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RESEARCH & DEVELOPMENT DIVISION
PROCESS ENGINEERING

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"47-PROCESS"
CONVERSION COST MODEL

By: F. J. Shannahan

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ABSTRACT

A proposal for a revision of the system used to calculate "47-Process" conversion costs is presented.

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SUMMARY

Introduction

For some time, Manufacturing Division has felt that the group cost system now in use was not yielding the type or quality of information that should be available to aid in decision making. In particular, it was thought that intra-group differences, batch size effects and inter-plant variations were obscured. Pinpointing high cost factors and the reasons for them was difficult to do.

It was decided that a cost system should be developed that reflected the realities of paint production.

Objective

Process Engineering was assigned the objective of devising the basic form of the expression for "47-Process" conversion costs which could then be used as a model for other production operation conversion costs. The expression was to accurately reflect production process realities and be useful in identifying those areas where cost improvements could be effected.

Conclusions

Data should be gathered as set-up costs and running costs for each individual production batch. For reporting and prediction, the data can be averaged only for each combination of product and production area; further summing and averaging will result in unacceptable distortions. Mathematical forms of the expressions are given in the body of the report.

Within a production area, equipment charges can be averaged; i.e., the hourly charges for all machines can be said to be equal without introducing unacceptable distortions.

The way in which the data are gathered can also permit evaluation of equipment utilization, conformance to operating standards and useful cost ratios.

Recommendations

The study should be taken over by the Business Analysis Section of A & BA Division. A six-month operational trial should be initiated to evaluate the overall utility of the system, to establish the cost of installing and maintaining it and determine the modifications that may be required to blend the system into the Business Analysis Section's overall computerized cost analysis scheme.

In addition, a study should be initiated by A & BA Division on the manner in which indirect costs are allocated among and within the several plants.

PREPARED BY: F. J. Shannahan
F. J. SHANNAHAN

APPROVED BY: J. G. Burke

FJS:IL

DISCUSSION

The Manufacturing Process

From a process standpoint, paint manufacture can be thought of as a sequence of batch processes. During actual processing, certain operations, such as sand grinding, act as continuous operations. However, even those operations are not truly continuous since the input materials are prepared as a batch and when the batch is exhausted, processing ceases. Even though the sand grinder itself may operate without interruption, it operates on sequenced batches.

The situation has long been recognized by Manufacturing and A & BA Divisions. Traditionally, "batch cards" have been issued to authorize processing of materials. The production areas produce and record by batch, regardless of the operation. For this study, we shall also use the batch approach.

Functions of a Cost System

For the purposes of this study, a cost system is viewed as a tool that will allow Management to:

1. determine the actual costs of operations that have been conducted.

2. identify high cost elements and indicate suitable areas for cost reduction efforts.

3. predict costs of future operations.

4. determine the effectiveness of investment utilization.

Cost Construction

There are several ways of accumulating and presenting cost data. There is no one "right" way. For each instance, the proper system to use is that system which accomplishes its defined objectives at the lowest system cost.

Average Costs: Our traditional manner of cost thinking has been in terms of bulk gallon averages. Costs and production are gathered and summed over the set in question, say a plant and the mean obtained by simple division.

Avg. Unit Cost (\$/Gal.) = Total Cost (\$)/Total Prod. (Gal.)

This type of averaging can be applied to any accumulation set desired. The average obtained, while mathematically correct, may have no real significance. If the standard deviation of the population is large, the average will provide little significant information about the action of the population. The average is, however, quite useful when plotted against time to show any tendency of the population toward drifting.

It is possible to glean a bit more information from a cost average if the concept of batch operation is used. Any batch process can be subdivided into a set-up segment and a running segment. The set-up portion is generally relatively insensitive to the batch size, with the running segment proportional to the batch size except for start-up effects.

The averages obtained are subject to the same significance factors as those mentioned above. However, the segmentation into set-up and running parts will improve the analysis and prediction functions of the system.

Specification Costs: It is possible to specify the rates at which all phases of any operation are to be performed. Operational costs can be constructed using the specified rates and actual production volumes for the items in question.

This approach recognizes that there may be significant cost differences among products. However, accuracy of the system is completely dependent on the actuality of conformance to specifications. Any deviations will result in distortions in stated costs.

In this case also, costs can be summed over any set desired and an average calculated. Since some information is available about the distribution of the set population, more meaningful analysis and prediction are possible than when gross averages alone are used.

Detail Costs: It is possible to accumulate cost elements in almost infinite detail and to any accuracy and precision desired. The minutiae can be summed over any set desired, and are available for any level of analysis or prediction desired. The balance to be determined is that between the value of the detail and the cost of obtaining and using it.

Initial Investigations

Since the basic unit of production is the batch, it was decided to accumulate costs on individual batches. Data necessary fall into two categories, the physical inputs and the dollar charges associated with those inputs. The complete costing of a batch would require inputs to the equation

$$C_b = S \times C_s + O \times C_o$$

where

C_b = total dollar cost of the batch
S = set-up hours
C_s = dollar charge per set-up hour
O = operating hours
C_o = dollar charge per operating hour

These inputs were not routinely available and had to be developed.

The Toledo Plant was selected for pilot investigation. Toledo routinely maintains a detailed record of "47-Process" operations in the form of a bar graph which gives a continuous record of the operational status of each sand mill. The inputs can be constructed from the data on the bar charts, batch cards, and plant accounting records, as shown in Table I.

TABLE I

"47-PROCESS" COSTS
DATA SOURCES

BATCH CARD	**BAR CHART**
Line No.	Line No.
Code No.	Code No.
Batch No.	Batch No.
Lb. In	Mill Used
Lb. Out	Cleaning Time
Specified Speed	Loading Time
Specified Mill Size	Mixing Time
Specified Passes	Milling Time
PLANT RECORDS	Maint. Time
Mill Size Vs. No.	Dept. Shifts Sched.
Investment Detail	**PLANT ACCOUNTING**
MISCELLANEOUS	Dollars Charged
Stay Time Equiv.	Man-Hr. Charged

Analysis of the data gathered at Toledo indicated that the approach chosen was valid and a Divisional analysis should be done. Accordingly, all paint manufacturing plants in the Division were asked to keep bar chart records on sand mill operations for the month of January, 1969.

A sample bar chart is shown in the Appendix in Figure 1. On the chart, the different operational steps are drawn in different colored inks. The blank spaces show machine idle time.

In addition to its use in a cost program, the chart provides an excellent tool for production supervision, giving an instant summary of a day's operation, current status, reasons for delays in production and an aid to allocating equipment and manpower.

The bar charts were kept by the operators as a part of their daily duties. We believed that it was crucial for the operators to realize that the bar charts were a record of machine operations and not a check on the men. Plants' supervision were instrumental in bringing about this realization, and should be commended for a job well done.

Arrangements were made for Plant Accounting sections to record the information needed from the batch cards and provide the other data needed. Here again, cooperation was outstanding.

Cost Allocations

Strictly, each sand mill has a slightly different cost of operation from every other sand mill. Obviously, units in one plant can have grossly different costs from those in a second plant. Our concern was whether all units in a single location could be treated alike or whether further subdivision was necessary. After considering factors such as operator attention required, depreciation, repairs, power, floor space and the like, it was decided that the error introduced by assuming equivalence of hourly expense was small enough that it would not affect the validity of the study.

When overall expenditures were compared, it was evident that, for Plants having more than one production area involved with sandmilling, each area must be considered separately.

The total cost of operating a sandmilling area including both direct and indirect costs had to be split between set-up and operating charges to provide inputs for the basic batch cost equation. It was decided to allocate costs for operating and for set-up on the basis of man-hours expended for each. Operating dollars were then reallocated to machine-hours operated. Admittedly, this distribution is more arbitrary than that regarding machine differences. It was felt, however, that most direct costs were associated more with time than other factors (such as volume) and that separate reallocation of the indirect costs was not justified for this study. If it is decided to carry this work forward, a reappraisal of the basis of cost allocation should assuredly be an integral part of the work.

Basis for Comparisons

The batch cost as calculated was used as the benchmark. When groupings were made, and averages cast, these were compared to the costs of the same batches calculated by batch.

Conformance to Specification

Before attempting to construct this type of cost, a survey was made of the degree of conformance to running specifications. The results are shown in Table II. It was immediately apparent that conformance was so poor that use of this model would be valueless.

TABLE II

"47-PROCESS" COSTS
CONFORMANCE TO FORMULA SPEED
PERCENT OF BATCHES

	Percent of Formula Speed					
	100 & up	100/80	80/60	60/40	40/20	20 & down
Plant	Percent of Batches					
All	16.6	11.2	18.2	23.8	23.6	6.7
A	27.3	14.7	26.9	22.6	11.1	1.1
B	25.0	12.9	14.5	20.2	16.2	11.3
C	0	2.9	14.7	38.3	40.2	2.9
D	28.2	10.5	14.7	21.2	20.5	4.9
E	10.7	11.1	17.8	20.1	28.2	12.1
F	5.4	10.8	29.0	25.7	25.7	5.5
G	8.3	33.3	25.0	25.0	8.3	0
H	8.8	12.8	20.0	27.7	26.9	3.6
I	35.2	9.1	13.7	21.6	19.3	1.1
J	15.0	5.4	12.4	18.5	30.0	18.6
K	10.3	7.8	12.1	31.9	32.8	5.2

Cost Calculations

Eleven major permutations of cost were calculated, including the individual batch cost (C_{11} below) used as the benchmark. The variations were constructed to determine the amount of averaging that could be tolerated without introducing unacceptable errors in cost statements and predictions. This, in turn, determines the degree of data detail that must be developed. While the data used here are from sandmilling, the equations as written can apply to any production operation or series of operations. The equations in general are sequenced in order of increasing level of data detail requirement.

1) Division overall average

$$C_1 = \frac{D_D}{G_D} \times B$$

D_D = total dollars charged by the division
G_D = total gallons produced by the division
B = gallons in the batch being costed

2) Plant overall average

$$C_2 = \frac{D_P}{G_P} \times B$$

D_P = total dollars charged by plant making batch
G_P = total gallons produced by plant making batch
B = gallons in the batch being costed

3) Division overall average setup per batch and division overall average running cost per gallon

$$C_3 = \frac{D_{SD}}{N_D} + \frac{D_{OD}}{G_D} \times B$$

D_{SD} = total dollars charged to setup by the division
N_D = number of batches made by the division
D_{OD} = total dollars charged to running by the division
G_D = total gallons produced by the division
B = gallons in the batch being costed

4) Plant overall average setup per batch and plant overall average running cost per gallon

$$C_4 = \frac{D_{SP}}{N_P} + \frac{D_{OP}}{G_P} \times B$$

D_{SP} = total setup dollars charged by plant making batch
N_P = total number of batches made by plant making batch
D_{OP} = total running dollars charged by plant making batch
G_P = total gallons produced by plant making batch
B = gallons in the batch being costed

5) Division average cost for the product

$$C_5 = \frac{D_{DC}}{G_{DC}} \times B$$

D_{DC} = total dollars charged to the product by the division
G_{DC} = total gallons of the product made by the division
B = gallons in the batch being costed

6) Plant average cost for the product

$$C_6 = \frac{D_{PC}}{G_{PC}} \times B$$

D_{PC} = total dollars charged to the product by plant making batch
G_{PC} = total gallons of the product made by plant making batch
B = gallons in the batch being costed

7) Division overall average setup cost per batch and division average running cost per gallon for the product

$$C_7 = \frac{D_{SD}}{N_D} + \frac{D_{ODC}}{G_{DC}} \times B$$

D_{SD} = total dollars charged to setup by the division
N_D = total number of batches made by the division
D_{ODC} = total running dollars charged by division to the product
G_{DC} = total gallons of product made by division
B = gallons in the batch being costed

8) Plant overall average setup cost per batch and plant average running cost per gallon for the product

$$C_8 = \frac{D_{SP}}{N_P} + \frac{D_{OPC}}{G_{PC}} \times B$$

D_{SP} = total dollars charged to setup by plant making batch
N_P = total number of batches made by plant making batch
D_{OPC} = total running dollars charged to product by plant making batch
G_{PC} = total gallons of product made by plant making batch
B = gallons in the batch being costed

9) Division average setup cost per batch of the product and division average running cost per gallon of the product

$$C_9 = \frac{D_{SD}}{H_{SD}} \times \frac{H_{SDC}}{N_{DC}} + \frac{D_{OD}}{H_{OD}} \times \frac{H_{ODC}}{G_{DC}} \times B$$

D_{SD} = total setup dollars charged by the division
H_{SD} = total setup hours charged by the division
H_{SDC} = total setup hours charged to the product by the division
N_{DC} = total number of batches of product made by the division
D_{OD} = total running dollars charged by the division
H_{OD} = total running hours charged by the division
H_{ODC} = total running hours charged to the product by the division
G_{DC} = total gallons of the product made by the division
B = gallons in the batch being costed

10) Plant average setup cost per batch of the product and plant average running cost per gallon of the product.

$$C_{10} = \frac{D_{SP}}{H_{SP}} \times \frac{H_{SPC}}{N_{PC}} + \frac{D_{OP}}{H_{OP}} \times \frac{H_{OPC}}{G_{PC}} \times B$$

D_{SP} = total setup dollars charged by plant making batch
H_{SP} = total setup hours charged by plant making batch
D_{OP} = total running dollars charged by plant making batch
H_{OP} = total running hours charged by plant making batch
H_{SPC} = total setup hours charged to the product by plant making batch
H_{OPC} = total running hours charged to the product by plant making batch
N_{PC} = number of batches of product made by plant making batch
G_{PC} = number of gallons of product made by plant making batch
B = gallons in the batch being costed

11) Individual batch cost

$$C_{11} = \frac{D_{SP}}{H_{SP}} \times \underline{H_{SB}} + \frac{D_{OP}}{H_{OP}} \times \underline{H_{OB}}$$

D_{SP} = total setup dollars charged by plant making batch
H_{SP} = total setup hours charged by plant making batch
D_{OP} = total running dollars charged by plant making batch
H_{OP} = total running hours charged by plant making batch
H_{SB} = setup hours consumed by batch being costed
H_{OB} = running hours consumed by batch being costed

Cost Equation Comparison

Figures 2 and 3 in the Appendix are partial plots of C_1, C_2, C_3 and C_4. The lines are C_3 (division) and C_4 (plants), and C_1 (division) and C_2 (plants) are shown as "X" on the lines. Partial plots are used to reduce clutter and increase the clarity of the illustration.

Use of C_1 implies that no plant or batch size cost differences exist. C_2 implies that while there may be cost differences among plants, there are no batch size effects. Use of C_3 recognizes that batch size affects costs but denies the existence of interplant differences. The effects of using C_1, C_2 or C_3 as a predictor are shown in Fig. 2 and 3, perhaps more compellingly in Fig. 3, the statement of per gallon costs. It is immediately obvious that there are significant cost differences 1) among the plants for a given batch size, and 2) within each plant as a function of batch size. C_1, C_2 and C_3 have small value as cost predictors.

To determine the usefulness of C_4, a least squares linear regression was run for each plant to check the goodness of fit of the C_{11}'s (the benchmark) and C_4. Correlation coefficients were found to range from 0.76 to 0. Coefficients greater than 0.5 were found only for the two lowest volume production areas. For illustration, the C_{11} scatter diagram for Plant A is shown in Fig. 4 in the Appendix together with the corresponding C_4 line. The implication is that product to product cost differences cannot be ignored, and C_4 should not be used as a predictor.

C_5, while recognizing inter-product differences, ignores any cost effects of plant and batch size differences and so suffers from the failings of C_1.

C_6 should show most of the failings of C_2 in that batch size cost effects are not recognized. When C_6 was used to predict the C_{11} results, a surprisingly high degree of accuracy was attained. Further analysis revealed the reason. In general, each production area tends to run each product in a particular piece of equipment and to use that equipment only for a particular, compatible group of products. This is done to minimize cleaning and contamination problems. This leads toward a standard batch size for each product for the area. The batch size effect on the cost prediction then becomes a lesser factor. However, there are times when smaller or larger batches are scheduled, the product is shifted to a different size sandmill or a sandmill with a different size premix tank is used. When this happens, the use of C_6 will result in prediction errors. Because this type of operational pattern upset is difficult to predict, it is believed dangerous to use C_6 as a predictor over any appreciable time span. If the study is extended by A & BA Division as proposed, the utility of C_6 should be further evaluated.

C_7, C_8, C_9 and C_{10} can best be analyzed by using a specific example. Figures 5, 6, 7 and 8 in the Appendix show the cost prediction plots for a particular mill base, 743-185, for the four production areas in which it was manufactured during the data gathering period. Table III shows the batch costs (C_{11}) and the predicted costs using the ten cost constructs being evaluated.

The table shows the magnitude of the errors introduced for each cost construct for the batches produced. The figures show the variations in batch cost estimates that would come about if batch sizes were changed.

From the table, we can see that C_1, C_2, C_3, C_4, C_7 and C_8 distort the figures for the batch, plant totals and divisional totals. C_5 and C_9 correctly assess divisional total costs but misstate batch costs and plant totals. C_6 and C_{10} correctly state both divisional and plant totals, failing only to predict individual batch costs. The potential dangers in the use of C_6 were previously discussed. We are left then with C_{10} as the most usable cost construct.

TABLE III

"47-PROCESS" COSTS
ANALYSIS OF 743-185

BATCH COSTS

BATCH	PLANT	GALS.	C11	C10	C9	C8	C7	C6	C5	C4	C3	C2	C1
1	A	446	$ 72	$ 123	$ 180	$ 124	$ 150	$ 125	$ 205	$ 162	$ 192	$ 194	$ 276
2	A	446	173	123	180	124	150	125	205	162	192	194	276
3	E	322	119	119	169	99	138	119	148	131	155	171	200
4	F	200	149	173	158	217	127	172	92	239	216	148	124
5	F	200	197	173	158	217	127	172	92	239	216	148	124
6	H	446	251	213	180	185	150	214	205	242	214	194	276
7	H	446	179	213	180	185	150	214	205	242	214	194	276
8	H	446	231	213	180	185	150	214	205	242	214	194	276
9	H	448	196	213	180	185	150	215	206	242	215	195	278
PLANT TOTALS													
1,2	A	892	$ 245	$ 246	$ 360	$ 249	$ 299	$ 250	$ 410	$ 324	$ 383	$ 388	$ 553
3	E	322	119	119	169	99	138	119	148	131	155	171	200
4,5	F	400	346	346	316	433	255	345	184	479	433	295	248
6-9	H	1786	858	852	721	738	598	857	821	969	857	777	1107
DIVISION TOTALS													
All	All	3400	$1569	$1563	$1566	$1519	$1291	$1570	$1564	$1902	$1828	$1631	$2108

Certainly, the use of C_{10} will not result in exactly predicting the cost of each batch made; C_{10} is an average. However, as the data input grows, we can expect the C_{10} estimates to become better and will, in fact, be able to apply reasonable confidence limits to the estimate.

Cost Analysis

Comparison of the plant cost data shown in Fig.2 with the operating data shown in Table II shows some apparent anomolies. For instance, from Table II, Plant C would be expected to be a high cost production site. However, Fig. 2 shows it to be a low cost location. The whole explanation for cost differences cannot, then, be only in physical factors.

Examination of any cost construct will show that it is the mathematical product of a physical event of observed magnitude and a dollar charge assigned to the unit event. To analyze costs, both the physical events and the charges must be investigated.

Table IV lists a number of cost analysis ratios for the four plants used in the earlier examples. When Plant C is compared to the divisional figures, it can be seen to be better in the physical factors, setup hr./batch and gal./mach.oper. hr., but the greatest difference lies in the dollar charges. The low dollar charges magnify the good performance. Note that gal./mach. oper.hr. is high even though conformance to running specifications is poor, implying the use of larger machines or a product mix based toward higher specification speeds. In the case of Plant F, the salient figures appear to be setup hr./batch and dollars/mach. oper. hr. Plant H has high dollars/dept. hr., dollars/man hr., dollars/setup hr. and man-hr./dept.hr.; low gallons/mach. oper. hr. is balanced by low dollars/mach. oper. hr. and high mach. oper. hr./ dept. hr. Plant A rides pretty close to average with highs balancing lows; ex., high setup hr./batch vs. low dollars/setup hr.

There are a variety of cost ratios that can be calculated. Those shown here were useful in the situation at hand to determine reasons for cost behavior and, as important, to indicate areas that exhibit unexpected or unusual behavior (dollars/man-hr., Plant C) or should be targets for cost reduction (setup hr./batch, Plant F).

TABLE IV

"47-PROCESS" COSTS
COST ANALYSIS RATIOS

	DIVISION	PLANT A	PLANT C	PLANT F	PLANT H
$/Dept.-Hr.	53.15	51.73	10.78	52.59	91.30
$/Man-Hr.	18.49	15.09	5.86	17.14	22.12
$/Setup-Hr.	26.00	12.65	5.15	31.24	64.54
Setup-Hr./Batch	5.98	7.08	3.65	9.84	6.73
$/Mach. Oper.-Hr.	5.94	5.34	5.86	11.32	4.09
Gal./Mach. Oper.-Hr.	31.17	43.10	50.54	32.07	19.58
Mach. Oper.-Hr./Dept.-Hr.	3.00	2.8	1.0	1.5	5.4
Man-Hr./Dept.-Hr.	2.88	3.44	1.84	3.07	4.13
Man.-Hr./Mach. Oper.-Hr.	0.96	1.22	1.84	2.03	0.76

Operational Analysis

A plant-by-plant analysis of conformance to operating throughput specifications can be made as was shown in Table II. While there are differences in the product mix among the several plants, the analysis would appear to be a good indicator of general plant effectiveness and if plotted on a time basis is an excellent indicator of trends in efficiency.

An analysis can also be made of the conformance to operating speeds for each item. Two specific examples are shown in Table V. In the first example (910-1123), there is a striking difference in performance between the two locations making the item. In the second example (32-6157) overall conformance is poor and all locations are operating in the same range regardless of unit size or batch size. To improve effectiveness, the two situations should be handled differently, a circumstance that is not obvious without this type of analysis.

It should be noted also that variability in conformance to operating specifications has implications for product quality. The data have been forwarded to Divisional Alignment Group to aid in their study of the effects of operating speeds on product uniformity in their effort to upgrade the quality of sandmill operations.

TABLE V

"47-PROCESS" COSTS
CONFORMANCE TO RUNNING SPECIFICATIONS

PLANT	UNIT SIZE	BATCHES	GAL.PER BATCH	GAL.PER HOUR	100+	100/90	90/75	75/50	50/25
					PERCENT OF SPECIFIED SPEED / PERCENT OF BATCHES RUN				
910-1123									
All	All	20	456	80	50	0	15	25	10
A	All	11	447	123	91	0	0	0	9
B	All	9	459	57	0	0	33	56	11
A	30	11	447	123	91	0	0	0	9
B	30	9	459	57	0	0	33	56	11
32-6157									
All	All	9	312	27	0	0	0	11	78
A	All	3	421	20	0	0	0	0	67
B	All	2	248	68	0	0	0	50	50
C	All	2	71	15	0	0	0	0	100
D	All	2	455	35	0	0	0	0	50
C	3	2	71	15	0	0	0	0	100
A	16	3	421	20	0	0	0	0	67
B	30	2	248	68	0	0	0	50	50
D	30	2	455	35	0	0	0	0	50

Having data available on machine utilization will allow analysis of the way that equipment is used. Table VI shows the way in which units were used in each location, and the way each size of unit was used in one specific location.

TABLE VI

"47-PROCESS" COSTS
MACHINE UTILIZATION

PLANT	UNIT SIZE	% SET-UP TIME	% OPERATE TIME	% MAINT. TIME	% IDLE TIME
All	All	11	25	5	59
A	All	24	24	5	47
B	All	10	28	6	56
C	All	10	11	1	78
D	All	3	11	2	84
E	All	9	28	4	59
F	All	14	19	1	66
G	All	11	16	0	73
H	All	6	28	1	65
I	All	9	38	7	46
J	All	6	22	21	57
K	All	32	45	8	15
H	3	5	20	0	75
H	8	4	29	1	66
H	16	10	46	0	44
H	30	9	29	4	58

Plants A and K have significantly higher setup percentages than the others. Plant K also has a higher operating percentage and a low idle percentage. Plant J has high maintenance time. In general, except for Plant K, idle time is high. We might investigate the maintenance time in Plant J (it was, in fact, due to an extended shutdown of one sandmill). We might also ask whether the high setup time for Plant K was due to frequent color change cleanups to meet production schedules, whether seasonal or chronic, and whether it might be improved by shifting work to other plants or by adding capacity. It is apparent that locations A, J and K could use further study and that, for the data period, excess capacity is prevalent.

Need for Further Work

The analytical approach taken here would appear to supply tools useful in costing, predicting and control. The narrowness of the data base (one month) makes quantification dangerous. Without quantification, the real utility and significance of the tools provided is obscured. Broadening the data base can only be done by taking data over a longer time span. Only if this is done, can the utility of the system be realistically evaluated.

There is a cost associated with the gathering, ordering and analysis of data. This cost should be determined as a part of the evaluation of the worth of the system. This can be done realistically only by setting the system into operation for a trial period since the various locations where the data will be gathered and ordered will doubtless operate in various manners.

Analysis of the several cost ratios and dollar charges used as inputs to the cost calculations also indicates that a look should be taken at the ways that dollar charges, direct and indirect, are assigned and allocated.

APPENDIX

PLANT ______ AREA/DEPT. ______ DATE ______

TYPE EQUIPMENT 47

OPERATE = RED LOAD = BLUE CLEAN = GREEN MIX = YELLOW DELAY = BLACK (NOTE REASON)

EQUIP. NO.	LINE - CODE
1.	32-5924
2.	42-505
3.	819-B-92945
4.	
5.	906-185
6.	910-1123
7.	901-2460

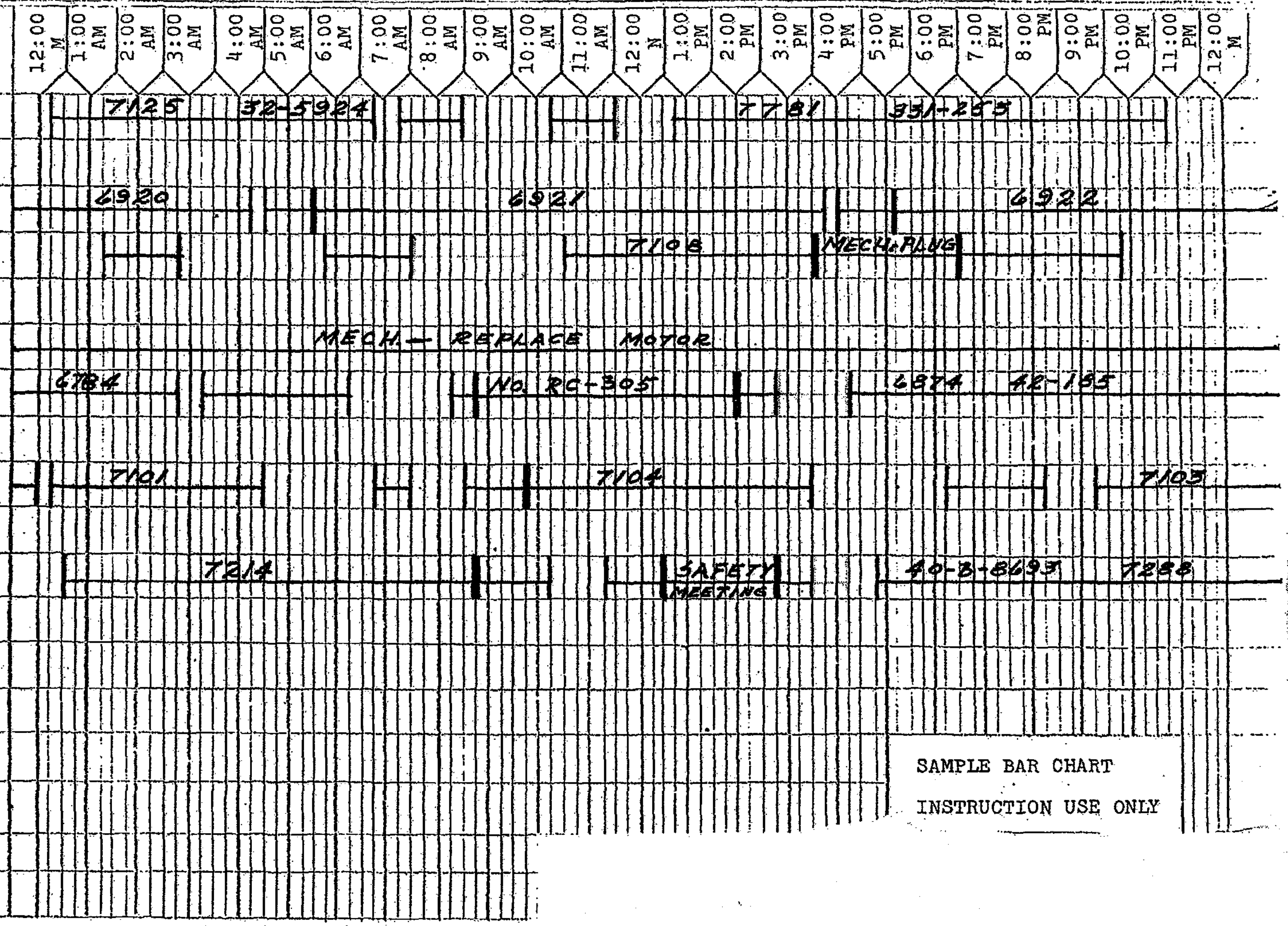


FIG. 1

"47 PROCESS" COSTS

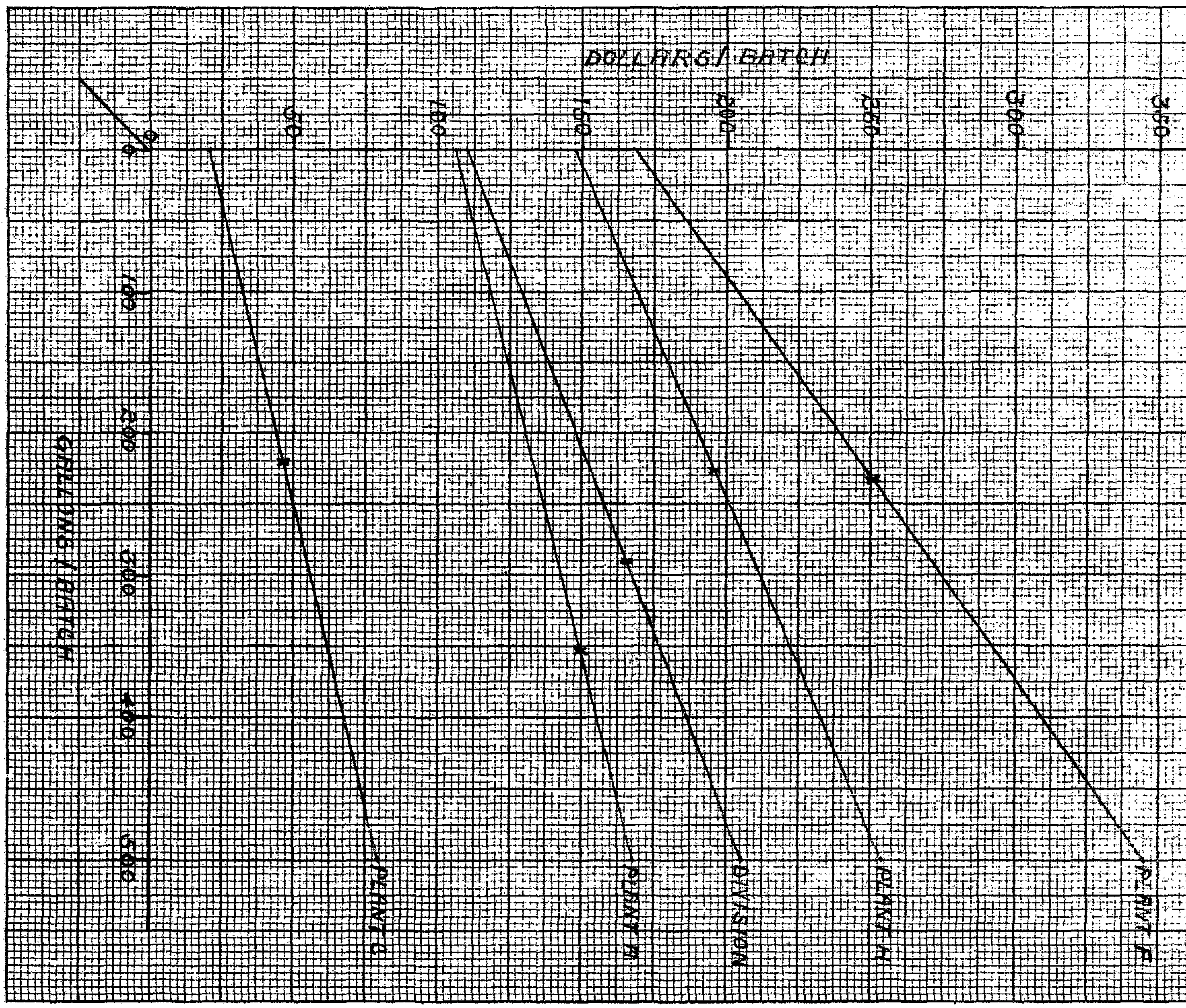
SAMPLE BAR CHART

SAMPLE BAR CHART

INSTRUCTION USE ONLY

DUP030002508

K+E 10 X 10 TO THE ½ INCH 358-11
KEUFFEL & ESSER CO. MADE IN U.S.A.



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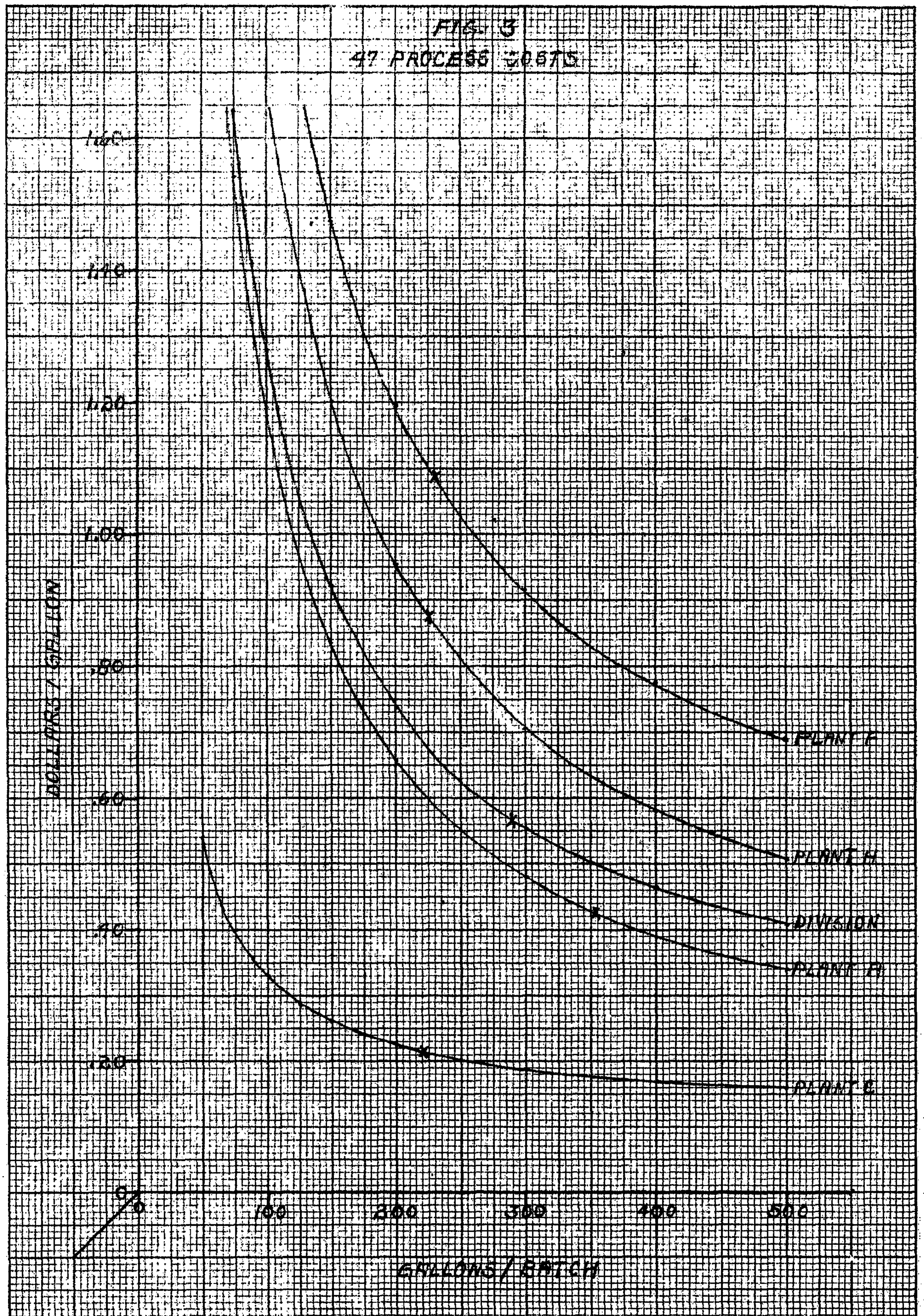


FIG. 3
47 PROCESS COSTS
1.60
1.40
1.20
1.00
.80
.60
.40
.20
0
DOLLARS / GALLON
PLANT F
PLANT H
DIVISION
PLANT A
PLANT C
100
200
300
400
500
GALLONS / BATCH

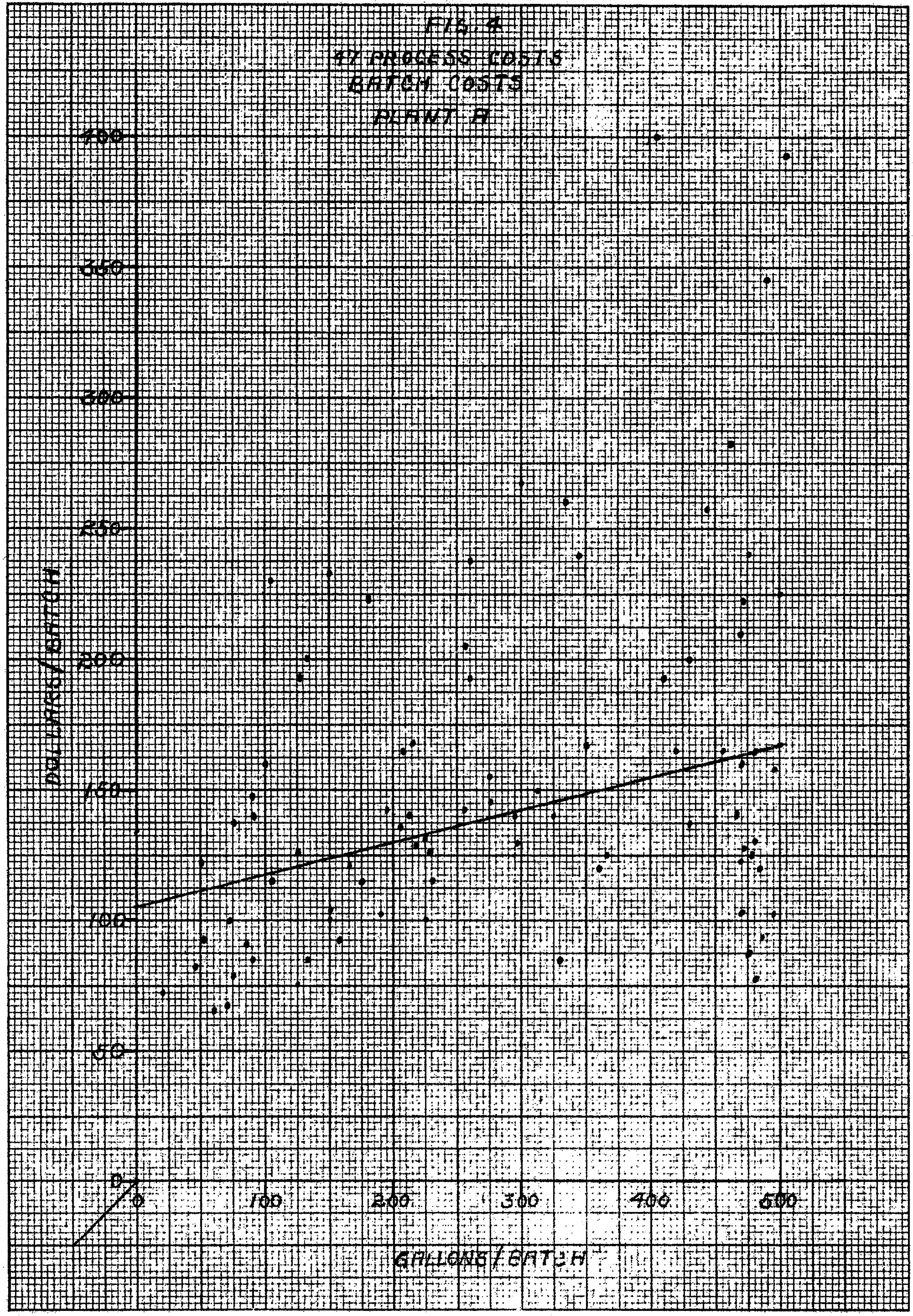
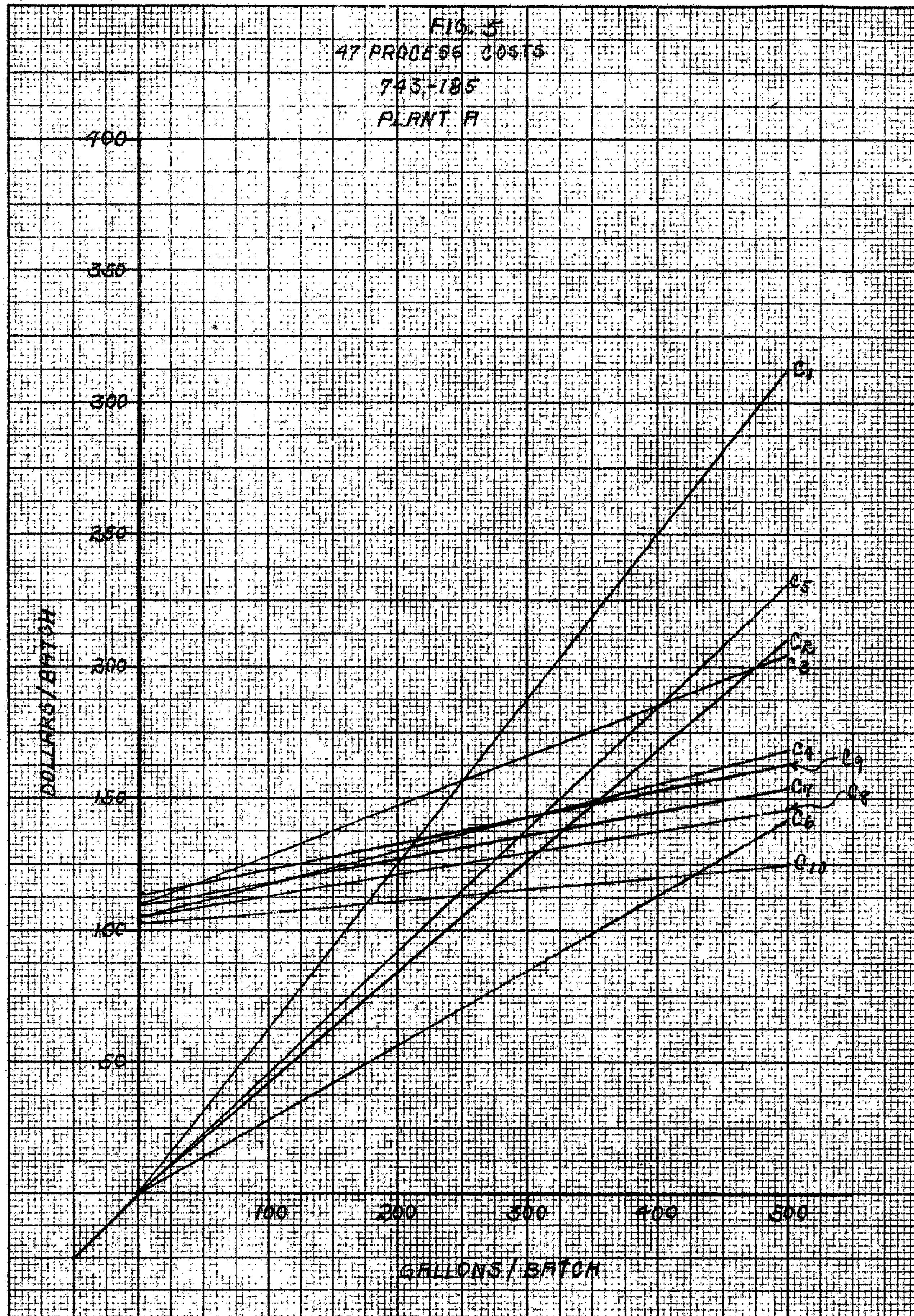
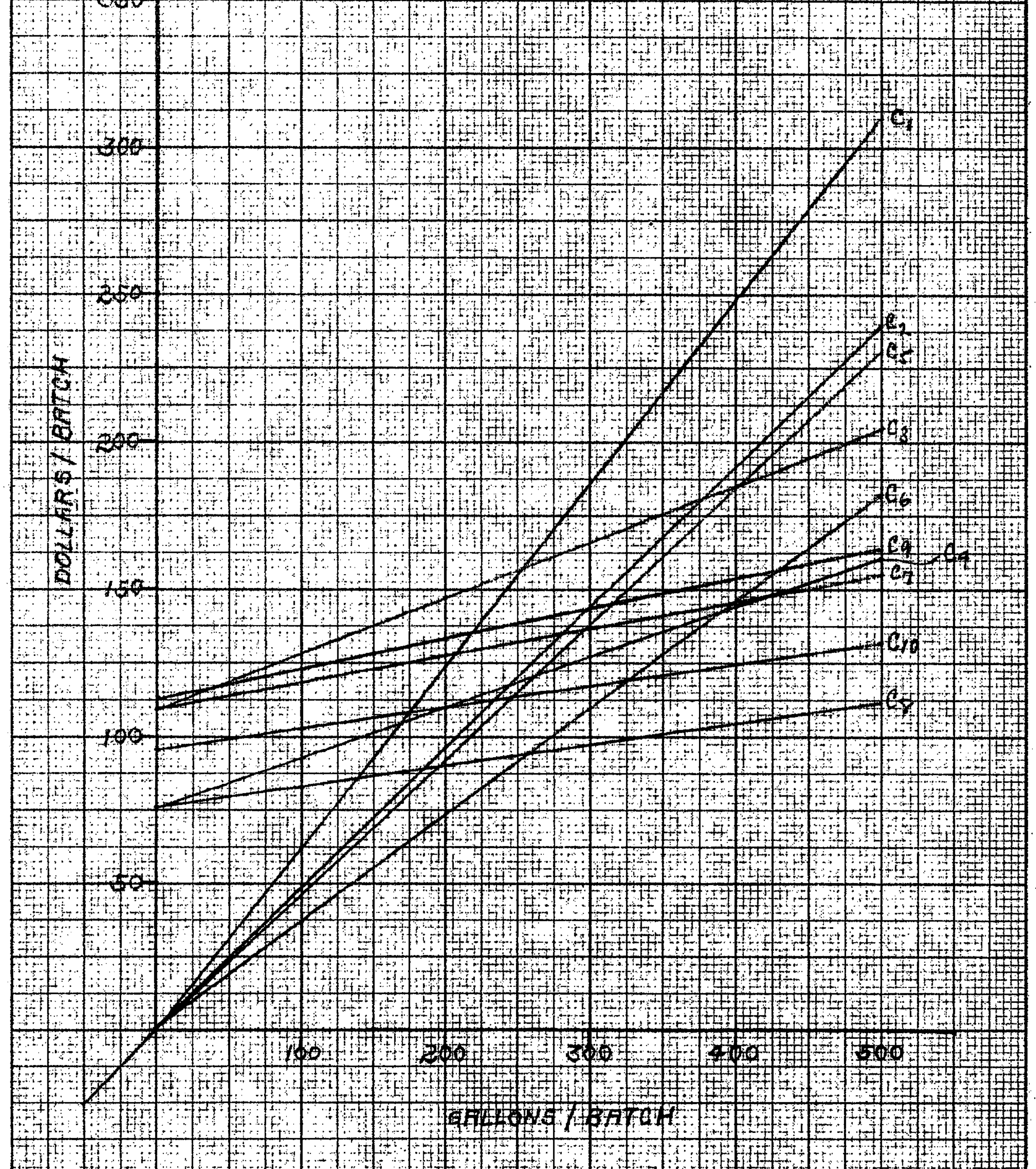


FIG. 4
47 PROCESS COSTS
BATCH COSTS
PLANT A
DOLLARS / BATCH
GALLONS / BATCH
0
50
100
150
200
250
300
350
400
0
100
200
300
400
500



DUP030002512



K+E 20 X 20 TO THE INCH 46 1240
KEUFFEL & ESSER CO.

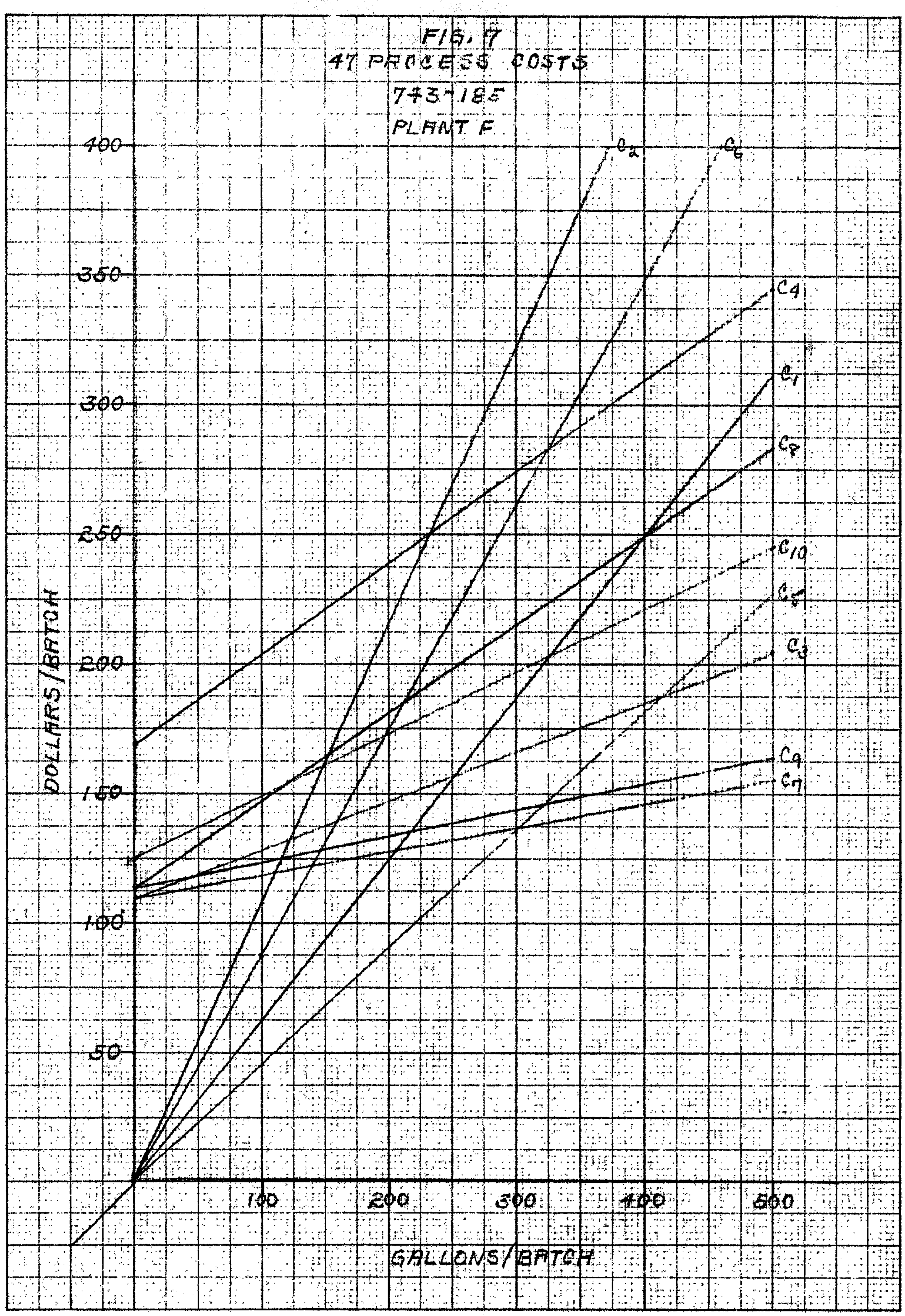
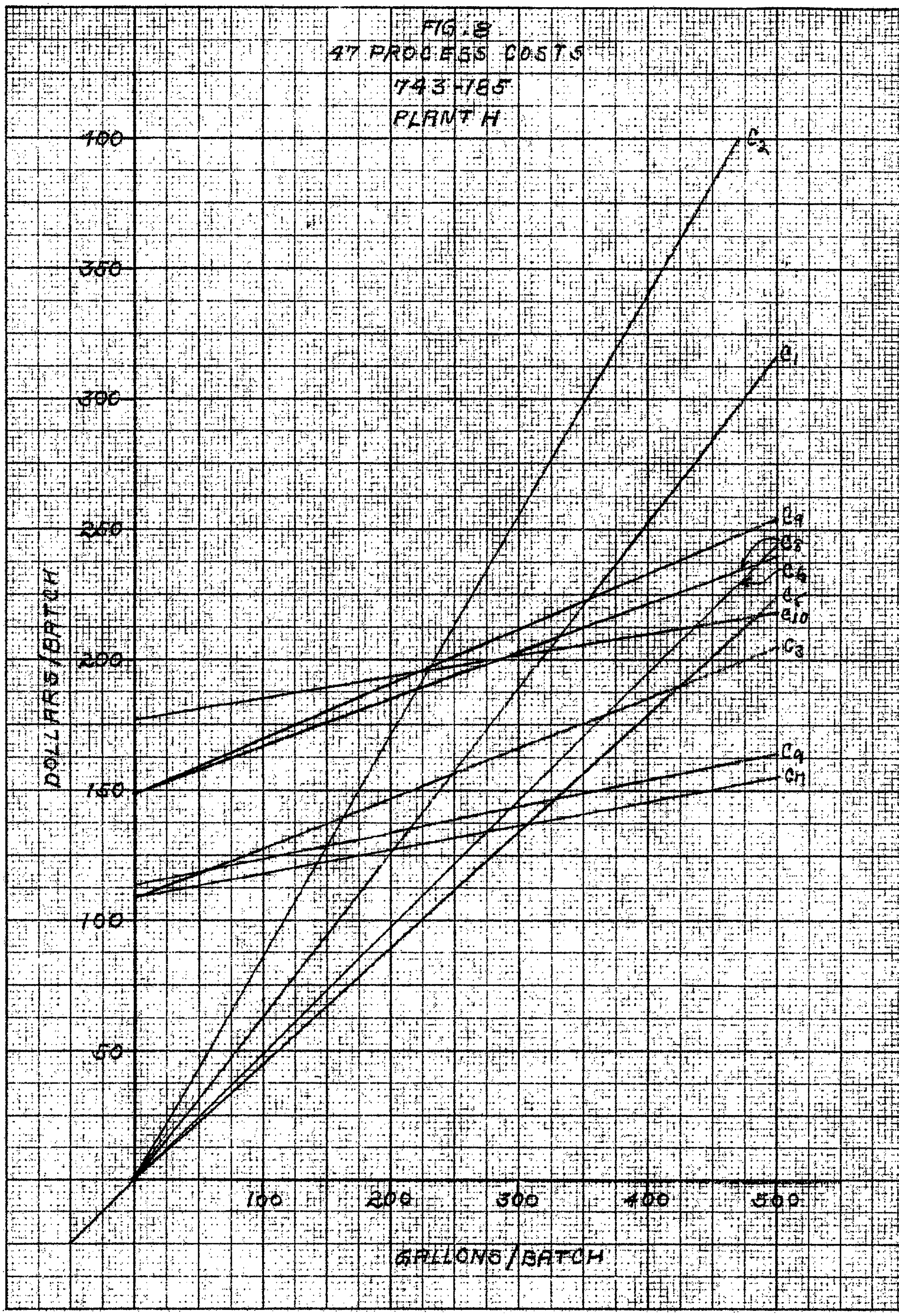


FIG. 7
47 PROCESS COSTS
743-185
PLANT F
400
350
300
250
200
150
100
50
100
200
300
400
500
DOLLARS/BATCH
GALLONS/BATCH
C2
C6
C4
C1
C8
C10
C5
C3
C9
C7



K&E 20 X 20 TO THE INCH 46 1240

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