ECONOMIC JUSTIFICATION

OF

INDUSTRIAL ROBOTS

MANAGEMENT OVERVIEW

MAJOR DETERENTS TO ROBOT APPLICATION INVESTIGATIONS

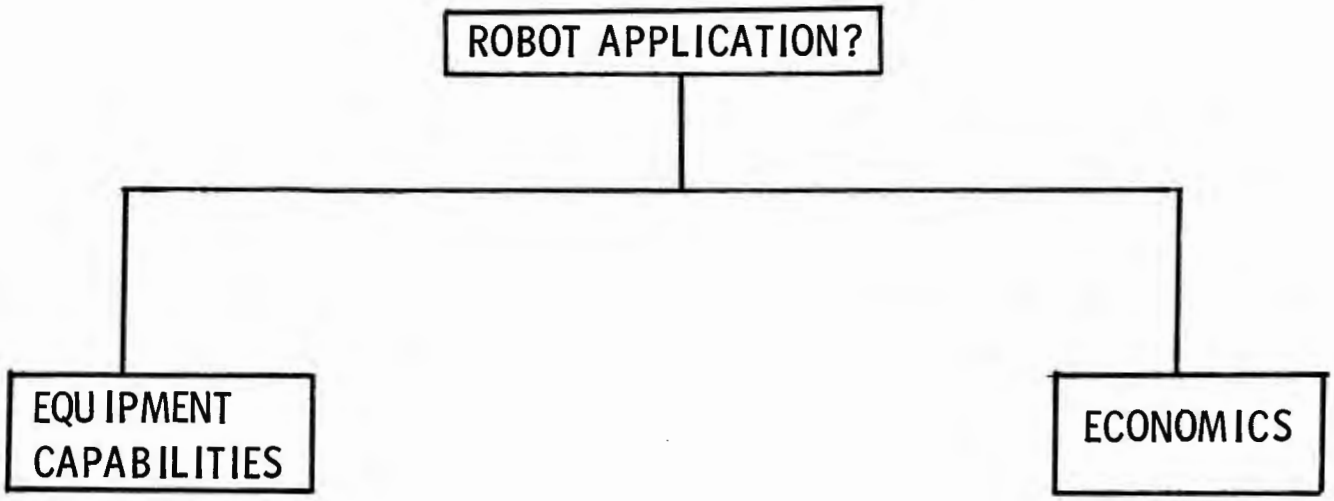
- WHERE TO BEGIN
- IDENTIFYING GOOD APPLICATIONS
- ESTABLISHING RESPONSIBILITIES
- SECONDARY TO MEETING PRODUCTION
- MANPOWER

PURPOSE OF THE PRESENTATION

- ATTEMPT TO CLARIFY THE JUSTIFICATION PROCESS
- PROVIDE ANALYTICAL TOOLS TO ASSIST ENGINEERS
- MAKE THE INITIAL INVESTIGATION FASTER
- DEVELOP A METHODOLOGY FOR THE INVESTIGATION

GOALS

- MORE EFFICIENT USE OF ENGINEERS
- CONSTRUCT THE APPLICATION TO ACHIEVE THE LOWEST MANUFACTURING COST
- PROVIDE INITIAL DIRECTION (GO/NO-GO)
- IDENTIFY THE BEST APPLICATIONS



ROBOT CAPABILITIES

MACHINE TOOLS OR PROCESS

PART ORIENTATION DEVICES

SENSORS

MAINTENANCE

SPACE REQUIREMENTS

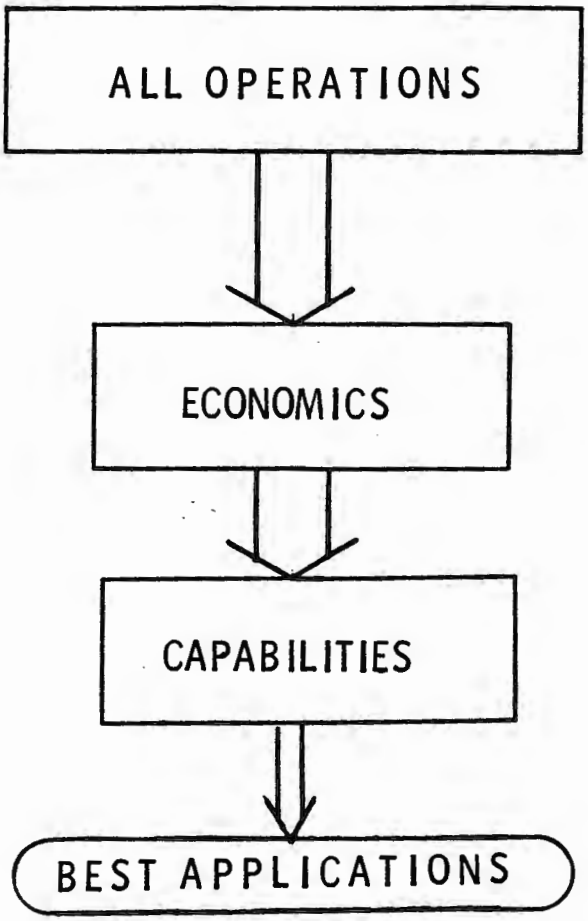
CAPITAL EXPENDITURES

SAVINGS

R. O. I.

RISK

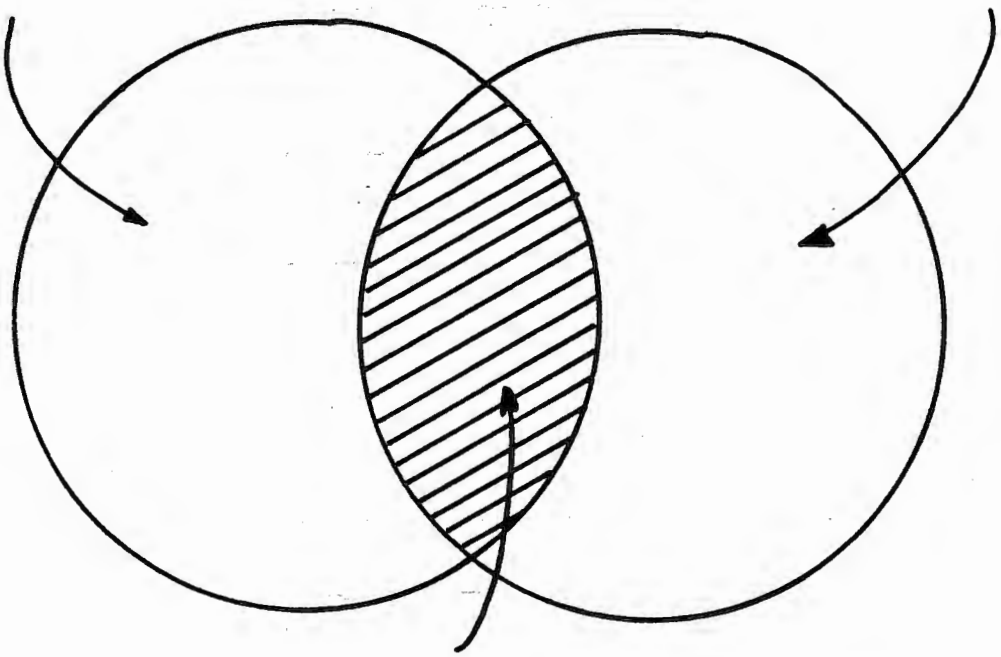
PRODUCTIVITY


ALL OPERATIONS
ECONOMICS
CAPABILITIES
BEST APPLICATIONS

TECHNICAL FEASIBILITY/ECONOMIC FEASIBILITY RELATIONSHIP

Operations that are technically feasible

Operations that are economically feasible



Operations that are both technically and economically feasible

ROBOT CAPABILITIES

ROBOTS CAN DO PRACTICALLY ANYTHING YOU WANT THEM TO DO

ROBOTS CAN DO PRACTICALLY ANYTHING YOU WANT THEM TO DO AND ARE WILLING TO PAY FOR

WHAT IS ECONOMIC JUSTIFICATION?

- CRITERIA FOR DECISIONS

- RELATIVE MEASURE

  - INDUSTRY TO INDUSTRY
  - COMPANY TO COMPANY
  - FACTORY TO FACTORY

- COMPARATIVE MEASURE

COSTS OF ROBOT SYSTEMS — Included Items

- ROBOT
- FIXTURING AND ORIENTING DEVICES
- INTERFACING SUPPLIES
- TRAINING
- SPARE PARTS
- TOOLING
- CONVEYORS AND RACKS
- MACHINE TOOL REVISIONS
- SAFETY EQUIPMENT
- INSTALLATION
- TAXES
- FREIGHT
- DESIGN
- LESS TAX CREDIT

SAVINGS AND EXPENSES IN NORMAL ROBOT APPLICATIONS

SAVINGS	EXPENSES	EITHER WAY
Direct Labor	Maintenance Labor	* Indirect Labor
Farmout Reduction	* Part Redesigns	Energy
Direct Material	Training	Floor Space
* Indirect Material	* M.E. Support	* Downtime
* Quality		
* WIP		
OSHA Compliance		
Scrap Reduction		
Resale of Old Equip.		
Depreciation Costs		

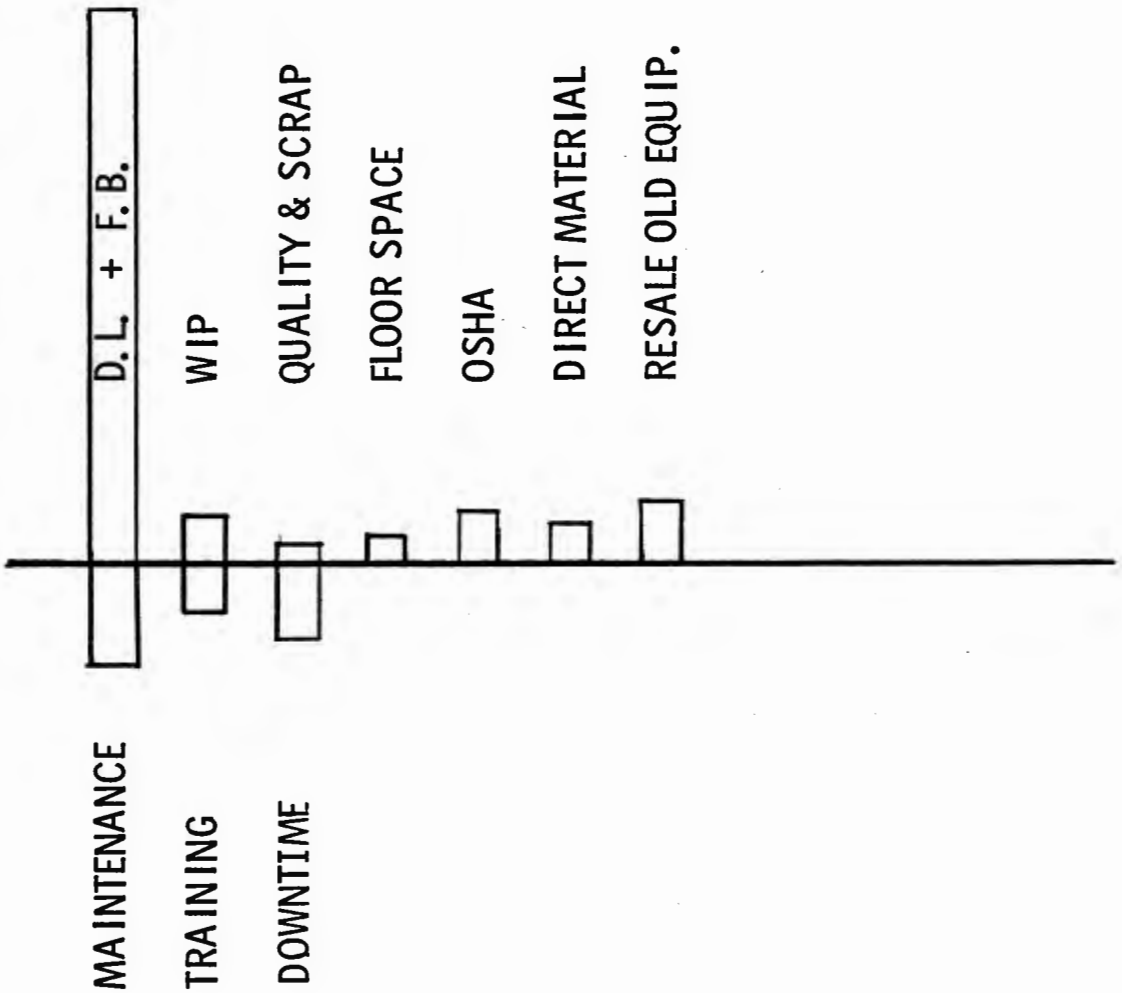
INTANGIBLES

* Safety
* Better Management Control
* Inflation
* Less Human Problems
* Step In The Right Direction For Future
* Capacity
* Maintaining State of the Art
* Meeting Product Demand

* ITEMS THAT ARE NOT NORMALLY INCLUDED ON AFE/DCF UNLESS SPECIFICALLY IDENTIFIABLE

SAVINGS VS. EXPENSES

SAVINGS



EXPENSES

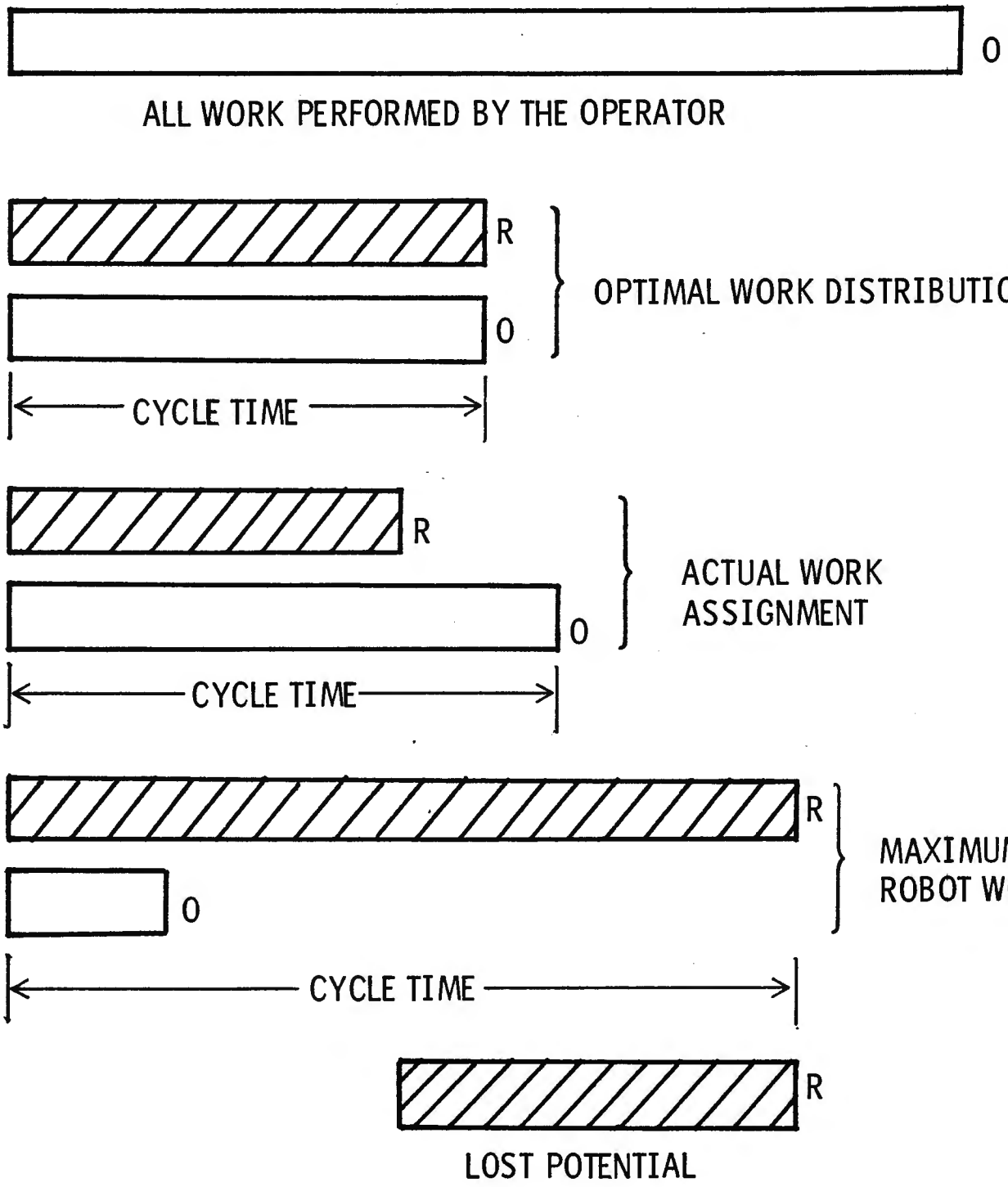
ASSUMPTIONS IN ROBOT ANALYSIS

- AN OPERATOR WILL BE ASSIGNED TO THE OPERATION
- IT IS PREFERABLE THAT THE OPERATION REMAIN ON INCENTIVE
- THE OPERATOR SHOULD BE GIVEN 130% INCENTIVE OPPORTUNITY
- SAFETY DEVICES WILL BE SUFFICIENT TO ALLOW THE OPERATOR AND ROBOT TO WORK IN THE SAME CELL

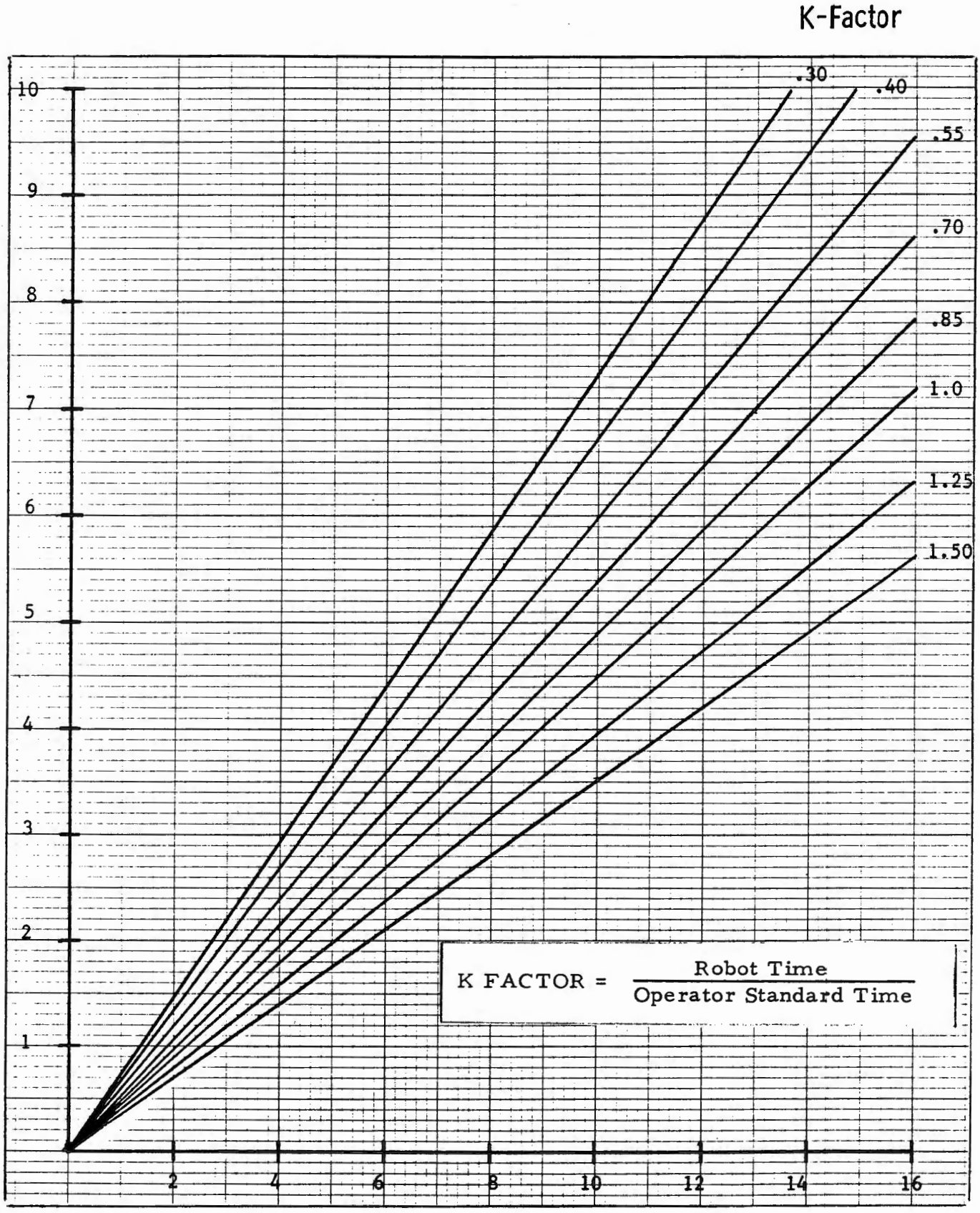
ROBOT WORK ELEMENT DISTRIBUTION

GRAPHIC DISPLAY

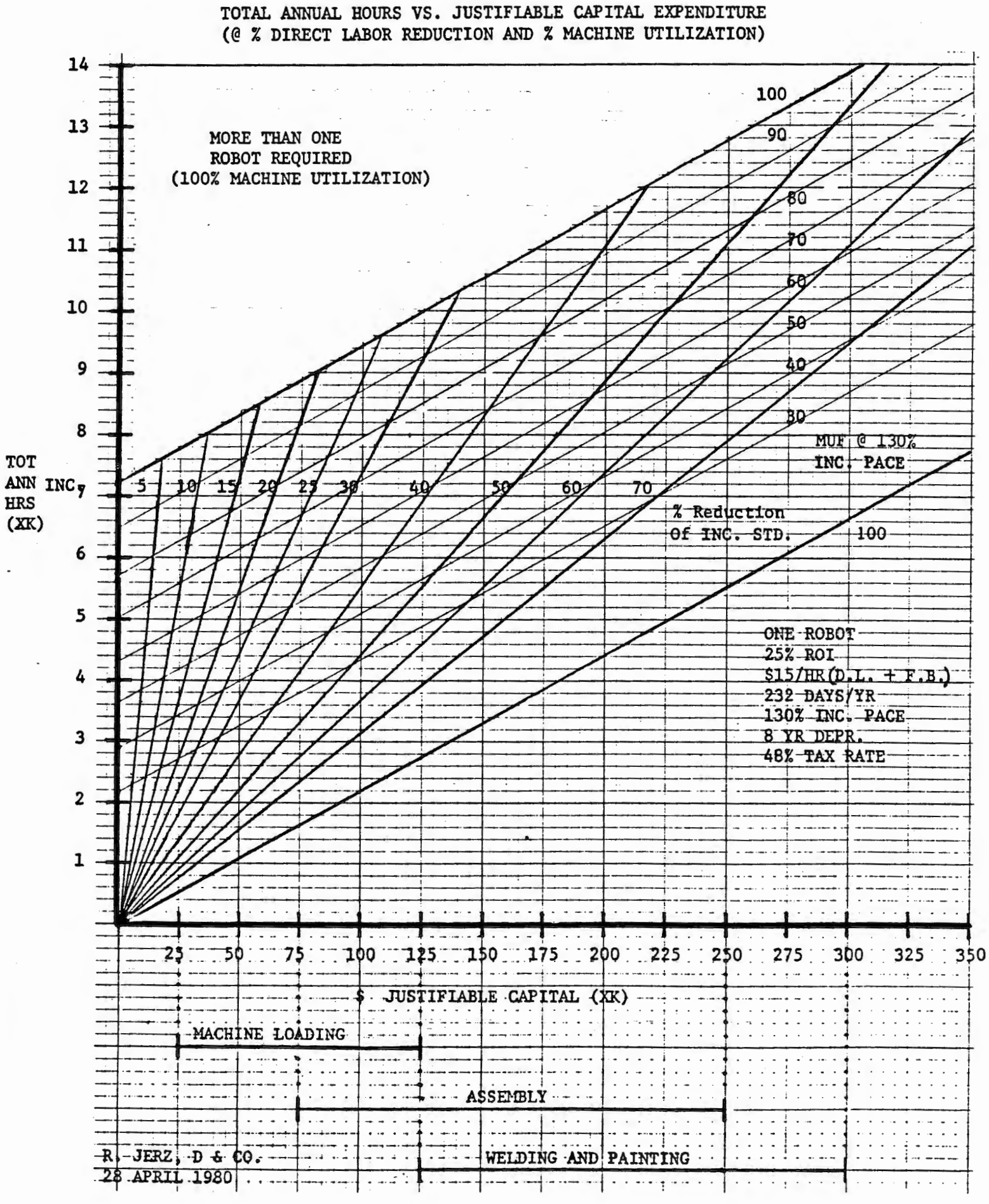
(SINGLE ROBOT SYSTEM)



Optimal Division of Total Standard Minutes (at 1.15 Avg. P&F Factor)

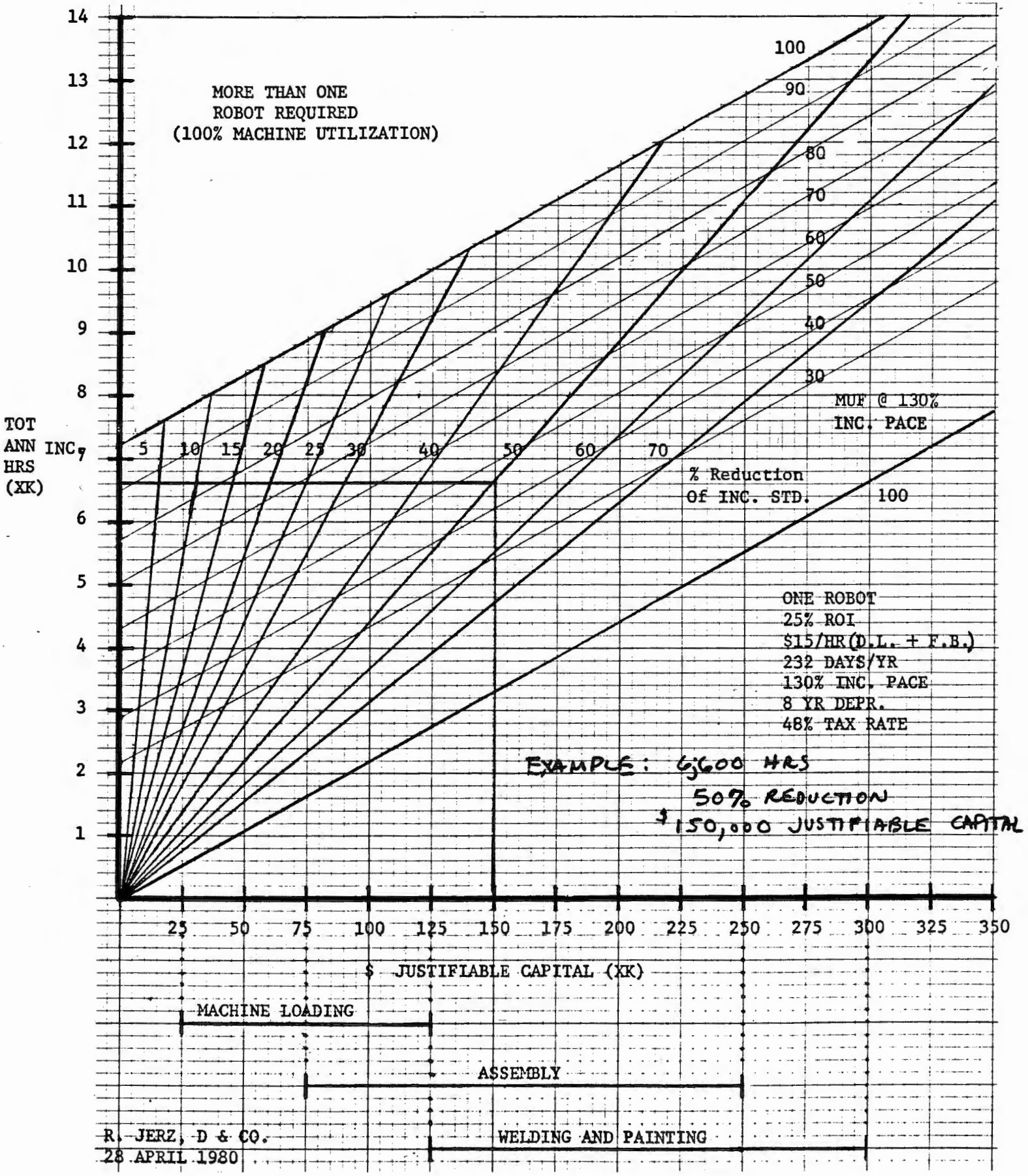


ROBOT ANALYSIS -- U.S. FACTORIES



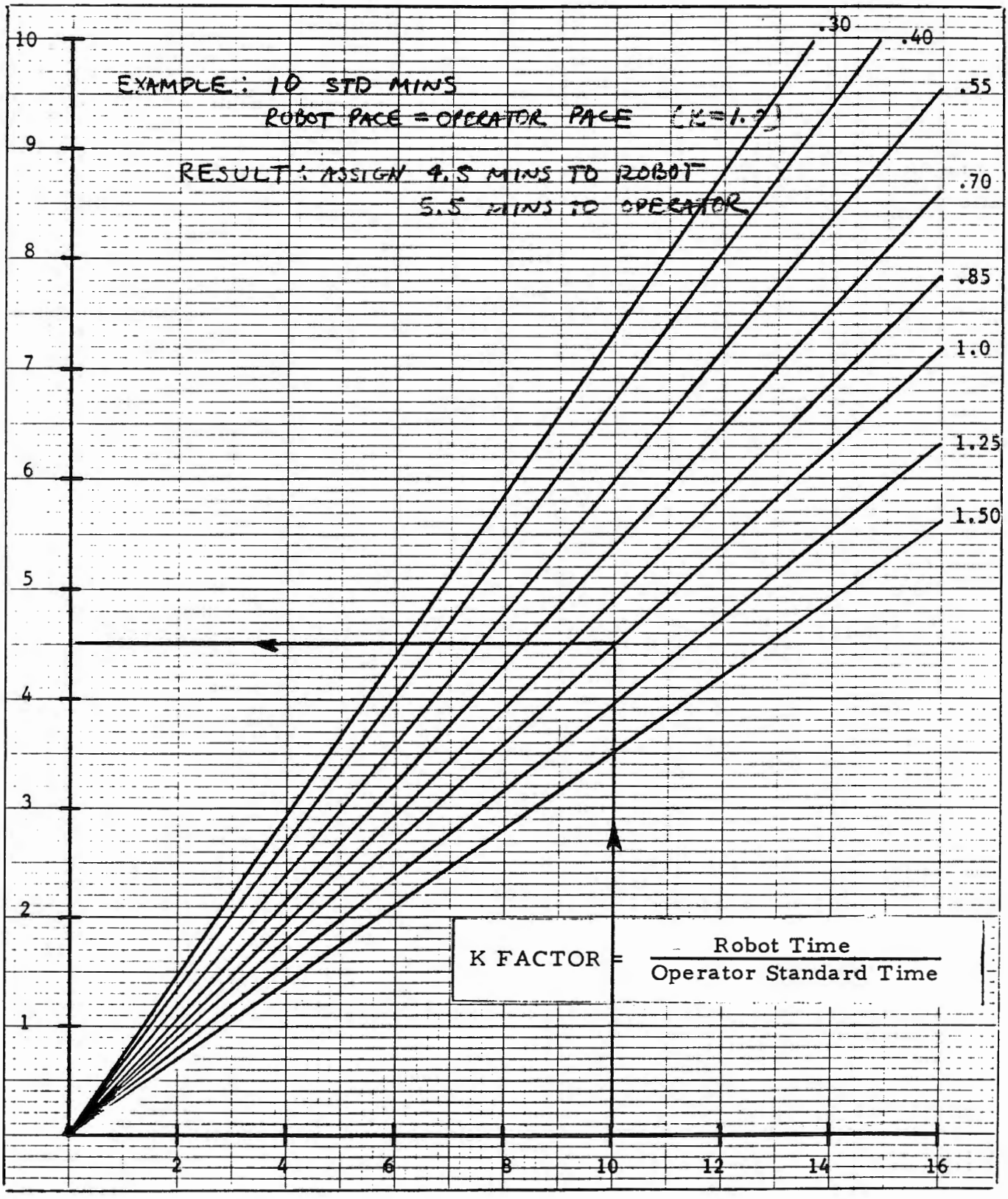
ROBOT ANALYSIS -- U.S. FACTORIES

TOTAL ANNUAL HOURS VS. JUSTIFIABLE CAPITAL EXPENDITURE
(@ % DIRECT LABOR REDUCTION AND % MACHINE UTILIZATION)



R. JERZ, D & CO.
28 APRIL 1980

Optimal Division of Total Standard Minutes (at 1.15 Avg. P&F Factor)



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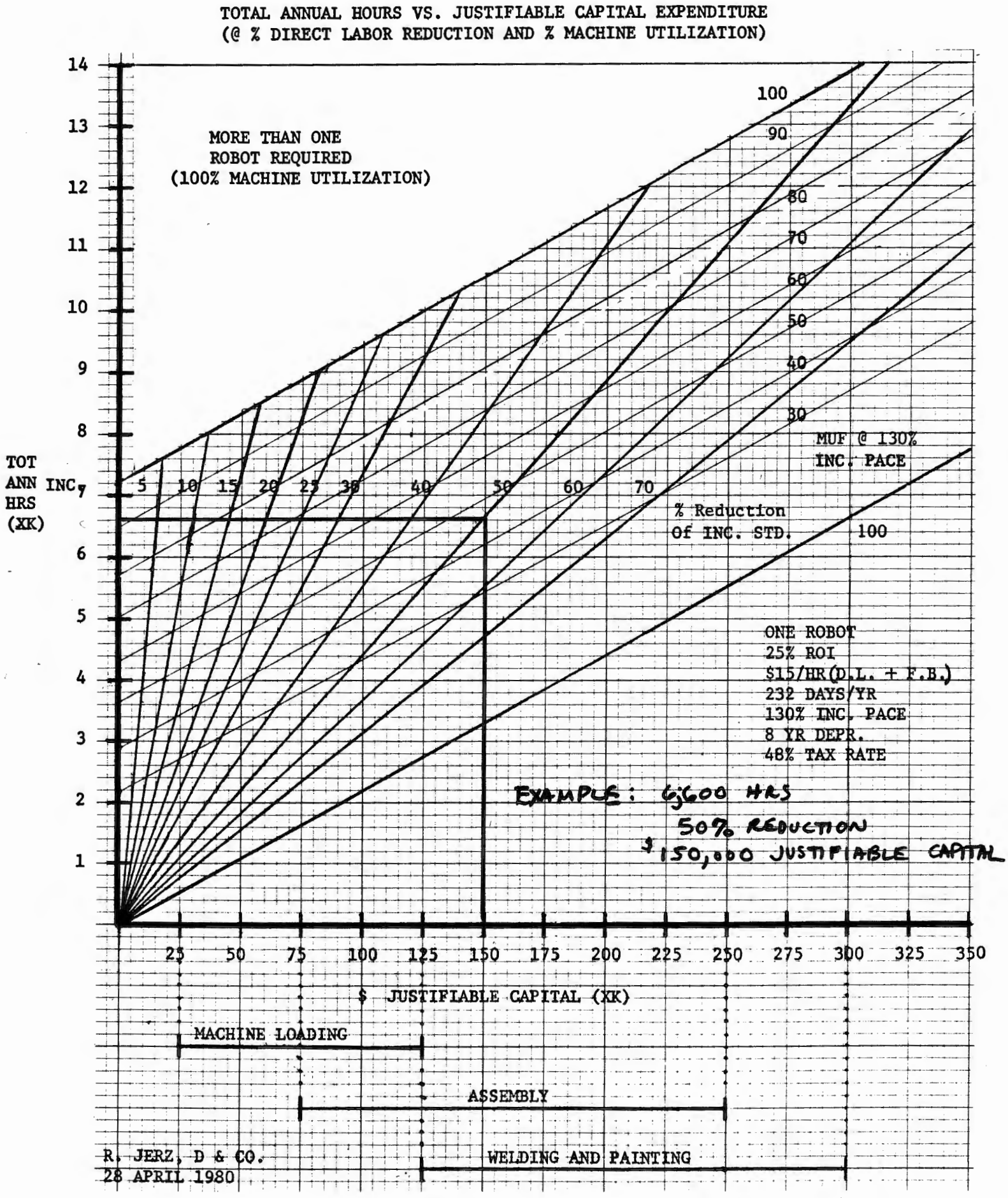

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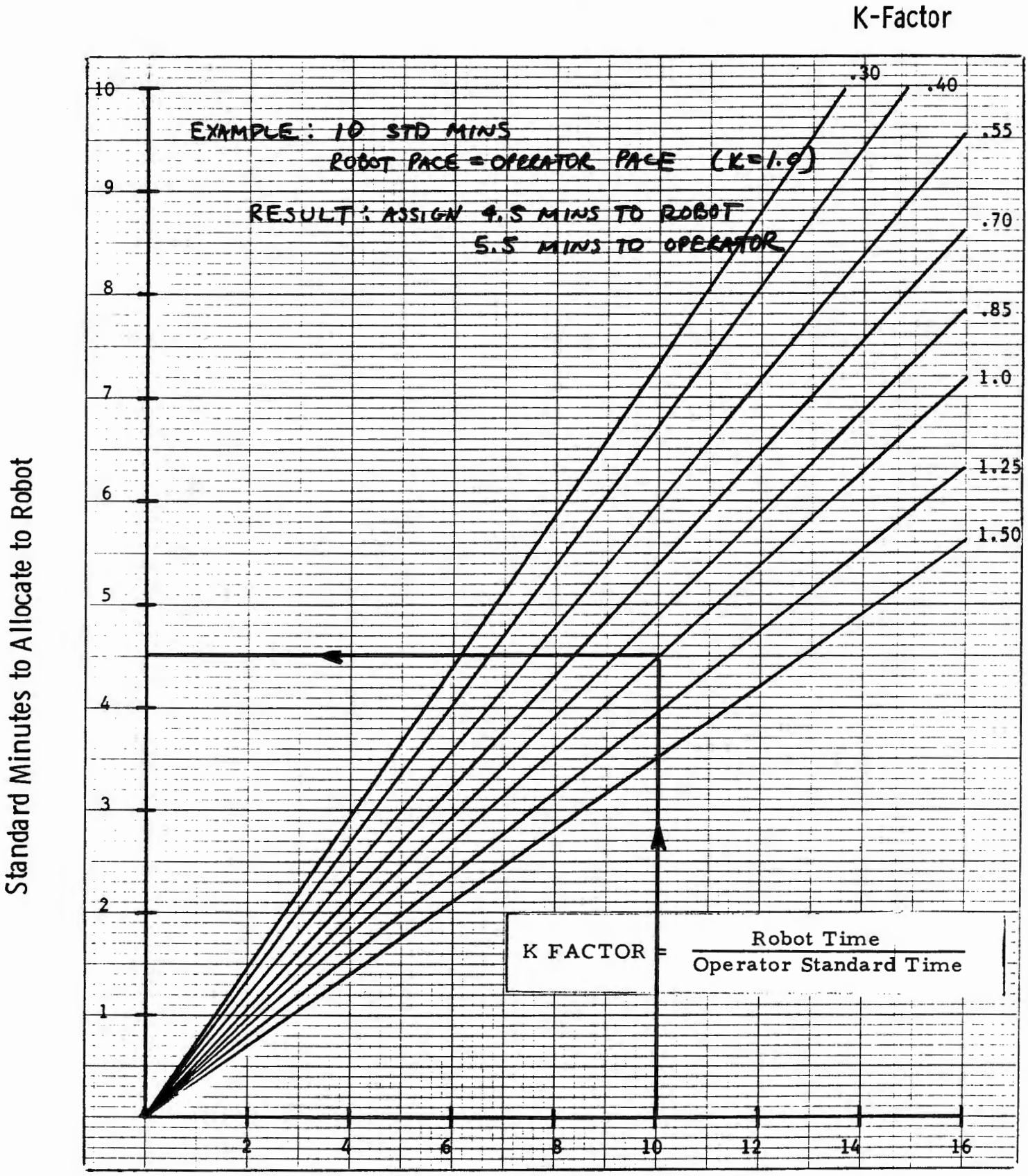
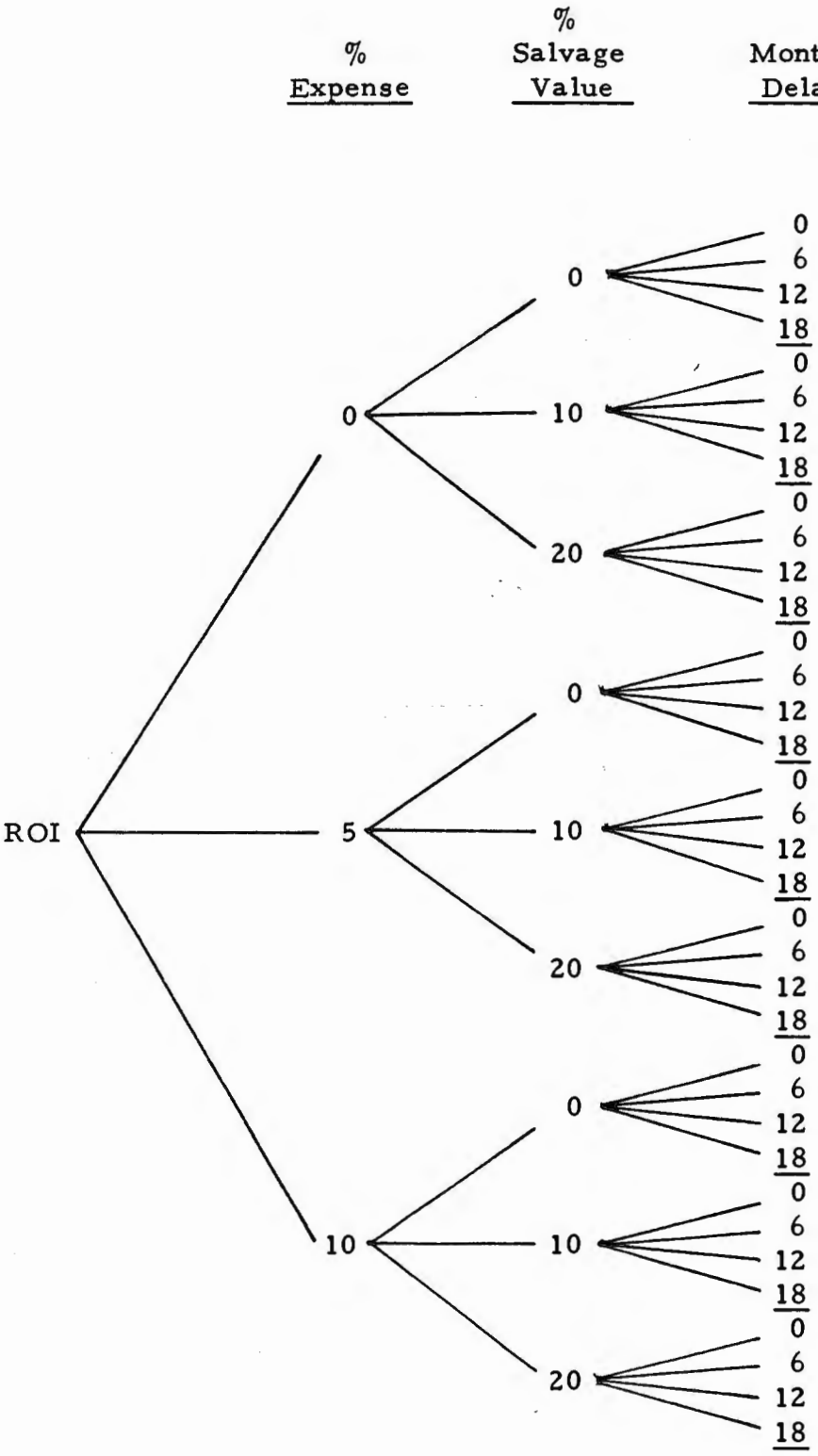


Total Investment Conversion Chart



Total Investment ROI		
15	25	35
1.70	1.14	.85
1.55	1.01	.72
1.40	.87	.59
1.27	.76	.50
1.74	1.15	.85
1.58	1.01	.72
1.43	.87	.59
1.29	.77	.50
1.77	1.16	.85
1.62	1.02	.72
1.46	.88	.59
1.32	.77	.50
1.71	1.15	.86
1.56	1.01	.73
1.40	.88	.60
1.27	.77	.50
1.74	1.16	.86
1.59	1.02	.73
1.43	.88	.60
1.30	.77	.51
1.78	1.17	.86
1.62	1.03	.73
1.46	.89	.60
1.32	.78	.51
1.72	1.16	.87
1.56	1.02	.73
1.41	.88	.60
1.28	.77	.51
1.75	1.17	.87
1.59	1.03	.74
1.43	.88	.60
1.30	.78	.51
1.78	1.18	.87
1.62	1.04	.74
1.46	.89	.60
1.33	.78	.51

EXAMPLE

HOT FORMING SCRAPER BLADES

CURRENT OPERATION

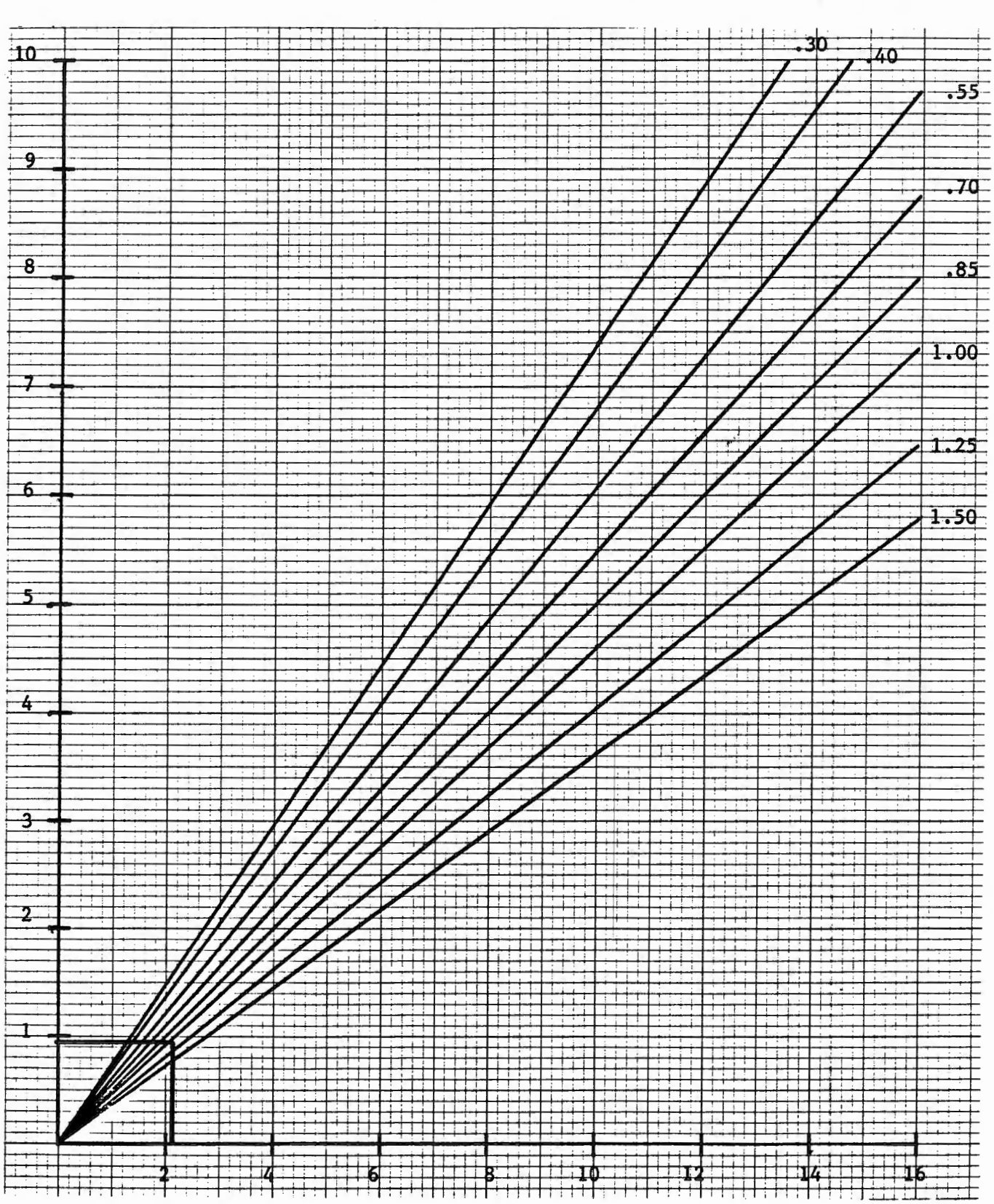
1 OPERATOR

4 PART NUMBERS

8104 YEARLY INCENTIVE HOURS

2.145 STANDARD MINUTES PER PART

Optimal Division of Total Standard Minutes (at 1.20 Avg. P&F Factor)

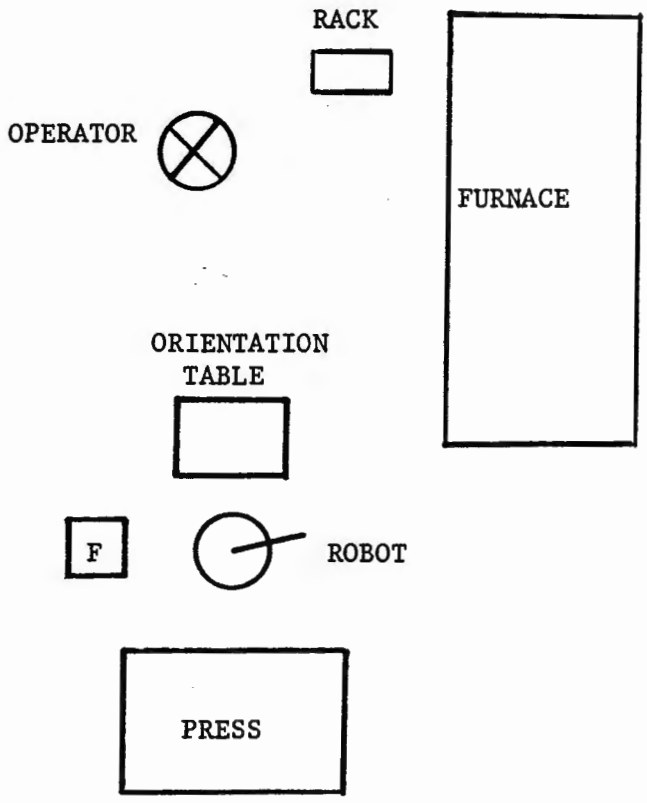


.95

2.145

HOT FORMING OF SCRAPER BLADES

ROBOT APPLICATION



OPTIMAL WORK DISTRIBUTION

.95 MINS. TO ROBOT

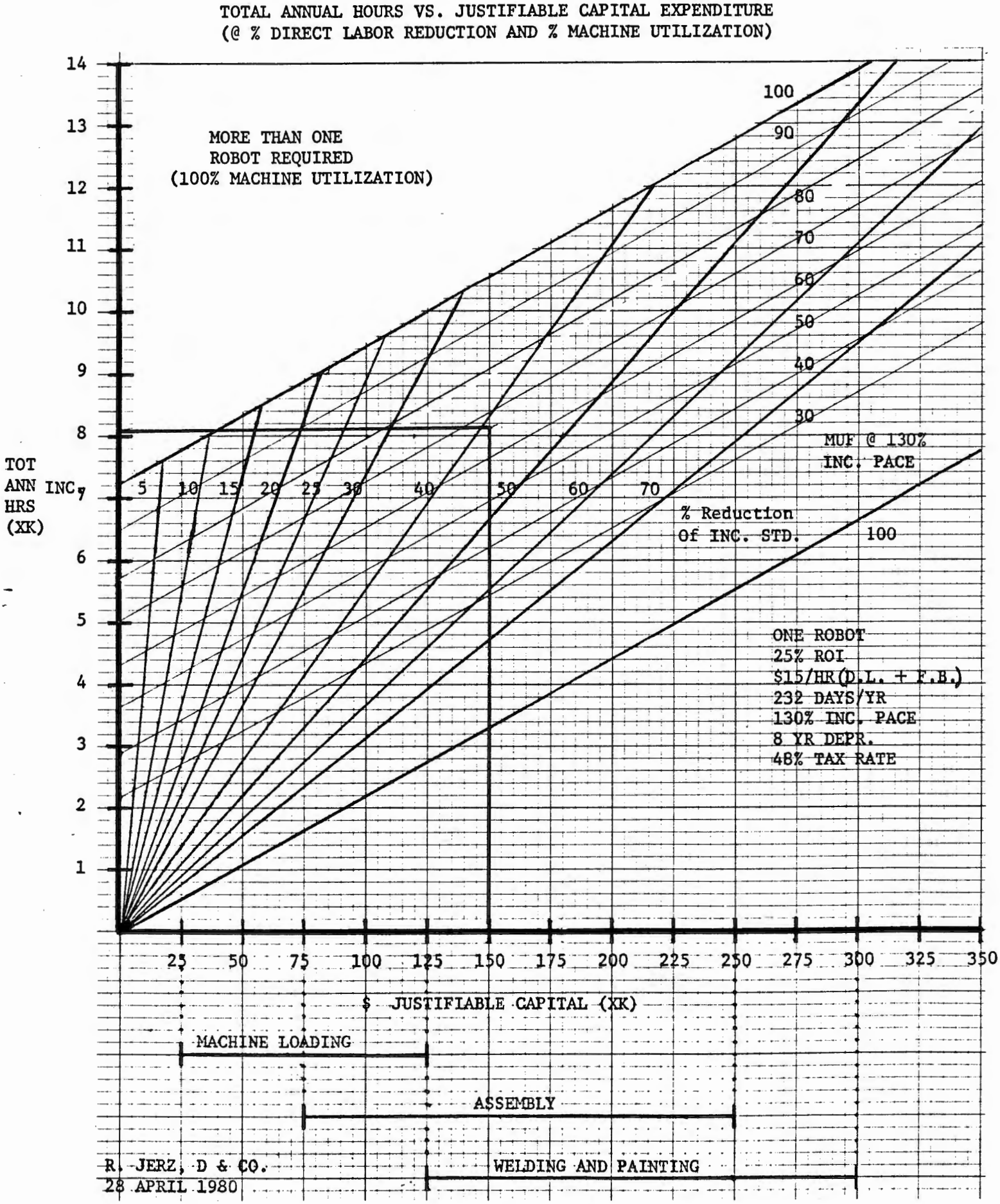
1.20 MINS. TO OPERATOR

ACTUAL WORK DISTRIBUTION

1.27 MINS TO OPERATOR

40.8 % LABOR REDUCTION

ROBOT ANALYSIS -- U.S. FACTORIES



RESULTS:

$150,000 JUSTIFIABLE CAPITAL @ 25% ROI

67% MUF

LOW HOUR ANALYSIS OVERVIEW

OBJECTIVE: TO ANALYTICALLY DETERMINE THE YEARLY HOURS THAT AN OPERATION MUST RUN BEFORE IT BECOMES ECONOMICALLY FEASIBLE TO AUTOMATE IT.

LOW HOUR ANALYSIS

EXAMPLE - WELDING

NUMBER OF SET UPS PER YEAR - 6

SET UP TIME FOR OPERATION - 3/4 HR

SET UP TIME FOR ROBOT - 1/2 HR

INCREMENTAL TOOLING COST - $15 K

ROBOT COST - $100 K

DIRECT LABOR COST PLUS F.B. - $15/HR

PAYBACK FACTOR - 3.0

PERCENT LABOR REDUCTION - 45

PERCENT DELAYS - 20

YEARLY HOURS = 1223

OF PARTS = 10.5

LOW HOUR ANALYSIS

EXAMPLE - MACHINE LOADING

NUMBER OF SET UPS PER YEAR - 12

SET UP TIME FOR OPERATION - ½ HR

SET UP TIME FOR ROBOT - ½ HR

INCREMENTAL TOOLING COST - $4 K

ROBOT COST - $75 K

DIRECT LABOR COST PLUS F.B. - $15/HR

PAYBACK FACTOR - 3.0

PERCENT LABOR REDUCTION - 45

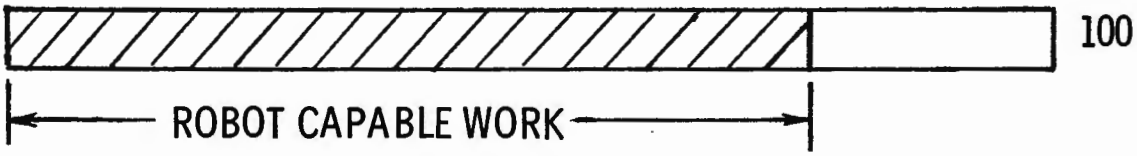
PERCENT DELAYS - 25

YEARLY HOURS = 309.6

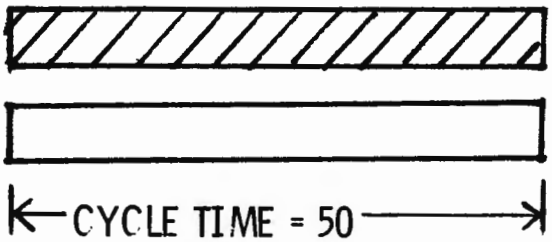
OF PARTS = 37.51

ONE ROBOT/ONE OPERATOR

ALL WORK CURRENTLY BEING PERFORMED



OPTIMAL DISTRIBUTION 50/50



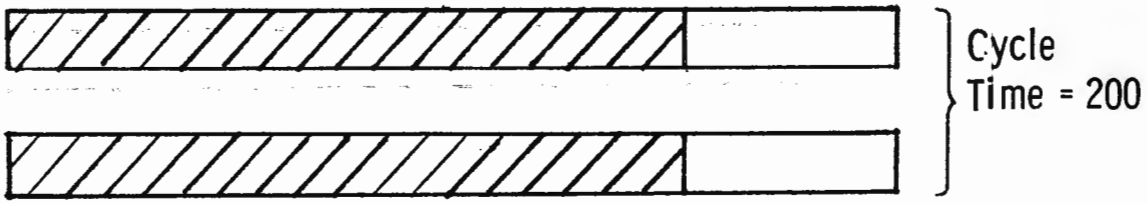
SAVINGS = 50

DUPLICATE SYSTEM (SUB-OPTIMIZATION)

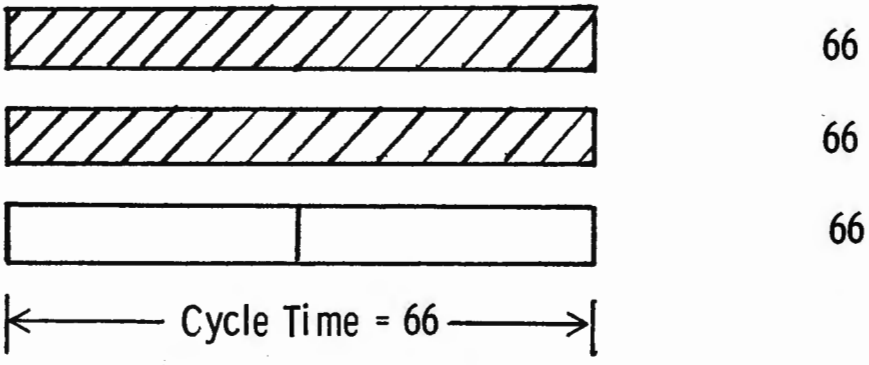
SAVINGS = 100

SYSTEM OPTIMIZATION

TWO ROBOTS/ONE OPERATOR



OPTIMAL DISTRIBUTION 1/3, 1/3, 1/3



SAVINGS = 134

EXAMPLE

MULTIPLE ROBOT ANALYSIS

NO. ROBOTS	A % SAVINGS PER OPERATION	B TOTAL ROBOT COST	C SAVINGS PER SHIFT	D ROI 1 SHIFT	2 SHIFTS	3 SHIFTS
1	40.5	100	9,584	4.5	15.4	25.0
2	52.6	200	24,894	8.0	21.2	33.2
3	63.0	300	44,724	10.8	26.0	40.3
4	69.6	400	65,880	12.5	29.0	44.9
5	74.3	500	87,910	13.7	31.1	48.2

ASSUMPTIONS

A. ROBOT PERFORMS AT OPERATOR'S NORMAL PACE

1.15 AVG. P&F

1.15 WAF TOTAL

130% INCENTIVE OPPORTUNITY

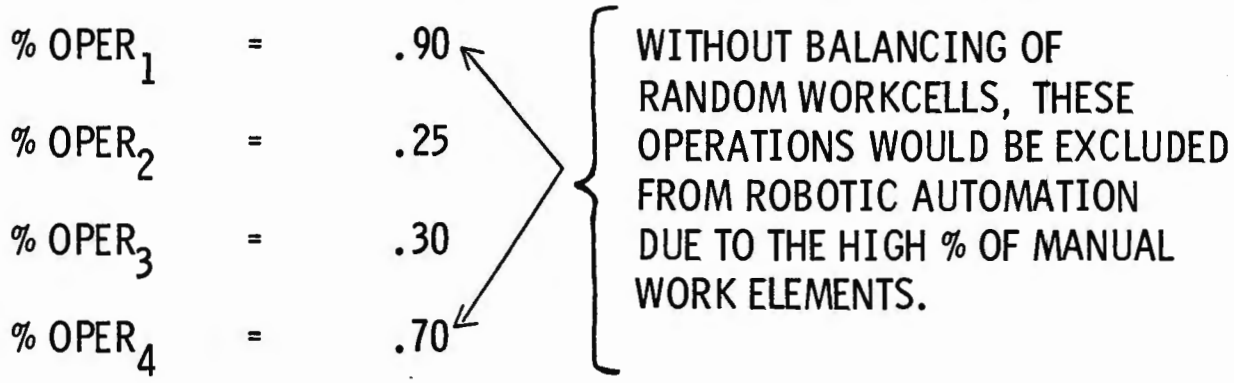
10% OF INC. STD. REMAINS AS "D" TIME

B. $100,000 PER ROBOT SYSTEM
$20,000 SALVAGE VALUE

C. SAVINGS = 8 HRS/SHIFT X 232 DAYS/YR X 85% UTILIZATION X $15/HR X % SAVINGS

D. BASED ON NUMBER OF SHIFTS OF CURRENT WORK LOAD

EXAMPLE: FOUR OPERATIONS - OPERATOR WORK PERCENTAGES



BY BALANCING, WE WOULD TRY TO RUN JOBS (1) AND (2) TOGETHER, AND (3) AND (4) TOGETHER.

BENEFITS OF SYSTEMS APPROACH

- GREATER SAVINGS ⟶ GREATER ROI'S

- ABLE TO BALANCE LOW ROBOT PERCENT OPERATIONS WITH HIGH ROBOT PERCENT OPERATIONS

- MAY START EFFECTING OVERHEAD ACCOUNTS FOR EVEN GREATER SAVINGS

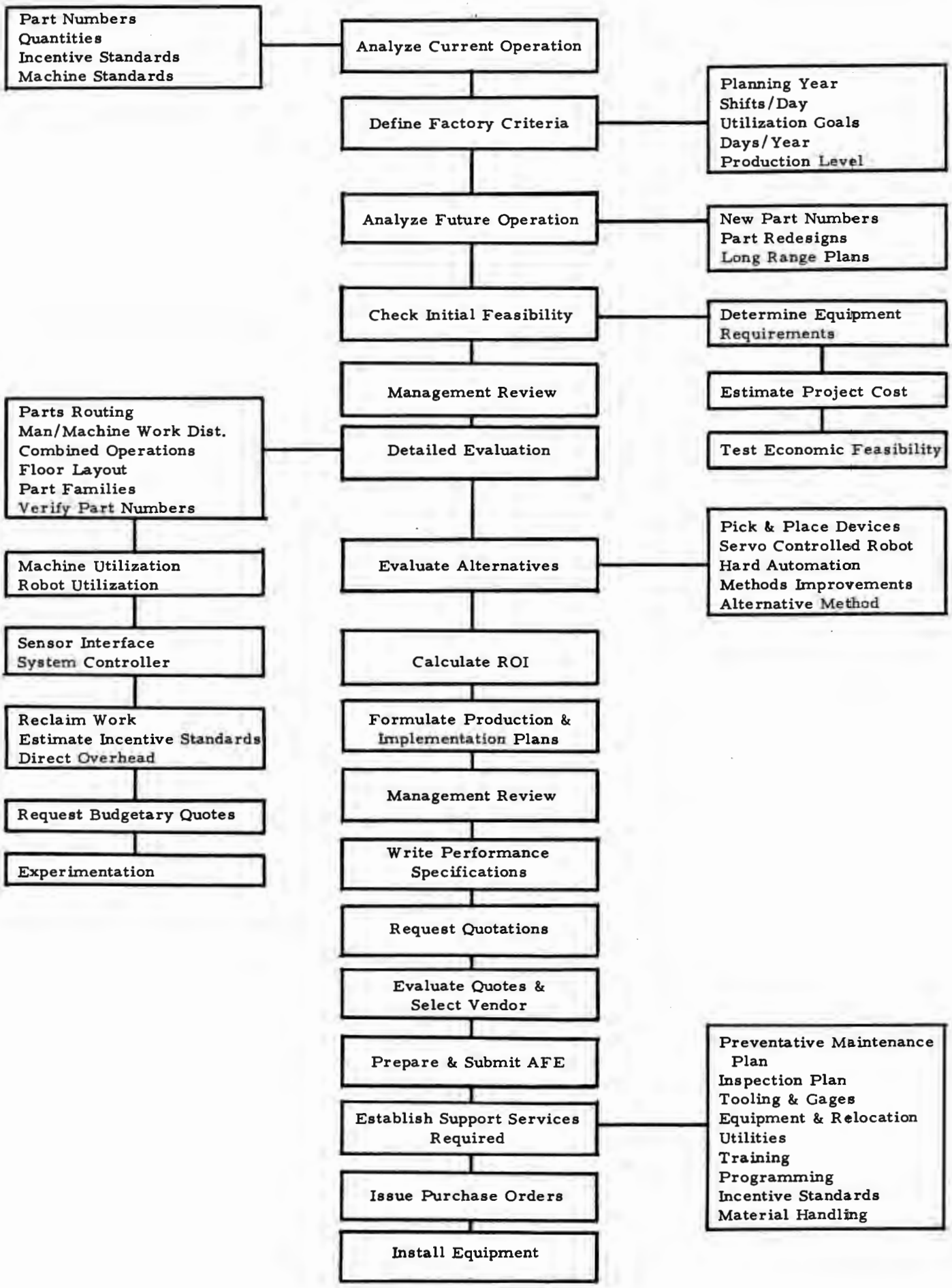
ADVANTAGES OF ANALYTICAL TOOLS

- TEST SENSITIVITY
- KNOW WHAT THE VARIABLES ARE
- CONCENTRATE ON IMPORTANT VARIABLES

SUMMARY OF ANALYTICAL TOOLS

TOOL	USE
OPTIMAL DIVISION OF WORK ELEMENTS	BALANCE WORK ELEMENTS TO MAXIMIZE ROBOT AND OPERATOR UTILIZATION
ROBOT ANALYSIS	DETERMINES JUSTIFIABLE CAPITAL EXPENDITURE, TOTAL HOURS, OR % REDUCTION
LOW HOUR ANALYSIS	HELPS ANALYZE AUTOMATION OF LOW HOUR OPERATIONS
SYSTEMS ANALYSIS	FOR MULTIPLE ROBOT APPLICATIONS
EXPENDITURE CONVERSION CHART	CONVERTS JUSTIFIABLE CAPITAL AT VARYING ROI'S AND START-UP DELAYS

ROBOT APPLICATION LOGIC CHART



SUMMARY

- ANALYTICAL TOOLS ARE AVAILABLE TO ASSIST ENGINEERS WITH ROBOT INVESTIGATIONS
- ROBOTS DO NOT HAVE TO PERFORM ALL TASKS CURRENTLY BEING PERFORMED BY OPERATORS
- MULTIPLE ROBOTIC SYSTEMS PROVIDE BENEFITS THAT MAY NOT BE OBTAINED IN SINGLE ROBOT SYSTEMS
- ROBOTS CAN WORK WITHIN THE DEERE INCENTIVE SYSTEM
- OPERATORS ARE AFFORDED GOOD INCENTIVE OPPORTUNITY