, that there was much evidence that "change had outstripped the understanding of change itself", such

as:

1. The present economic depression.
2. World-wide unrest irrespective of cyclic depression. The leavening urge of "equality" growing in intensity among the masses within the present era--European countries in the grip of a social revolution, expressive of fundamental unrest--the spirit of economic nationalism the world over, particularly rampant within the last decade.
3. Social and political conditions in the United States. Crime and rackets--worship of the almighty dollar--disintegration of the family--crowded cities--growth of cults and fads--profitless prosperity--high pressure salesmanship--etc., etc.
4. In industry itself. Restriction of output--low morale--accidents--spoiled work--all of these among the laboring classes. On the higher levels of management--blind alley jobs--nepotism--bluff, politics, and incompetence.

Passing on to the second proposition, I pointed first to the general belief that the social sciences had lagged behind. The need for "human engineering" has been a football for propagandists within recent times; so much so that their views have gained wide acceptance. My contribution to this deluge of words was the following:

"The formation of the texture of society under conditions of advanced industrialism has been left largely to expediency."

For supporting evidence I pointed out that the capitalistic system was ill adapted to conditions of advanced industrialism. In industrial infancy a system which places great premiums on individual initiative may be excusable and justifiable; but as conditions advanced, cooperation and interdependence became the central problem (through the specialization of labor). Therefore the capitalistic system is anachronistic. Its continuance under modern industrial

conditions, its emphasis on "rugged individualism", the gravitation of the control of productive facilities into the hands of those motivated solely and chiefly by self interest are clear evidence of the inability of social institutions to become modified in accordance with changed conditions. The emphasis on self interest, moreover, through the operation of pecuniary emulation, has warped all mankind to a materialistic and selfish aim in an industrial scheme of things, in which self interest is actually only a factor of minor importance, and cooperation a factor of major importance. Capitalism in its social aspects, as contrasted with its technologic developments, is sadly out of tune.

Another approach to this second thought is the anthropologic one, noted by Dr. Mayo; it lends color and support to the rule of expediency in human affairs under industrial conditions. Industrialization has brought about occupational and geographic redistribution of labor. That is, there has been mobility of labor not only with respect to place, but also through the process of "upgrading" to adaptation to new jobs. Inevitably there has accompanied this mobility a disintegration of the individual's social milieu. Disrupt the favorable milieu in which the individual finds himself and you sow the seeds of unrest. The isolation of the family in the modern city, characteristic of modern times, is evidence of the disruption and disintegration of former cultures, in which the individual found point and significance in the activities in which he was engaged. The lack of balance between the solution of technologic and social

problems again finds echo in the anthropologic approach.

Finally, in the present interest in economic planning I thought that I saw again restated the idea of lack of balance. Obviously, economics deals with the satisfaction of human wants and needs; hence, economic planning implies the use of foresight in determining these wants and needs. But inasmuch as this determination has been left largely to expediency, it is quite obvious that a more precise determination of these things would be prerequisite to a sound method of economic planning. As a matter of fact, the interest in economic planning implies that somehow the progress of modern industrialism has gotten out of touch with both the tangible and intangible needs of the masses. That is to say, that the aims and purposes of business must be restated in terms of human rather than technological values.

So much for the main aspects of the superstructure that I had contemplated as pointing to the study of the "human factor" in industry as the crux of modern progress. Much of it is plausible, but there is in it an element of speculation and sweeping generalization, which undermines its validity as a means of justifying a more precise approach into the problems of human relations.

It must be granted that there is much evidence of maladjustment, and yet any judgment on this score implies the concept of a norm. For example, the United States in the last decade has led the world in the movement toward economic nationalism. Is this normal? It seems to me that before it can be definitely pronounced abnormal,

many factors would have to be taken into consideration. Is restriction of output in industry abnormal? To say that it is, implies an intellectual detachment and a preconception of what constitutes normality.

To attribute maladjustment, admitting for the moment that it does exist, to a lack of understanding of human as contrasted with technologic change may also be in error. There may be other factors. For example, it is probable that a good deal is already known of the human factor. It has been neglected more because of lack of courage and initiative in putting through remedial measures than lack of understanding.

Finally, the present popular thought on the lack of balance between the human and technological factors cannot be taken as a safe guide. Much of it is based on an analogy which may or may not hold. Research has accomplished a great deal in the physical sciences, ergo, research into human problems has great constructive possibilities. That is the depth of the popular arguments pro "human engineering".

I concede that the relating of the study of the human factor to human welfare, on a cosmic scale, is beyond my reach. Nevertheless, some one may succeed in doing it, with a greater semblance of rigor. I have, then, had to narrow my conception of human welfare to some degree. I believe that it is possible to justify the intensive study of the human factor in the urge for self analysis and self improvement within the industrial unit itself.



It seems to me that a constant reexamination of the various devices, human and material, within the confines of an individual company may be justified not merely on the basis of the probability of improvement, but on the grounds of at least preserving the particular gains that have been made in the past. We are no longer in cosmic realms when we say that individual companies rise and fall. It is an outstanding characteristic of the competitive system. Of industrial companies it may be said without any fear of hasty generalization that "the understanding of change has not kept pace with change itself". In addition to this we have the positive urge to inaugurate remedial measures provided by the competitive system itself. The number of companies with moribund managements is legion, and this statement can be made with absolute certainty. It is not necessary to indicate the processes of decay in managements; the ease with which companies fall into desuetude makes it almost possible to formulate a law as rigorous as the conservation and degradation of energy. In every case, however, there is a certain momentum which carries them along and obscures the fundamental factors of management and contributes a feeling of false security.

There is a certain preachiness and dogmatism to the above statements, admittedly. Self analysis and self improvement, meaning the constant reexamination of all of the methods, plans, schemes, devices, and a reevaluation of the capabilities of the members of the organization, serve not only to bring to light errors which indicate the beginnings of ultimate decay, but also to show clues

for possible improvements.

This constant reexamination is then, as I see it, an essential feature of management which cannot be evaded. To try to evaluate the cost of projects aimed in this direction, in terms of direct savings in labor costs, for example, is beside the point. It is worth something at least to be ahead or abreast of the competitive procession. Even in the devising of new machinery there has been too much counting of pennies. In this field alone it is worth while to employ engineers to continuously scrutinize the methods of production without too much estimation of savings in direct labor. The result of such surveys serves to reevaluate the importance of certain processes and methods; often the new machinery suggested is too costly for immediate adoption. But the important thing is that the management, as a result of the survey, has received a new interpretation of its technical processes. If, then, the human factor is more susceptible to retrogression than inanimate machinery, a fortiori, how important is it to reassess and survey the human factor?

If improvements resulting in lower labor costs are forthcoming, cannot the objection of exploitation of labor be leveled against the management? Accepting the more rigorous economic theory, it cannot; but there is evidence that there is a certain gap in economic theory on this point. I see no way out except that the managers of labor, in order to defend their self-respect from the taint of exploiting their fellow-men, demand that the cost of improvements be borne by

those who gain most from their introduction.

I do not advocate a reexamination of the human factor as an isolated project; it should be a part of the fabric of management itself. There are two reasons for the learning and application of this technique at the present time. In the first place, the urge to reexamine and reevaluate has been gaining ground in industry in recent years. Inevitably so, as industry has become more complex and competition more severe. To extend the inquiry to the human factor is a mere extension of the general method, or rather of the urge to learn more of the intimate working of the industrial machine. The method is essentially different, as will be shown later, from that of technological investigation, yet the motivating factor back of such investigation is essentially the same. On the other hand, those managements which for some reason interpret every new approach in terms of reduced labor cost are finding that the installation of machinery is entering a period of diminishing returns. Such managements perhaps through a curiosity stimulated by the false mechanical analogy already referred to, may turn to an investigation of this sort. Finally, it is to be hoped that the industrial engineer, who up to this time has regarded as his own particular field the important questions of restriction of output and incentives will revamp his point of view to a broader conception, and a more realistic one, of the human factor. But the essential thing is that managements should not regard such investigations as apart from managerial technique itself.

The objection may be raised that other factors beside those of internal management determine their rise and fall of individual companies. External factors do play a large part, and yet there are sufficient cases of failure due to internal decay to support the general contention that reexamination and reevaluation of all the internal factors is a central problem of importance. As a matter of fact, there is no reason why the technique of studying the human factor inside the plant cannot be applied with modification to external affairs in which the human factor also plays a part, as for example, advertising.

The train of reasoning is this: reexamination and reevaluation is an essential function of management; a technique is being developed which makes it possible to extend the inquiry to the human factor. The experimental attitude perhaps with the profit motif woven into the orchestration, serves as a basis for examining the progress in the development thus far.

2. MISCELLANEOUS COMMENTS ON THE WESTERN ELECTRIC INQUIRY

A. Motives back of the inquiry.

The preceding discussion has probably been unnecessarily longwinded. At the same time it is essential for one to constantly keep in mind the general objective of the approach stated in general terms and related to the immediate economic scheme. The idea of an experimental attitude and the relation of an intensive study of the human factor to managerial policy is probably the most important and significant thing that I have noticed in my visit. To come across such an attitude in American industry where pious lip service for the working man coupled with the dullest precepts for handling labor, magnified into the proportion of universal laws (see any of the articles in "Factory and Industrial Management") is the rule, is extremely refreshing.

B. The test room experiment

The discovery of the preponderant importance of mental attitude in the industrial situation is a major pioneering development. Morale is the subject of a vast inspirational and exhortative literature; it is the common meeting ground of expert and layman. It is one of those intangibles par excellence on an equal basis with "it".

Munsterberg hinted at the importance of emotional rapprochement; Myers, in his writings, hints also at the significance of peculiar personality quirks on the part of supervisors which affect the adjustment of the worker. I myself, when I was a rate-setter, had a

dim feeling that if the mental set of the operator I was timing was not reasonable to some degree, I could never expect by any known means of statistical manipulation to come out with a rate that was fair and equitable.

The evaluation of the mental attitude factor as being chiefly responsible for a 40-62% increase of production, under the test room conditions, is a point as Dr. Mayo says, "that must give industry pause."

Note for the profit-minded: in every other type of investigation, such as the engineering, motion study, etc., and also in the typical psychological selection investigation, it is necessary to study intensively each job; but if, as results seem to indicate, supervision is the main factor in attitude, then a new generally applicable method of supervision can be determined and the cost of this development spread over a large number of laborers. Cost per laborer low, but the potential gains probably in excess of anything that could be devised by other methods.

Another important aspect of the test room experiment is the development of method; that is, the evaluation of multiple independent variables in a complex situation. The testing for the effect of a single variable is unsound because as the variable is manipulated the internal equilibrium between the other independent variables is changed. That is to say, in the absence of control over the many variables, it is necessary to evaluate each at each stage of the experiment by empirical observation.

One more comment on mental attitude. Carver, in his "Essays on Social Justice", at the start is very careful to rule out of his method of approach any intuitive feelings of contentment on the part of workers as a factor which makes for survival value. He then states that high productivity of labor is a factor that contributes to survival value. The close connection between mental attitude and productivity, demonstrated in the test room, demands a reexamination of economic theory.

The industrial engineer has consciously been entirely impervious to the suggestion that mental attitude affects productivity, although he has posed as an expert on questions of incentive. What success he has had must be attributed to an unconscious realization of the factor as important. That is to say, the various systems that he talks about are irrelevant; the essential thing is that intuitively he grasped the importance of mental attitude; the system themselves are mere masses of imperfect rationalization. This is reasonable too, because, admitting the fact that in a number of cases he has been successful, it is a striking fact that others who have copied the word and letter of the system have failed. It seems to me that the test of any system or approach is the application to a wide number of cases. The conclusion that the systems of the industrial engineer are faulty is therefore sound, and the chief reason for such unsoundness is indicated by the results of the test room experiment.

The development of the test room as a method of defining the industrial situation is of course a contribution of major import-

ance to the science of management. The long run nature of the experiment makes it unique in industrial history. And yet the important findings are derived mainly from the long run nature of the test. Without going into detail, it seems to me that the essential thing is the method. I have studied the various records, the history sheets, the productivity records, the progress reports, etc., and the enlightening thing is the application of a method of dealing with a complicated situation by means of empirical observation. Of course significant findings have been made, chief of which is the realization of the effect of mental attitude on productivity. The test room group has further to define the components of mental attitude. It is quite obvious that the same method of empirical observation must be extended in this process.

C. The supervisory training program.

The first thing that interests me is the perseverance over a long period of time in a general program of supervisory training. This could be justified in the same terms as any sort of adult education. Nevertheless it is necessary to specify more exactly the gains which may be expected from such a program. Any reasonable instruction seems to have possibilities for the acquisition of new points of view for the students. In a company the training of supervisors is sure to result in a certain broadening influence on the attitude of supervisors. Therefore, I have a certain preconception of the value of supervisory training, whatever road it may take. This seems to have about it an air of smugness; nevertheless



an effort to broaden the viewpoint of supervisors is a hopeful one, particularly in a large organization.

The conference method has a great deal to be said for it, particularly in that it makes for participation in the discussion, relates abstract material to concrete experience, and heightens interest. On the other hand there is the possibility of a certain shallowness due to the fact that the material is new. It might be possible to overcome this difficulty by passing out material, particularly case material, for individual consideration a week or so before the conference takes place.

The use of the employee interviews as conference material is an interesting development in the case method. It has operated in two ways, both beneficial. In the first place it has livened up the meetings, and provided a basis for the development of social intelligence (which psychologists tell us is subject to training regardless of inherent ability) In the second place, the interviewing program has been symptomatic of an open attitude on the part of management. The determination of the management to take into consideration the natural impulses and desires of the employees has had important repercussions. It accounts for the general tone of the freedom of discussion. In my recollection of certain foremen training courses elsewhere there were certain subjects which if not "verboten" were at least tactfully side-tracked. I attended a couple of the Western Electric conferences, and in spite of the fact that the subjects were mainly of an informative nature there was a hopeful

freedom from apprehension.

The development of social intelligence is a larger question. Good reasoning, an objective attitude, and a fair knowledge of psychology seem to be the main requisites. Obviously the case method is called for. If I were developing a supervisory training course I think that I would compile a series of cases analogous to Vol. 4 of the Harvard Business Reports. Naturally the employee interviews would furnish valuable material. In presenting the cases I would be very careful to steer clear of any abstraction at the end of any precepts or maxims to be used as a guide in other situations. The discussion would be confined to a study of the case itself and the formation of a solution for that particular situation, the assumption being that each case had its own data and setting, different from any other. The idea back of it is of course that the important thing is the method and not the particular solution reached. The development of an objective attitude is of great importance. In fact I wonder (but have yet to work out the various connections) if an objective attitude is not essentially the same as freedom from preoccupation and pessimistic revery. If so, then it stands at the very center of the problem of the human factor.

The need for supervisory training received its greatest impetus from the test room experiment and was later corroborated in the employee interviews which showed the influence of the supervisor to be the most important factor in employee morale.

It is quite clear that the question of training supervisors,

that is, the general method, is not completely answered. The method involving a large area of the human factor must rightly be considered a subject for research. Hence the remarks in the preceding paragraph may be entirely premature. As I interpret Dr. Mayo's theory of capitalizing our ignorance, I wonder whether some admittedly imperfect techniques might not be tried out. But it is possible that such procedure will have to await a more thorough investigation of the employee-supervisor relationship itself.

D. The total situation psychology.

Dr. Mayo has said "that the industrial psychologist must restate his science in terms of total situation." If industrial psychology, broadly considered, is the study of the integrative functioning of an individual's cognitive, conative and effective tendencies under the conditions of industrial life, this would involve investigation of the expression of these tendencies not merely in acts of concentration but also in periods of dispersed thinking of revery.

Unless a behavioristic bias is assumed in every case, the inquiry is steadily reduced to a study of motives first, and then to fundamental traits. The psychoanalysts have a deeper method of getting at the whys of the content of thinking. On the other hand the correction of abnormal preoccupation is concerned mainly with the form of thinking, in which phase Janet was primarily interested. Nevertheless, the more difficult problem of deriving superior managerial techniques must of necessity be concerned with the content of thinking. One can take the view that the essential

thing is to determine and evaluate the relative importance of personality traits under industrial conditions.

I do not think that the method of total situation does particular violence to the older academic psychology. The academic psychologist speaks of apperception, of spontaneous attention, and of reflective thought, etc. It seems to me that the contribution of Mayo is to the form and the method of elaboration under conditions of revery. That this revery has an important bearing on the conduct of the individual seems obvious. But the material, including the meaning supplied by the individual, must assuredly be considered in terms of personality traits, as well as in terms of previous experience. To get at the meaning of "schemas of assimilation" it seems that some basic assumptions must be made as to personality traits unless a completely behavioristic stand is taken. To get at the reasons why an employee thinks as he does, in order to determine the validity of new managerial techniques, one must evaluate fundamental tendencies, unless a behavioristic approach is followed.

The interviewing technique is a method of eliminating falsification by the employee. That is in the interview the problem is not, what are the person's beliefs? Rather, is he thinking reasonably about them? Is there an objective attitude being taken? The interview as a means of correcting faulty methods of logic by the employee is a contribution from the clinical psychology, which appears to work out with good success. Nevertheless, it is quite obvious that those managerial devices which conflict least

with strong tendencies are those which conduce least to falsification. The problem then is first to get employees to take an objective attitude and second to devise situations which will make the taking of such an attitude easy. This involves the taking of an objective attitude first by the management itself; it implies a norm of reasonability to start with. Quite obviously, a propagandistic approach is out of the question.

The results of the test room experiment and the interviews in pointing to the quality of supervision corroborate this view. Apparently some strong fundamental trait is in conflict with the type of supervision now in use generally in industry. This situation conduces to the form of preoccupation in the manner which Dr. Mayo suggests. Under such conditions an objective attitude is difficult of attainment.

The only purpose in elaborating on this idea of traits is to get clues for further inquiry through the method Dr. Mayo has himself suggested; namely, a restatement of traditional psychology in terms of total situation.

#### E. Interviewing program.

The interview appears as a sound managerial technique when viewed from any angle. Not only on theoretical grounds but on practical ones as well can it be justified. More exact determination of its exact value to management in terms of production and turnover are being made. Undoubtedly the interview will survive, perhaps with modifications; for it, as a technique, forms

a subject for research.

It is not intended here to repeat all the conclusions that can be drawn from the progress of interviewing thus far. These are mainly random remarks. It is significant that the employees have apparently welcomed the program; and reading of interviews indicates that any reserve that might reasonably have been expected has been cast aside.

The interview as a tool of research distinct from a managerial device is now, it seems to me, the real problem. Some imperfect half way measures may have to be tried. My remarks on total situation should not be taken seriously; obviously they have an amateurish caste. The psycho-analytic approach may yield results. If it is necessary to make a bow to the academic psychology, it is to be hoped that experimentalistic extremes directed toward the production of a topographic chart of the human mind will be avoided.

One final partially incubated idea. Cannot the interviewing technique be adapted to executives who have to "get things done" by subordinates? Obviously not in the giving of instructions which need to be at once carried out. But there are more subtle situations where a change in point of view is necessary. First, scrutinize the solution to see that it has a norm of reasonableness and objectivity. Second, approach the subordinate and bring out cooperation, not by direct argument, but by using the interviewing technique, directing it primarily at correcting falsification. You direct the form of his thinking, the content takes care of

itself. I am convinced that this is what is done to a large extent by effective executives any way. But an explanation of the process might lead to wider application. Of course, under present conditions a man is circumspect in what he tells his boss. The possibility of modifying the employee-supervisor relationship to make a more natural and free contact has been one of the outstanding findings of the test room experiment.

F. General summary

1. It is difficult to relate a study of the human factor to general social and economic conditions. The speculations of a general nature may suggest that the clues for improvement lie in the social structure itself.

2. The justification for an examination of the human factor lies in the need under present competitive conditions to reexamine and reevaluate all the factors in the industrial unit.

3. The importance of mental attitude in the industrial situation has been demonstrated by the test room experiment. It is a discovery of major importance.

4. The relation of supervision to mental attitude of the workers has directed attention to the possibility of a new method of industrial control.

5. The interview as a managerial technique is a development of importance in itself.

6. The clues for the use of the interview as a tool of research may lie in the restatement of industrial psychology in

terms of total situation. A psychoanalytic approach may be helpful.

### 3. POSSIBLE INDEX OF MALADJUSTMENT

Does a frequency distribution of outputs in equal units of time have a characteristic shape?

From rate-setting experience and from curves in Vernon's book this seems possible.

#### Method:

1. From the 15 minute interval data of the test room experiment I set-up class intervals and sorted the data into these class intervals.
2. Added up the frequencies for each class interval for a week period. Had five sets of weekly data. Constructed rough frequency polygons.
3. Plotted data on probability paper (normal curve plots as a straight line) To do this, took cumulative totals of frequencies, then reduced to a percentage. Plotted percent vertical and class limites horizontal.

Note: For more precise comparison one might compute std. deviation and index of skewness preferably by method of moments.

Also it is probable that with the new recording apparatus with time as the variable one would get more skewness, because the reciprocal of the present data is essentially being plotted.

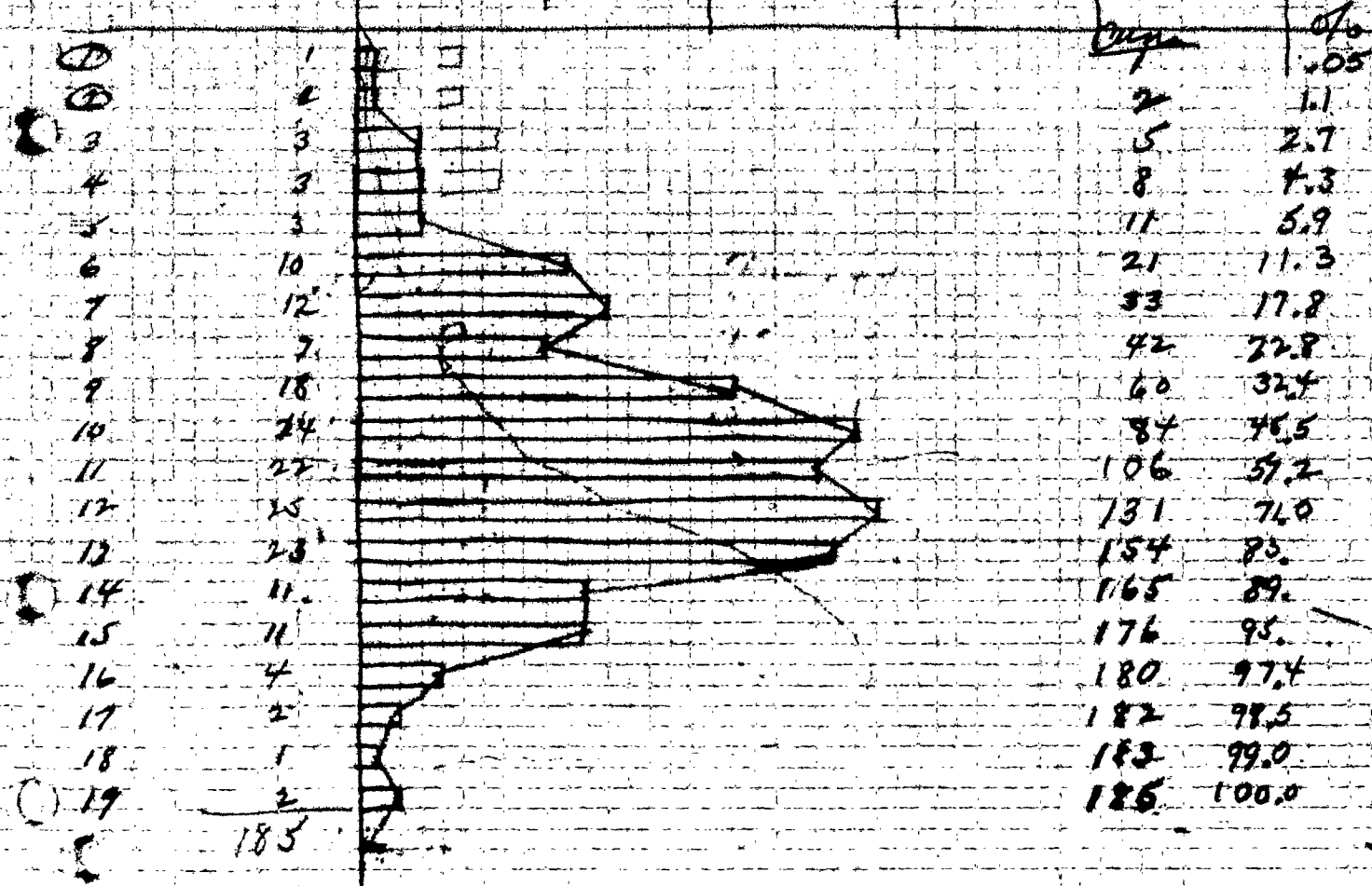
Rough illustrative graphs may be found accompanying library copy.

SV



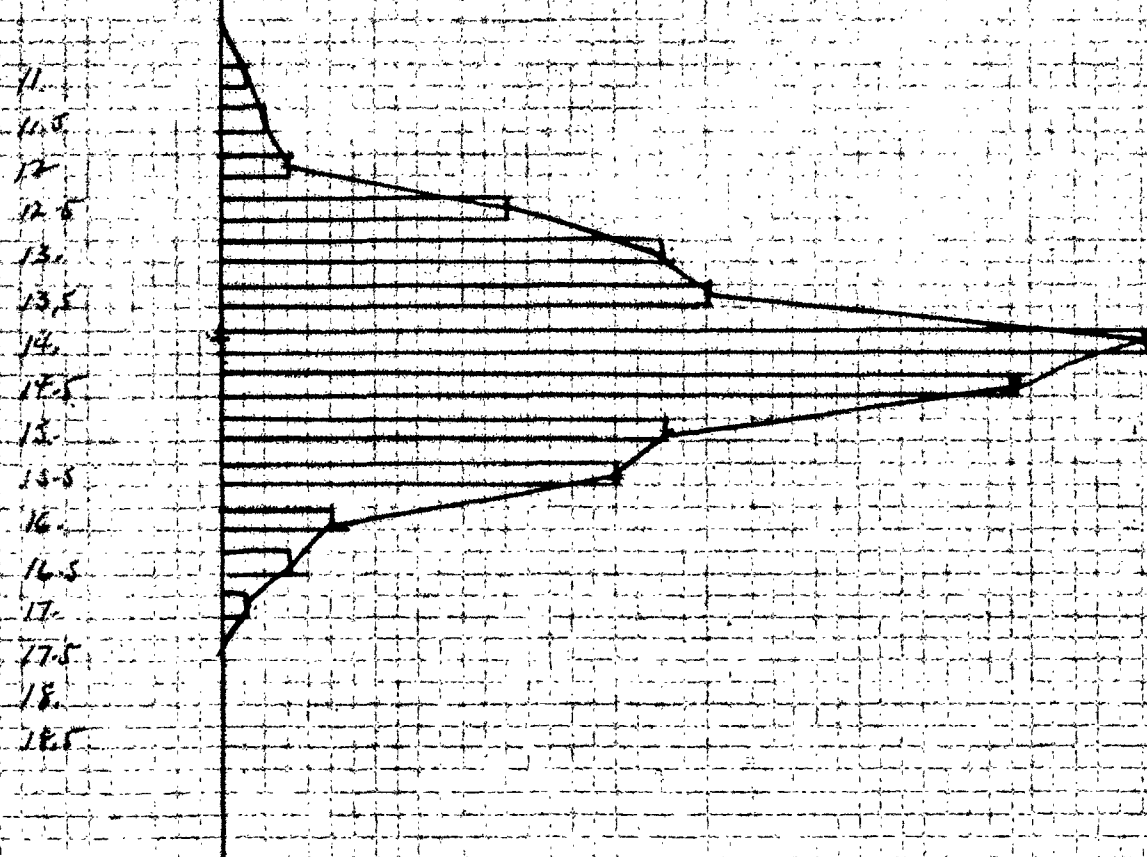
CHARTS TO BE FOUND IN ORIGINAL  
FILED IN DIVISIONAL LIBRARY

		OP #2						CASE 1
		MON 5-7	TUES 5-8	WED 5-9	THUR 5-10	FRI 5-11	SAT 5-12	
① 11.0 - 11.49						X		
② 11.5 - 11.99				X				
③ 12.0 - 12.49				X	X	X		
④ 12.5 - 12.99		✓	X		X	X		
⑤ 13.0 - 13.49	X	✓	XX					
⑥ 13.50 - 13.99	XX	✓	XXX		XX	X	XX	
⑦ 14.0 - 14.49	XX	✓	XX	XXX	XXX		XX	
⑧ 14.50 - 14.99	XXX	✓	XX		X	XX	X	
⑨ 15.00 - 15.49	XXXXXXXX	✓	XXX	XXXX	XX	X	XX	
⑩ 15.50 - 15.99	XXX	✓	XXXX	XXXXX	XXX	XXXXX	XXXXX	
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⑮ 18.0 - 18.49			XX	XX		XXXXXXXX		
⑯ 18.50 - 18.99		✓			XX	XX		
⑰ 19.0 - 19.49		✓				XX		
⑱ 19.50 - 19.99			X					
⑲ 20.0 - 20.49					X	X		



Op #2 Relay E-90/ I

	MON 5-21	TUES 5-22	WED 5-23	THUR 5-24	FRI 5-25	SAT 5-26	TOTAL	CUMTOT	AVG
11-11.4							1	1	11
11.5-11.9	✓	X ✓			X		2	3	11.6
12.0-12.4			XXX				3	6	12
12.5-12.9	X	XX	XX	XXX	XX	XXX	13	19	12.7
13.0-13.4	XXXX	XXXXX	XXXXXX	XX	X	XX	26	39	13.0
13.5-13.9	XXXXXXXXXX	XX	XXX	XXX	XXXXX	X	22	61	13.2
14.0-14.4	XXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXX	XXXXX	41	103	14.3
14.5-14.9	XXXXXXXXXXXX	XXXXXX	XXXXXX	XXXXXX	XXXXXX	XX	36	139	14.6
15.0-15.4	X	XXXX		XXXXX	XXXXXXX	XXX	20	159	15.3
15.5-15.9	X	XXXXXX	XX	XXXXXXXX	XX		18	177	15.6
16.0-16.4			X	XXX	X		5	182	16.2
16.5-16.9					XX	X	3	185	16.7
17.0-17.4					X		1	186	17.1
17.5-17.9									
18.0-18.4									
18.5-18.9									
19.0-19.4									
19.5-19.9									
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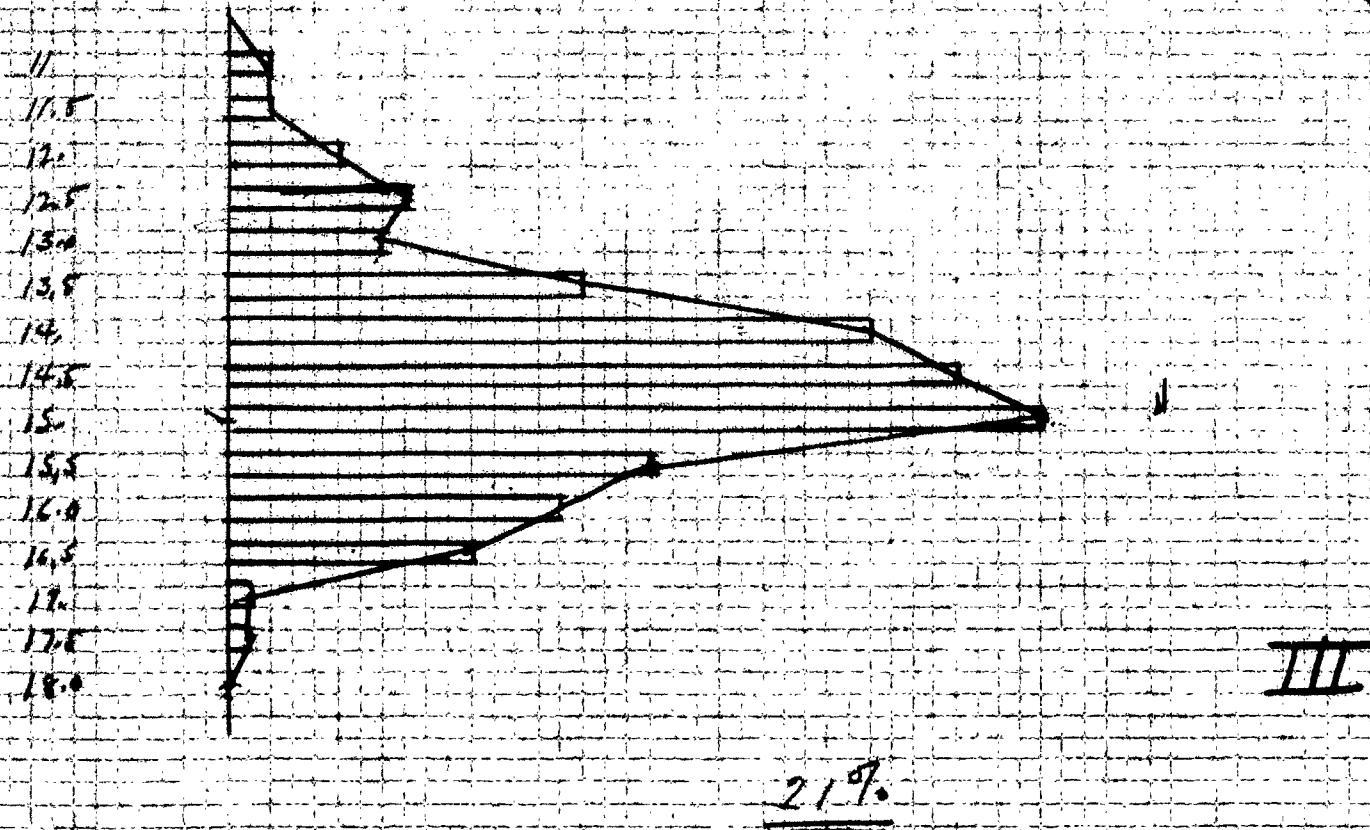


II

Op # 1 Relay R/3/6

	MON 5-21	TUES 5-22	WED 5-23	THUR 5-24	CASE III FRI 5-25	SAT 5-26	TOTAL	COMPUT.	COM %
11-11.4	X				X		2	2	1.07
11.5-11.9				X	X		2	4	2.15
12.0-12.4	X		XX	XX			5	9	4.84
12.5-12.9	X	XXX	X	X	X	X	8	17	9.15
13.0-13.4	X		XX	XX	XX		7	24	12.9
13.5-13.9	XXXXX	XX	XXX	XXX	X	XX	16	40	21.5
14.0-14.4	XXXXXXXXX	XXXX	XXXX	XXXXX	XXX	XXXXX	29	69	37.0
14.5-14.9	XXXXXXXXX	XXXXXXXXX	XXXXX	XXXX	XXXXXXXXX		33	102	55.0
15.0-15.4	XXXXX	XXXXXXXXXX	XXXXX	XXXX	XXXXXXXXXXXX	XXX	37	139	74.6
15.5-15.9	XXX	XXX	XXXXXX	XXXXX		XX	19	152	85.0
16.0-16.4	X	XXXX	XXX	XX	XXX	XX	15	173	93.0
16.5-16.9		X	XXX	XXXXX	X	X	11	184	99.0
17.0-17.4					X		1	185	99.5
17.5-17.9					X		1	186	100
18.0-18.4									
18.5-18.9									
19.0-19.4									
19.5-19.9									
20.0-									

186



Op #2 Relay R-1316

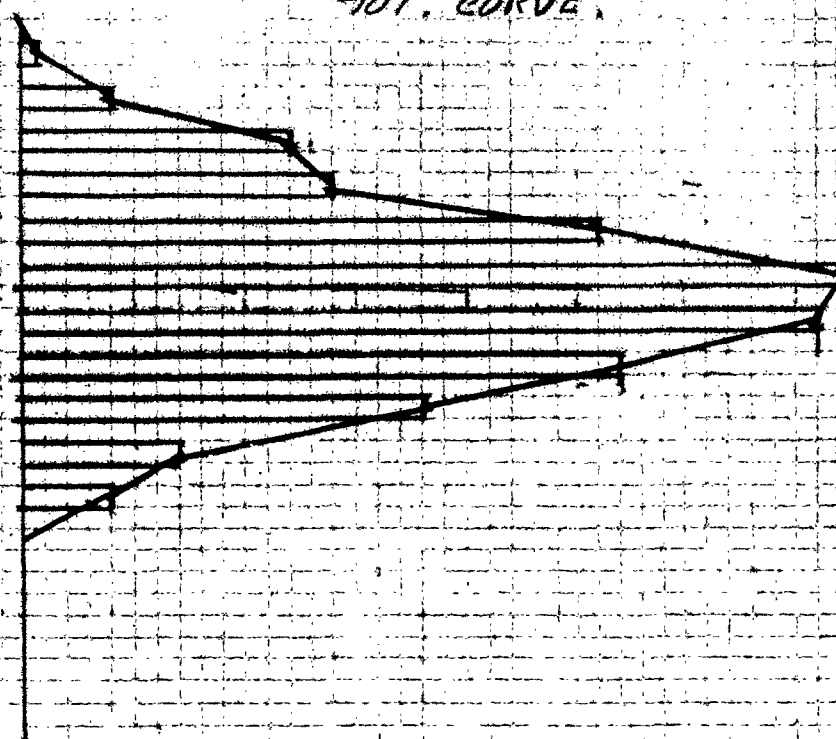


	MON 5-21	TUES 5-22	WED 5-23	THUR 5-24	FRI 5-25	SAT 5-26	CASE IV TO	CUM TOTAL	CUM OP
11-11.4									
11.5-11.9									
12.0-12.4		X					1	1	0.5
12.5-12.9	X			XX	X		4	5	2.70
13.0-13.4	XXXX				XXXX	XXXX	12	17	9.1
13.5-13.9	XX	XX	XX	XXXX	X	XXX	14	31	16.7
14.0-14.4	XXXX	XXX	XXXX	XXXXXXXXXX	XXXXXXXX	X	26	57	30.2
14.5-14.9	XXXXXX	XXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	XX	37	94	50.5
15.0-15.4	XXXXXXXXXX	XXXXXX	XXXX	XXXXXX	XXXXXX	XXXX	36	130	70.
15.5-15.9	XXX	XXXXXXXXXX	XXXXX	XXX	XXXXX	XX	27	157	81.5
16.0-16.4	XXXXXX	XXX	XXXXXX	X	XXX		18	175	91.
16.5-16.9		X	XXXX		XX		7	182	98
17.0-17.4		X	X	X	X		4	186	100
17.5-17.9									
18.0-18.4									
18.5-18.9									
19.0-19.4									
19.5-19.9									
20.0-									

186

TOT. CURVE

12  
12.5  
13.  
13.5  
14.  
14.5  
15.  
15.5  
16.0  
16.5  
17.  
17.5  
18.



IV

25%

OP#3 Relays E-1187  
R-1317

IV	MON 4-16	TUES 4-17	WED 4-18	THUR. 4-19	FRI 4-20	SAT 4-21	TOT. TOT	CUM TOT	IV CUM %
11-11.4									
11.5-11.9									
12.0-12.4		XX		X			3	3	1.6
12.5-12.9	X						1	4	2.1
13.0-13.4		X		X	X		3	7	3.3
13.5-13.9	X	XX	X	XX	X	X	8	15	6.0
14.0-14.4	XXXX	XXX	XXXX	X	XXXXXX	XX	20	35	15.8
14.5-14.9	XXXXXX	XXX	XXX	XX	XXXX		17	52	23.8
15.0-15.4	XXXXXXXXXX	XXXXX	XXXXXXXX	XXXXXXXX	XXXXXX	XXXXX	37	89	40.0
15.5-15.9	XXXXXXXXXX	XXXXX	XXX	XXX	XXXXXX	XX	26	115	62.0
16.0-16.4	XXXX	XXXXXX	X	XXXXXXXXXX	XX	XX	23	138	78.2
16.5-16.9	XXX	XXX	XXXXXXXXXX	XXXXX	XXXXX		24	162	87.2
17.0-17.4		XXX	XXXX	XXXX		XX	13	175	94.2
17.5-17.9		X	XX	X	XX	XX	9	184	99.4
18.0-18.4					X		1	185	99.7
18.5-18.9							0		
19.0-19.4		X					1	186	100.0
19.5-19.9									
20.0-									

Oper #3 Relay E-901

11

11.5

12.0

12.5

13.0

13.5

14.0

14.5

15.0

15.5

16.0

16.5

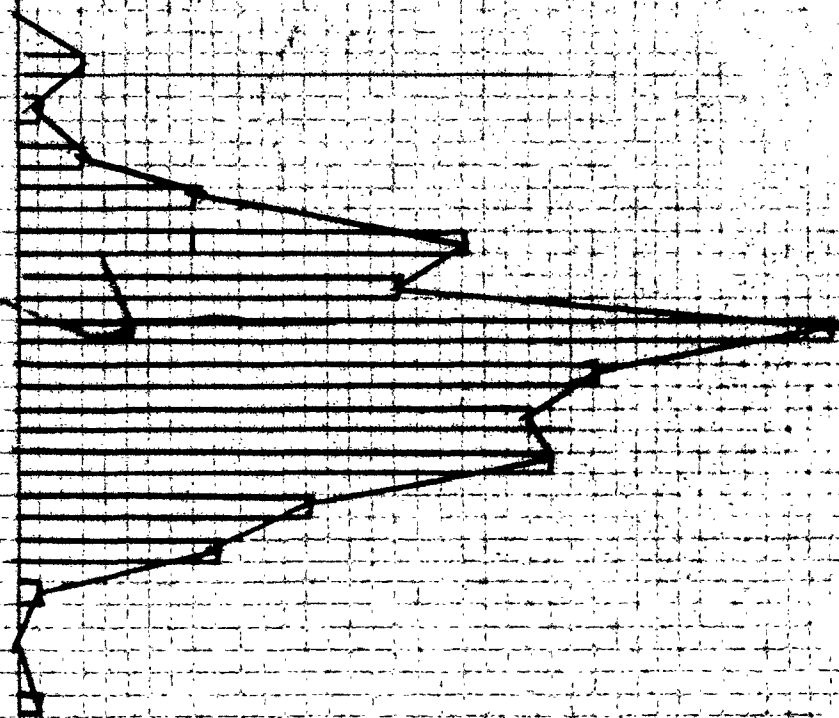
17.0

17.5

18.0

18.5

19





Arithmetic Probability Paper

