CHAPTER 5

INTEGRATING DECISION TABLES INTO A SYSTEM

The decision table, as it was discussed in Chapter 4, is a versatile tool for individual analysis and documentation situations. These same tables, now many hundreds in number describing the logic for a complete engineering design system, can be integrated into a total systems documentation package with little extra effort. To show how decision tables work in groups, and also to demonstrate a wider application for this systems techniqu a series of interrelated tables are descirbed as they automatically generate engineering design logic.

The case study, drawn fron races tabular applications over three major product assemblies, and shows computer printouts from test runs.

CUSTOMER SPECIFICATION

The system is set in motion by the receipt of a customer order requesti :

CUSTOMER ORDER

Catalog Number:	60353
Product Description:	Special 3 chart recorder with scale illumination.
Chart Range:	1000^{o} - 1100^{o} F for iron constantan thermocouples (TC).

Number of Recording Points:	3 (continuous)
Time per Point:	15 seconds
Chart Drive:	Standard 10:1 Speed Reduction.
Chart Speeds:	120" and 12" per hour
Drive Shaft Speed:	25 R. P. M.

Special Features:

(1) Calibration checking circuit with thermocouple key to check calibration.

(2) Fluorescent scale illuminating lamp with switch.

Figure 25

Note: Only the specification elements applying to this example have been included here. Otherwise, the specification would be much more detailed.

The specification is first reduced to punched cards in a format acceptable to the ADE system The verified card deck is then introduced to the computer and processed through three major assemblies of the product:

- o measuring circuit
- o scale design
- o gear train selection

MEASURING CIRCUIT DESIGN

From table #360, a wiring diagram for the measuring circuit is to be selected:

Table #360 - Drawing Selection

Rule Number	1	2	3	4	5	6
1. Type of Element EQ	TH	TH	TC	TC	RAY	RAY
2. Number Points EQ 1	Y	N	Y	N	Y	N
3. Select Drawing	SSR-311-A-100	SMR-311-A-100	SST-311-A-11	SMT-311-A-11	SSA-311-A-10	SMA-311 A-10
4. Go To Table 361	X	X	X	X	X	X

In condition row #1, TH refers to a thermohm element, TC to thermocouple, and RAY to a Rayotube. Instruments may be either single or multiple point recorders, and this condition is denoted in the second row by a "Y" for single, an "N" for multiple point. The only combination of conditions meeting the specification requirement of a multiple (3) point recorder with thermocouples is displayed in rule #4, which is paraphrased:

IF the type of element is a thermocouple

and

the number of points does not equal one (i. e., it is more than one, or multiple)

THEN select drawing number SMT-311-A-11 as the appropriate measuring circuit wiring diagram

and

go to table #361 for the next processing step.

The results of processing this table then can be printed out from the computer as follows (as each table is discussed, the form of the printer output will be displayed at that point):

TABLE 360. BASIC DRAWING SELECTION

SELECT DRAWING # SMT-311-A-11

This wiring diagram is shown in figure 26.

The last action row is prefaced by a "GO TO" operator and signals a table transfer from #360 to #361 for the next series of operations. This second table is a typical example of limited entry tabular form, where the entire action statement is contained to the left of the vertical double lines, or stub area. Entries to the right of this line are simply an indication that the action is to be executed (X) or is not pertinent (blank).

Where the condition or action statement is shown partly in the stub and extended over into the entry (as in the first condition and first action rows of table #360), the table is referred to as extended entry.

In table #361, only rule #5 is appropriate for the stated customer specification, and it reads:

IF the element is a thermocouple

and

the number of spans equals one

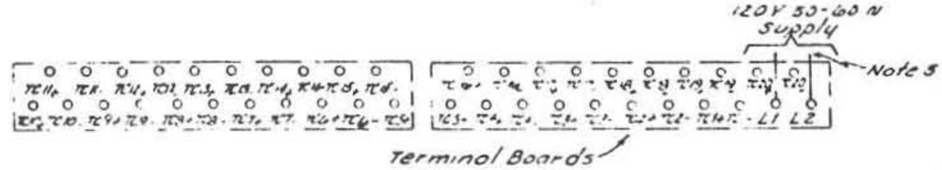
and

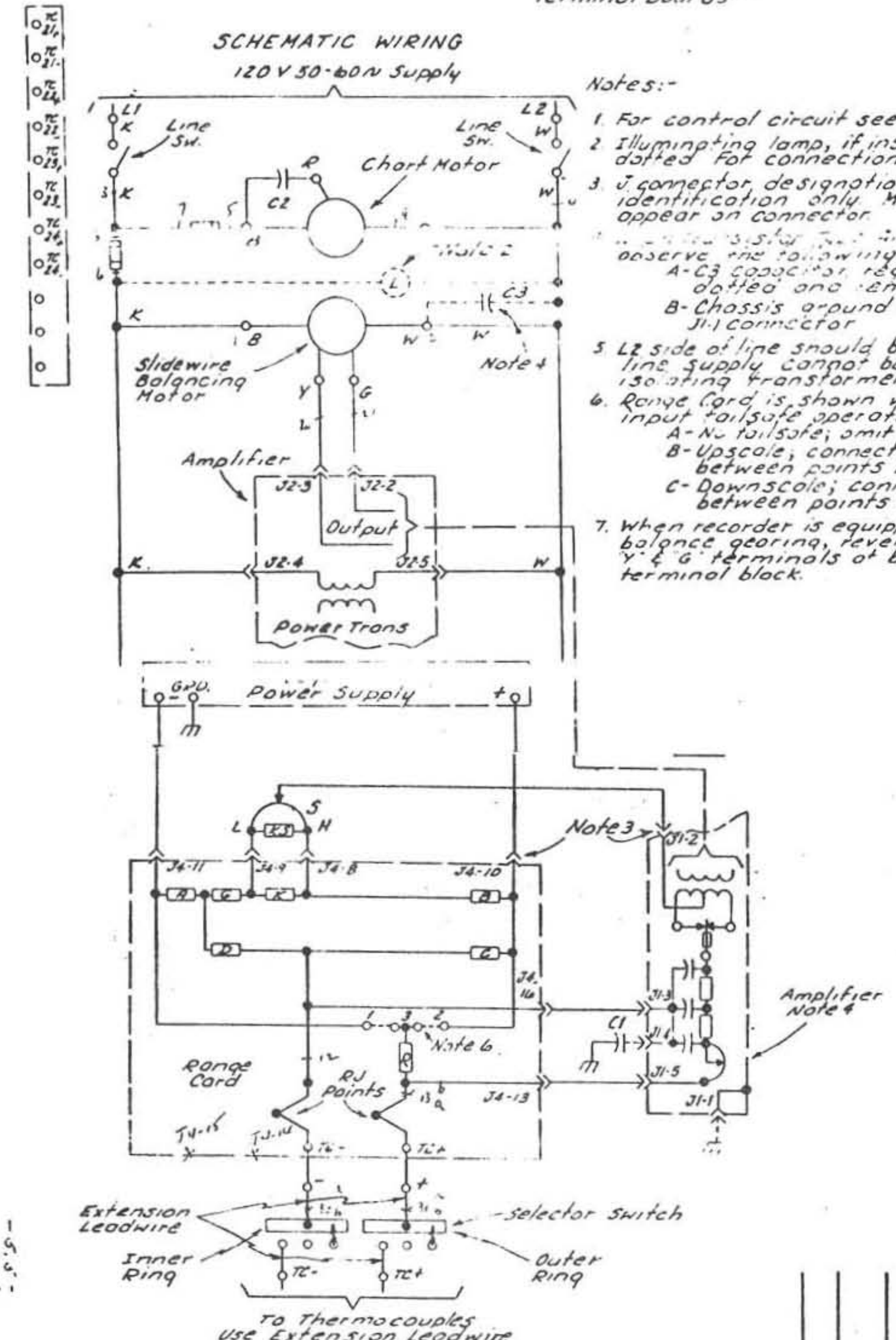
the number of charts equals three

THEN the "A" resistor is set equal to 46 ohms

and

formula #1 is evaluated (the expression is shown in note #1 at the bottom of the table).





Notes:-

1. For control circuit see separate diagram.
2. Illuminating lamp, if installed, is shown dotted. For connections see SD-299-A
3. J connector designations are for wiring identification only. Markings do not appear on connector.
4. ... observe the following:-
   - A- C3 capacitor required as shown dotted and remove (W) connection
   - B- Chassis ground required at J1-1 connector
5. L2 side of line should be grounded; If line supply cannot be grounded, add isolating transformer & ground.
6. Range Card is shown with provision for input failsafe operation.
   - A- No failsafe; omit dotted Jumpers
   - B- Upscale; connect dotted Jumper between points 2 and 3.
   - C- Downscale; connect dotted Jumper between points 1 and 3
7. When recorder is equipped with one second balance gearing, reverse connections to "Y" & "G" terminals of balancing motor terminal block.

Figure 26

COLOR CODE	
K - BLACK	Y - YELLOW
W - WHITE	A - GRAY
R - RED	P - PINK
B - BLUE	S - SLATE
N - BROWN	T - TAN
O - ORANGE	

THERMOCOUPLE EXTENSION WIRE TABLE

THERMOCOUPLE COMBINATION	EXTERNAL TO INSTRUMENT					INTERNAL OF INSTRUMENT	
	DUPLEX			SINGLE COND.			
	+	−	[illegible]	+	−	+	−
COPPER CONST TYPE T	COPPER B	CONST R	B	COPPER B	CONST R-B	COPPER W-G	CONST R-Y
[illegible]	IRON	CONST		IRON	CONST [illegible]	IRON W-R	
CHROMEL CONST TYPE E	CHROMEL Y	CONST R	Y	CHROMEL Y	CONST R-B	CHROMEL W-Y	
CHROMEL ALUMEL TYPE K	CHROMEL Y	ALUMEL R	Y	CHROMEL Y	ALUMEL R-Y	COPPER W-G	
PLAT RHOD PLAT TYPE S/R	COPPER K	ALLOY R	G	COPPER K	ALLOY R-K	COPPER R-G	ALLOY R-G

FORM 1322

1 (962215)

MEAS. & MOTOR CIRCUIT - SPDX G
MULTI-PT. TC RECORDER

DRAWN B.J.S.	CHECKED	APPROVED G S Talbot
DESIGNED	DESIGN APPROVED	DATE 9 12 61

FIRST MADE FOR L&N ORDER NO. LN

DWG. NO. B-SMT-311-A-10

Table #361 - Measuring Circuit TC Resistance Calculation

	Rule Number	1	2	3	4	5	6	7	8
1	Element EQ TC	Y	Y	Y	Y	Y	Y	Y	N
2	Number SPANS EQ	1	1	1	1	1	2	3	.
3	Number CHARTS EQ	1	1	1	2	3	.	.	.
4	Number SUPPRESSIONS EQ	1	2	3	.	.	.	.	.
5	GO TO 362						X	X	
6	GO TO Resistance CALC. TH								X
7	A EQ 46	X	X	X	X	X			
8	C. EQ 0	X							
9	Beta EQ 0	X	X	X					
10	DO formula 5		X	X					
11	DO formula 6			X					
12	DO formula 1				X	X			
13	DO formula 2				X	X			
14	C_2 EQ 0	X	X		X				
15	C_2 EQ C_1					X			
16	DO formula 3				X	X			
17	C EQ 11. 9-C_1-C_2	X	X	X	X	X			
18	DO formula 4	X	X	X	X	X			
19	K EQ 200 . S/200-S	X	X	X	X	X			
20	G EQ K/4	X	X	X	X	X			
21	B EQ 118-S	X	X	X	X	X			
22	GO TO TABLE 344	X	X	X	X	X			

Notes:

1. Formula 1: DEADBAND = Start PT (2)-start PT (1)-scale width
2. Formula 2: C_1 = . 2 (scale width+deadband/scale width). Value span
3. Formula 3: Beta = (No. of charts-1) (Deadband) (Span value) /scale width
4. Formula 4: S = . 204 [(No. of charts) (Span value) + Beta]
5. Formula 5: C_1 = . 2 (Suppression 2 - suppression 1)
6. Formula 6: C_2 = . 2 (Suppression 3 - suppression 2)

<u>and</u>

formula #2 is evaluated to determine the resistance values of the C, resistor (resistance is in ohms).

<u>and</u>

The value of the C_2 resistor is set equal to the value of the C_1 resistor

<u>and</u>

do formula #3

<u>and</u>

set the C resistor equal to 111.9 minus the resistance value of C_1, minus the resistance value of C_2

<u>and</u>

do formula #4, which is the resistance value for the S resistor.

<u>and</u>

Set the K resistance value equal to the formula:
200 times S resistance value divided by 200 minus S resistance value

<u>and</u>

set G resistance value equal to the resistance value of K divided by 4.

<u>and</u>

set B resistance value equal to 118 minus the resistance value of S.

<u>and</u>

go to table #344.

The computer printout shows the input parameters of the circuit and resulting resistance values for each of the resistors:

TABLE 361 RESULTS. RESISTANCE CALCULATIONS FOR THERMO-COUPLE CIRCUITS.					
INPUT PARAMETERS					
NUMBER OF SPANS EQ 1.				RANGE	1000F - 1100F
NUMBER OF CHARTS EQ 3.				SPAN	29.5MV - 32.7MV
TYPE COUPLE EQ IRON CONSTANTIN					
OUTPUT RESISTANCE VALUES					
RESISTOR	A	46.00	OHMS	.25 WATT	
	C	110.62	OHMS	.25 WATT	
	C1	3.64	OHMS	.25 WATT	
	C2	0.64	OHMS	.25 WATT	
	S	2.04	OHMS	.25 WATT	
	K	2.01	OHMS	.25 WATT	
	G	.50	OHMS	.25 WATT	
	B	115.96	OHMS	.25 WATT	

The term SPAN, as used for this measuring instrument, refers to the difference between the end points of the range on the scale (ie., for this specification the range is 1000° - 1100° F; therefore, the span equals 100). Although three separate critical points are being measured, only one span is involved in this problem. The recording chart looks like this:

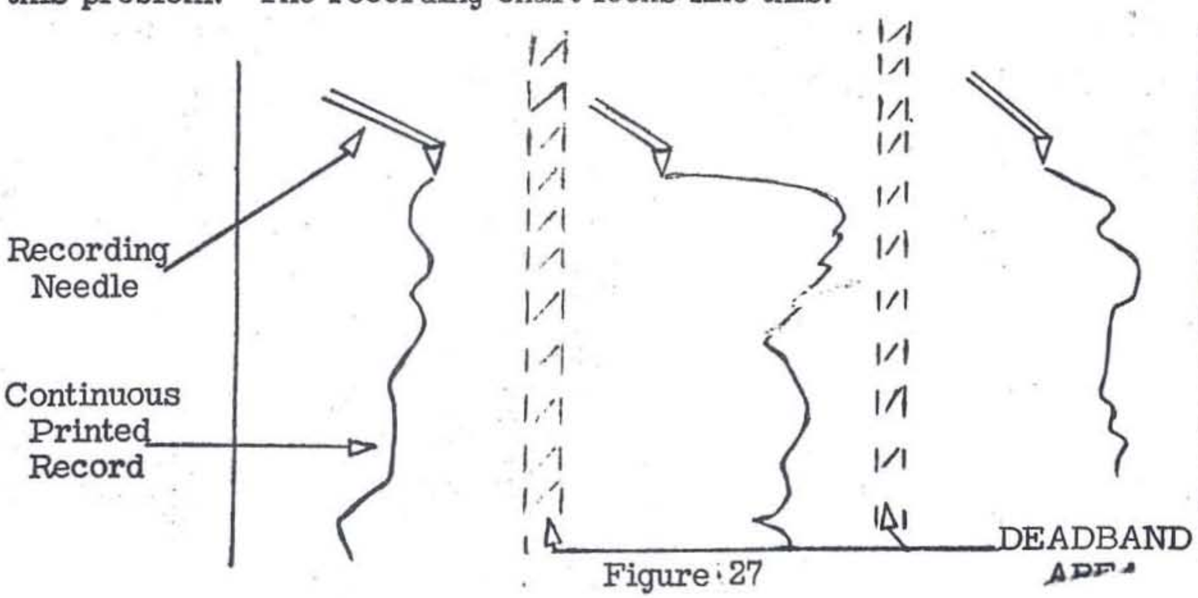


Figure 27

The shaded area separating the chart into three segments is called the "deadband" area, since none of the three recording needles are permitted to print on these strips.

Resistance values for B, G, K, and S resistors are determined by the process of "design;" choice of a resistance for the A resistor is made through the process of "selection", even though only one value is involved in this instance.

The next table (#344) to be processed in the measuring circuit series is the wiring instruction for connecting the checking key (a special feature called for in the customer specification) to the basic circuit.

Table #344 - Special Condition - Thermocouple Group

	Rule Number	1	2
1	Checking Key is Present	Y	N
2	GO TO 345		X
3	Select 4P-2T Telephone Key (#3232-7)	X	
4	Disconnect 12 and 13	X	
5	Connect P_2-C to 13 b	X	
6	Connect P_4-C to 12 b	X	
7	Connect P_3-C to 12 a	X	
8	Connect P_1-C to 13 a	X	
9	Connect P_2-T_1 to CK TERM +	X	
10	Connect P_1-T_1 to CK TERM +	X	
11	Connect P_2-T_1 to P_1-T_2	X	
12	Connect P_4-T_2 to P_3-T_2	X	
13	Connect P_4-T_1 to CK TERM -	X	
14	Connect P_3-T_1 to CK TERM -	X	
15	GO TO 312	X	

This table is coded to the generic diagram SMT-311-A-11 called for in table #360, and used in table #361.

Rule #1, the correct rule for this particular specification reads:

IF the checking key is present

THEN select a 4 pole, double throw telephone key, number 3232-7

and

disconnect points 12 and 13 in the basic circuit

and

connect the second pole common terminal of the checking key to 13 b of the measuring circuit (the two open ends of disconnected point 13 are identified as 13 a and 13 b).

and

connect the fourth pole common terminal to 12 b

-etc.

The rest of the action rows read in much the same way (row nine: connect the second pole, single throw to the positive side of the checking terminal, which is not indicated here, but would be shown in the full system), and the table concludes with the instruction GO TO TABLE 312.

This table is essentially a list of directions for connecting the checking key to the basic circuit, and it is printed out from the computer for manufacturing as follows:

TABLE 344. SPECIAL CONDITION TC GROUP.
TEMPERATURE CALIBRATION CHECKING KEY.
THE FOLLOWING MODIFICATIONS TO THE GENERIC WIRING CHART **MUST BE COMPLETED** .

1.	SELECT 4 POLE 2 THROW TELEPHONE KEY.	STD.-3232-7		
2.	DISCONNECT	12	TO	13
3.	CONNECT	P2-C	TO	13-B
	CONNECT	P4-C	TO	12-B
	CONNECT	P3-C	TO	12-A
	CONNECT	P1-C	TO	13-A
	CONNECT	P2-T1	TO	CK TERM PLUS
	CONNECT	P1-T1	TO	CK TERM PLUS
	CONNECT	P2-T2	TO	P1-T2
	CONNECT	P4-T2	TO	P3-T2
	CONNECT	P4-T1	TO	CK TERM MINUS
	CONNECT	P3-T1	TO	CK TERM MINUS

The conventional system alternative to this would be to draw a special wiring diagram for an iron constantan thermocouple with a checking key, and duplicate multiple copies for distribution to the manufacturing section.

The following table, #312, establishes the routine for connecting the fluorescent illumination (with switch) to the measuring circuit, as requested in the customer specification.

Three conditions are necessary:

- o Is illumination present?
- o Is light switch present?
- o Is a separate terminal present as called for by the sales engineer?

The specification indicates "yes" for the first two, but not the third, so rule #1 is appropriate:

Table #312 - Special Conditions - TC

Rule Number	1	2	3	4
1. Illumination is present	Y	Y	Y	N
2. Light SW is present	Y	Y	N	-
3. Separate TERM is present	N	Y	Y	-
4. GO TO 313				X
5. Select 2P-1T SW #36715	X	X		
6. Connect P-$_1$ between J_2-4 and contact 1	X			
7. Connect P-$_2$ between J_2-5 and contact 2	X			
8. Insert TERM LT-1 adjacent L_1		X	X	
9. Insert TERM LT-2 adjacent L_1		X	X	
10. Connect P-$_1$ between LT-1 and contact 2		X		
11. Connect P-$_2$ between LT-2 and contact 2		X		
12. Connect LT-1 to contact 1			X	
13. Connect LT-2 to contact 2			X	
14. GO TO 201	X	X	X	

Successively, rule #1 selects a double - pole single - throw switch #36715, and calls for connecting the first pole between J2-4 and contact 1 of the light bulb, and the second pole between J2-4 and contact 2.

Again, no separate wiring diagram is needed showing the connections to be made for this special product feature, since computer printout states:

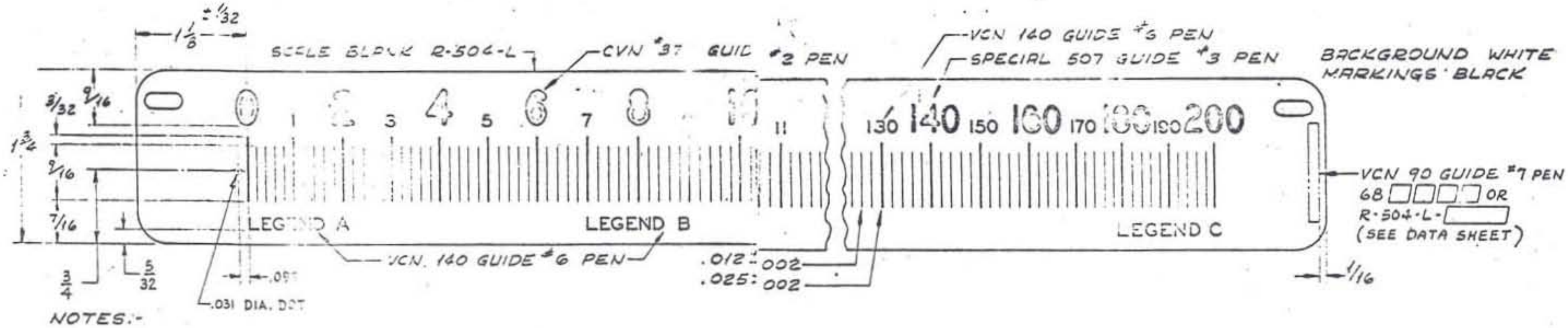
```
TABLE 312.  SPECIAL CONDITION - COMMON.
        ILLUMINATION WIRING
             1.  SELECT DOUBLE POLE, SINGLE THROW SWITCH #36715.

             2.  CONNECT P-1 BETWEEN J2-4 AND LIGHT CONTACT 1
             3.  CONNECT P-2 BETWEEN J2-5 AND LIGHT CONTACT 2
```

Although there are many other measuring circuit tables, this is the last one included in this demonstration series.

SCALE DESIGN

The five tables in scale design select the major line divisions of the instrument scale and indicate the distance these major divisions are to be located from the beginning of the scale. The output of these calculations is a printed scale diagram with supplementary packing instructions. Figure 28 is an engineering drawing of the scale with major line divisions marked off and numbered with large numerals. Semi - major and minor divisions are developed from another series of tables.

The first scale design table is an example of an unconditional table; i.e., it has no conditions and only one rule:



NOTES:-

1- VERTICAL DIMENSIONS APPLY TO ALL SINGLE RANGE SCALES.

2- HORIZONTAL LOCATIONS OF CALIBRATION LINES, CHARACTER OF NUMERALS, PART NO. & LEGENDS "A", "B" & "C" AS SPECIFIED.

3- WHEN SPACE LIMITATION REQUIRES USE OF CONDENSED #507 GUIDE, IT SHOULD NOT BE MIXED WITH #575 GUIDE ON SAME SCALE.

4- WEIGHTS OF CALIBRATION LINES AS SPECIFIED ON THE DATA SHEET.

5- PART NO. IS SHOWN IN THE TITLE BOX OF THE DATA SHEET.

6- LEGEND "B" IS CENTERED BETWEEN LEGENDS "A" & "C".

7- CALIBRATION LINES ARE TO BE LOCATED WITHIN .010" OF SPECIFICATION.

8- ERROR IN SPACING BETWEEN ADJACENT LINES IS LIMITED TO .004 ± WHERE LINES ARE SPACED 1/16" APART, OR LESS. A TOLERANCE OF ±.006 MAY BE GIVEN WHERE LINES ARE MORE THAN 1/16" APART.

9- IF MASTER IS AVAILABLE, DIVIDE SCALE ON RATCHET MACHINE, USING SINGLE RANGE LINE GUIDE. IF MASTER IS NOT AVAILABLE, DIVIDE SCALE ON HANDWHEEL MACHINE, USING SD-150 LINE GUIDE.

10- EXTEND LINE AT ZERO INCHES 1/8" BELOW NORMAL LENGTH WHEN VALUE AT LOW END DIVISION IS NOT EQUAL TO ADJACENT DIVISION (i.e. A FRACTIONAL PART.) SEE SKETCH BELOW.

EXAMPLE:-
RANGE 566-1600°F
LOW END DIVISION = 4
ADJACENT DIVISION = 10

11- LETTERING GUIDES & PENS BY WOOD-REGAN CO.

12- FINISHED SCALES TO BE SPRAYED ALL OVER PER E.S.S. 3.15.37. REVERSE FACE TO BE CLEANED OF SMUDGES.

13- PACK SEPARATELY IN GLASSINE ENVELOPES, USING WHITE CARDBOARD PROTECTOR ON PRINTED FACE.

ON THERMOCOUPLE SCALES USE NEW ASA DESIGNATIONS

OLD LEGEND	NEW LEGEND
I.C. COUPLES	I-C TC TYPE J
CHR. AL. COUPLES	CHROMEL-ALUMEL TC TYPE K
CHR. CONST. COUPLES	CHROMEL-CONST. TC TYPE E
COPPER CONST. COUPLES	Cu-CONST TC TYPE T
PLAT., 10% RHOD. COUPLES	Pt, 10% Rh-Pt TC TYPE S
PLAT., 13% RHOD. COUPLES	Pt, 13% Rh-Pt TC TYPE R

6	4-20-62	75	A61361
5			A61046
4			A53637
3			(A-53556) MC
2			A50245
1			A50241 (REDRAWN)

LAYOUT OF STRIP CHART SINGLE RANGE RECORDER SCALE

DRAWN: L. BINCZAK
CHECKED: M.J.B.
APPROVED: M.J.B.
DATE: 5-27-60

FIRST MADE FOR L&N ORDER NO. LN

DWG. NO. SD-150

UNLESS OTHERWISE STATED ALL DIMENSIONS IN INCHES. TOL ON DECIMAL DIM ±.005 | SCALE

Table #201 - Calculate Span

1	Set SPAN EQ Max Range - Min Range	X
2	Do INCREMENT SELECT	X
3	Set FACTOR EQ Min Range/Increment	X
4	GO TO MAJOR DIV. CALC	X

In the first action row, SPAN is set equal to maximum range minus minimum range (SPAN being the difference between end points on the range, or 1100°-1000° = 100).

Then in the second action row, another table is called upon for processing, entitled: INCREMENT SELECT, table #202:

Table #202 - Increment Select

Rule Number	1	2	3	4
1. SPAN GE	8.0	16.0	33.0	80.0
2. SPAN LR	16.0	33.0	80.0	160.0
3. SET INCREMENT EQ	1	2	5	10
4. SET MANTISSA EQ	1	2	5	1
5. SET MULTIPLIER	1	1	1	10

Another tabular feature is revealed in the relationship of these two tables. So far, all the decision tables have been entered at the top, and as a set of conditions was satisfied and executed by multiple actions, control was turned over to another table by the operator GO TO.

Now a DO operator appears in table #201, temporarily transferring control to another table for a series of processing steps. When they have been completed, control reverts back to the original table. In this respect, table #201 is an "open table," while table #202 is a "closed table," since the latter has no influence over the order in which tables are executed; here, table #202 is a slave to any table carrying an instruction to enter it, execute a rule, and return to the original table.

Some of the terms in table #202 require explanation:

<u>increment</u>:	numerical or algebraic difference between two neighboring major line divisions.
<u>mantissa</u>:	decimal portion of the entire number (dimension)
<u>multiplier</u>:	conversion of numbers to a higher order of values. (eg., hundreds to thousands).

SPAN in this problem equals 100, so rule #4 is appropriate:

IF	SPAN is greater than or equal to 80, but less than or equal to 160
THEN	set increment equal to 10
	<u>and</u>
	set mantissa equal to 1
	<u>and</u>
	set multiplier equal to 10

Since this is a closed table, control reverts back to action row 3 of table #201:

Set FACTOR equal to minimum range divided by increment (i. e., $1000 \div 10 = 100$; therefore, on this scale, the first line will be 100), and go to the table entitled: MAJOR DIVISION CALCULATION. FACTOR, in this case, is the numeral associated with the first line on the scale, or 0 for this scale Other scales can start with higher numbers.

The MAJOR DIVISION CALCULATION table appears as:

Table #203 - Major Division Calculation

1	Set FACTOR EQ INT (FACTOR)	X
2	Set N: EQ 1	X
3	Set N: Value EQ FACTOR * Increment	X
4	GO TO VALUE CALCULATION	X

This table is primarily for non - linear scales and scales which do not have numerals associated with the first line.

It reads:

Set FACTOR (selected above) equal to the integral of the FACTOR..

and

Set the number equal to 1.

and

Set the number called value equal to the FACTOR times the increment.

and

GO TO the table called VALUE CALCULATION.

In this rule, FACTOR is the first numeral on the scale, and VALUE is an arbitrary reference to the particular numeral being worked on at the present time. It could be any numeral on the scale, except the first. The rather special actions in this table are needed to set the numeral in the right place for non - linear scales.

The VALUE CALCULATION table repeats itself over and over in the determination of:

- o distance
- o variable
- o value

for each point progressively down the scale.

Table #204 - Value Calculation

Rule Number	1	2	3	4
1 N: Value LR Max Range	Y	Y	N	N
2 UNITS EQ	"centigrade"	"fahrenheit"	"centigrade"	"fahrenheit"
3 Set Work A EQ N: Value	X	X	X	X
4 Set Work A EQ Temp. Conv.	X	.	X	.
5 DO COEFFICIENT SELECT	X	X	X	X
6 Set N: Variable EQ Poly	X	X	X	X
7 Set N: Distance EQ Dist Calc	X	X	X	X
8 Set N EQ + 1	X	X	.	.
9 Set N: Value EQ (N-1): value + increment	X	X	.	.
10 DO	204	204		
11 GO TO			Division Fill	Division Fill

Notes:		
1. Temp. Conv.	=	WORK A * 9/5 + 32
2. Polynomial	=	$C_0 + C_1$ * WORK A
		+ C_2 (WORK A ** 2)
		+ C_3 (WORK A ** 3)
3. Dist. Calc	=	Scale width * (N: Variable - Min. Variable) / (Max Variable - Min Variable).

Rule #2, the correct one for this table reads:

IF the number called VALUE is less than the maximum range (1100)

<u>and</u>

the units are measured in fahrenheit.

THEN Set the work field A (a computer term) equal to a number called VALUE (this makes the work field worth 100, since the first value is 100)

<u>and</u>

line 4 is not pertinent (as denoted by the mark :), since no temperature conversion is required.

<u>and</u>

DO the table COEFFICIENT SELECTION:

Table #205 - Coefficient Selection

Rule Number		1	2
1. Element	EQ	"Iron Const TC"	"Chromel Alum TC"
2. Set C_0	EQ	- .17285	-2.60614
3. Set C_1	EQ	.076045	.0258357
4. Set C_2	EQ	- .0000436	.000001
5. Set C_3	EQ	0.0	0.0

This table selects the correct coefficients for primary elements such as iron constantan, chromel aluminum, etc. Data already existed in tabular form relating temperature to millivolt output for each element, but it was necessary to convert the tables for automatic processing. This was accomplished by modifying an IBM 1620 curve fit program to permit generation of a millivolt output from a given temperature through a polynomial type formula. The table then calculates four coefficients for the formula which produces a millivolt output.

With the coefficient selected in line 5 of table #204, the reading continues:

> set the number called variable equal to the millivolt output (or set the millivolt output equal to the result of computing the polynomial formula in note 2) to calculate a millivolt output for that particular value (in this case, 100)
>
> <u>and</u>
>
> set the number called distance equal to the distance calculation in note 3

and

increment the number by one (to get to the next numeral)

and

set the number called value equal to the number minus one times the value plus the increment

and

repeat the table again until the maximum range is reached.

The Division File instruction covers related calculations for semi - major and minor scale divisions.

From the following printed output, manufacturing would know that numeral 101, for example, would be located on the scale 1. 138 inches from the scale starting point:

SCALE DESIGN
FOR GENERAL DESCRIPTION OF SCALE SEE DRG. SD-150

LEGEND A - DEG. CENT.
LEGEND B - MULTIPLY BY 10
LEGEND C - I-C TC TYPE J

DISTANCE	NUMERAL	LINE
0.0	100	MAJOR
.283		
.378		
.473		
.568		
.663		
.758		
.853		
.948		
1.043		
1.138	101	MAJOR
1.233		
1.328		
1.423		
1.518		
1.613		
1.708		
1.803		
1.898		
1.993		
2.088	102	MAJOR
2.183		
2.278		
2.373		
2.468		
2.563		~~SEMI-MAJOR~~
2.658		
2.753		
2.848		
2.943		
3.038	103	MAJOR
3.133		
3.228		
3.323		
3.418		
3.513		~~SEMI-MAJOR~~
3.608		
3.703		
3.798		
3.893		
3.988	104	MAJOR
4.083		
4.178		
4.273		
4.368		
4.463		~~SEMI-MAJOR~~
4.558		
4.653		
4.748		
4.843		
4.938	105	MAJOR

5.033		
5.128		
5.223		
5.318		
5.413		~~SEMI-MAJOR~~
5.508		
5.603		
5.698		
5.793		
5.888	106	MAJOR
5.983		
6.078		
6.173		
6.268		
6.363		~~SEMI-MAJOR~~
6.458		
6.553		
6.648		
6.743		
6.838	107	MAJOR
6.933		
7.028		
7.123		
7.218		
7.313		~~SEMI-MAJOR~~
7.408		
7.503		
7.598		
7.693		
7.788	108	MAJOR
7.883		
7.978		
8.073		
8.168		
8.263		~~SEMI-MAJOR~~
8.358		
8.453		
8.548		
8.643		
8.738	109	MAJOR
8.833		
8.928		
9.023		
9.118		
9.213		~~SEMI-MAJOR~~
9.308		
9.403		
9.498		
9.593		
9.688	110	MAJOR

USE PEN # 2 FOR LARGE DIGITS
USE GUIDE # CVN-375 FOR LARGE DIGITS

FOR LOCATION OF STARTING LINE , SIZE AND LOCATION OF NUMERALS AND LINES
SEE DRAWING INDICATED ABOVE.
SURFACE TO BE PREPARED IN ACCORDANCE WITH E.S.S. 3.1.5.37.
KEEP REVERSE SIDE FREE FROM SMUDGE OR PAINT. PACK EACH SCALE IN GLASSI
ENVELOPE WITH WHITE CARDBOARD PROTECTION ON LITHOGRAPHED SURFACE.

This display would replace drawing #SD-150 shown earlier, as an instruction to manufacturing.

GEAR SELECTION

The first table in the gear series selects shafts for the gear drive mechanism:

Table #1 - Chart Drive Shafts

Rule Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 Chart Drive TYPE Equals	STANDARD				INSCO RATIO				MP 4:1 RATIO				MP 4:1			
2 Main Chart Dr. Shaft Speed Equals	25 RPM	50	100	1000	25	50	100	1000	25	50	100	1000	25	50	100	1000
3 Set Dr. Shaft EQ R-802-AW	X	X	X		X	X	X		X	X	X	E	X	X	X	E
4 " " " " 059550				X				X								
5 Set. Horiz. Dr. Shaft EQ 059524	X	X	X	X									X	X	X	
6 " " " " 059560					X	X	X	X	X	X	X					
7 Set Counter Dr. Shaft EQ 059525	X	X	X	X	X	X	X	X	X	X	X		X	X	X	
8 Set Cluster Dr. Shft EQ 059526	X	X	X	X	X	X	X	X	X	X	X		X	X	X	
9 Set Vertical Dr. Shft EQ R-501-6	X	X	X	X	X	X	X		X	X	X		X	X	X	
10 " " " " " 059559								X								
11 Assemble Per Dwg RS-1802-139	X	X	X	X	X	X	X	X	X	X	X					
12 GO TO Table #	5	5	5	4	4	4	4	4	5	5	5		5	5	5	
13 Error												X				X

Table #1 is an example of "selection," with rule one being the proper choice for the customer specification. The Else rule (E) in columns 12 and 16 of the entry area is another tabular convention used to transfer control to an error table when none of the conditions of this table are satisfied.

The printed output for table #1:

```
TABLE # 1......CHART CRIVE TYPE SELECTICN
          CHT DR SHAFT                     R-802-AW
          HCRIZ DR SHAFT                   059524
          CCUNTER DR SHAFT                 059525
          CLUSTER DR SHAFT                 059526
          VERTICAL DR SHAFT                R-501-G
       ASSEMBLE PER CWG                    RS-1802-139
```

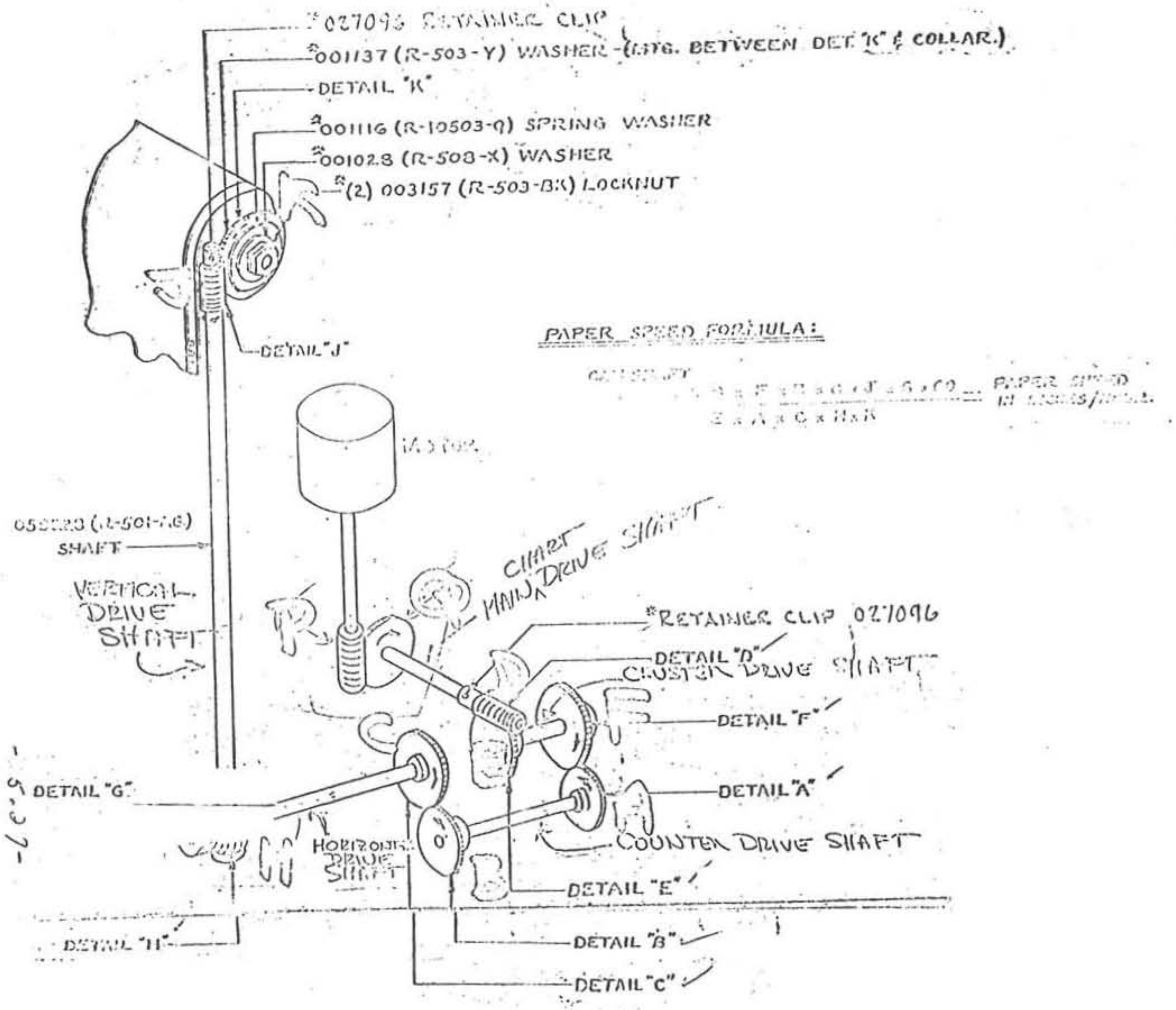
The assembly drawing is illustrated in figure 29.

Table #5 selects the variable parts for the speed changer, the first two conditions being specified by the customer, and the last by the sales engineer.

Action row line 14 demonstrates how a part quantity is handled in the table. Lines 16 and 17 reveal how limited and extended entry tables can be combined with the drawing number placed in the stub, while the suffix is listed in the entry.

The output appears as:

```
TABLE # 5..... SPEEC CHANGER SELECTION
          MAIN DR GEAR                     R-1802-148-1-A
          SPACER                        2# 00162
          SCREW                         2# 7/16-32 RHBCP
          WASHER                        2# #1208 SPLW
       ASSEMBLE PER DRAWING                RS-1802-148-SK-31A
```



SHOP NOTES:

1- PARTS MARKED WITH ⊕ ARE PART OF 124147 (SUPPLIED WITH SHOPWORK) & ARE MOUNTED PER ASSEMBLY DWG. 352556 (R-503-1).

2- TENSION OF [illegible] SET AS FOLLOWS: TENSION AT THE [illegible] AT THE OTHER [illegible] 2 TO 2½ LBS [illegible] REQUIRED TO SLIP CLUTCH, WITH [illegible] HELD.

3.- [illegible]

ENG. NOTES:

1- SKETCH NUMBER DESIGNATES PAPER SPEED IN INCHES PER HOUR. (E=EXACT, N=NOMINAL.)

6	[illegible]	[illegible]
5	[illegible]	[illegible]
4	[illegible]	A S0952
3	[illegible]	[illegible]
2	[illegible]	[illegible]
1	[illegible]	A [illegible]

PAPER SPEED
GEARING ARRANGEMENT
60,000 SERIES RECORDER

Figure 29

SHEET 1

Table #5 - Speed Changer Selection

Rule Number	1	2	3	4	5	6	7	8	9
1 Main Chart Drive Shft Speed EQ 25 RPM	Y	Y	Y	Y	N	N	N	N	E
2 50 RPM	N	N	N	N	Y	Y	N	N	
3 100 RPM	N	N	N	N	N	N	Y	Y	
4 Line Frequency EQ or 50 CPS	Y	Y	N	N	N	N	N	N	
5 60 CPS	N	N	Y	Y	Y	Y	Y	Y	
6 Auxiliary Shaft (RS-1804-7) is present	N	Y	N	Y	N	Y	N	Y	
7 Set Main Drive Gear EQ R-802-C_2			X	X					
8 " " " " " RS-1802-148A					X	X			
9 " " " " " RS-1802-148B							X	X	
10 " " " " " RS-1802-148-1-A	X	X							
11 Spacer is (2) 001626	X		X		X		X		
12 Position Pin is (2) STD 12638		X		X		X		X	
13 Screw is 3/8 8-32 RHBCP		2		2		2		2	
14 Screw is 7/16 8-32 RHBCP	2	1	2	1	2	1	2	1	
15 Washer is # 1208 SPLW	2	3	2	3	2	3	2	3	
16 Assemble Per Dwg RS-1802-148-SK			1A	1B	2A	2B	3A	3B	
17 " " " RS-1802-148-1-SK	1A	1B							
18 GO TO Table 40	X	X	X	X	X	X	X	X	
19 Speed Changer error									X

Table #40 is a value list of fixed parts for the speed changer, complementing the variable list outlined in the previous table. When the two tables are combined, a complete speed changer material list or bill of materials becomes available to manufacturing.

The value list is then printed to show:

TABLE # 40 PARTS FCR SPEED CHANGERS

ANTI-CLICK CEVICE	R-206-Y
SHAFT BUSHING	R-502-C
ACTLATOR ASSEMBLY	161011
SPUR GEAR	9-3-3-1
THRUST BALL BEARING	8-4-3-1
GEAR - PLATE ASSEMBLY	R-802-CP
BALL BEARING	8-1-3-1
BEARING SPACER	44-4-1-1
SLEEVE	R-802-CM
CLUTCH	R-802-CK
SCREW	1 4-40FHBCRB
SHAFT PIN	5-2-3-4
THRUST WASHER	R-505-N
SHAFT COLLAR	R-66-N
SET SCREW	1/2 IN 10-32 SOC. SET SCREW CUP POINT

ASSEMBLE PER DWGS RS-1802-148 ANC RS-1802-148-1

The final table in the gear series (#10) is a look-up table for selecting gears to go on the shaft in accordance with the main chart drive speed.

Table #40 - Speed Changer Parts

1	Anti Click Device	R-206-Y	X
2	Shaft Bushing (2)	R-502-C	X
3	Actuator Assembly	161011	X
4	SPUR Gear	9-3-3-1	X
5	Thrust Ball Bearing	8-4-3-1	X
6	Gear & Plate Assembly	R-802-CP	X
7	Ball Bearing	8-1-3-1	X
8	Bearing Spacer	44-4-1-1	X
9	Sleeve	R-802-CM	X
10	Clutch	R-802-CK	X
11	Screw	1" 4-40 F. H. B.	X
12	Shaft Pin	5-2-3-4	X
13	Thrust Washer	R-505-N	X
14	Shaft Collar	R-66-N	X
15	Set Screw	1/8" 10-32 SOC Set Screw Cup	X
16	Assemble per Dwg	RS-1802-148 & 1802-148-1	X
7	GO TO Table 10		X

Table #10 - Gear Look up

Rule Number	1	2	3	4
1 Main Chart Drive Speed EQ	25 RPM	50 RPM	100 RPM	1000 RPM
2 Set Chart Speed EQ	Chart spd	Chart spd/2	Chart spd/4	Chart spd/40
3 Look up Chart Speed in Generated Gear Table	X	X	X	X
4 Print Drive Gears	X	X	X	X
5 Assemble per DWG RS-1802-139 SK1	X	X	X	X
6 GO TO Table 11	X	X	X	X

Previous tables were of the regenerative type; i. e., only the logic is stored in the computer and data is regenerated as required. This table emphasizes that file reference, too, is a valid storage method in systems design. The table could have been structured around a formula which would regenerate a series of gears from a given chart speed. Actually, it was constructed by first compiling a list of all possible gear combinations for all chart speeds (1410), then reducing it to some 350 practical and logical combinations. The result was filed for reference as gear sets are required to maintain a given chart speed.

A typical printout from this table would be:

```
TABLE # 10 ....CHART PAPER SPEEC GEARING SELECTION
       A GEAR IS  9362
       B GEAR IS  9365
       C GEAR IS  9345
       D GEAR IS  9362
       E GEAR IS  9314
       F GEAR IS  9316
       G GEAR IS  9374
       H GEAR IS  9356
       J GEAR IS  9325
       K GEAR IS  9314
       P GEAR IS  9345
       Q GEAR IS  9356
       ASSEMBLE PER DWG # RS-1802-139-SK1
```

SUMMARY

These 13 decision tables are representative of the variety of situations encountered in an ADE system. Complete systems will include hundreds of similar tables, each linked to the others to permit a continuous and integrated processing of data in which product characteristics are generated automatically from customer specifications.

The decision table is not the only form of documentation a study team can use, but it does demonstrate certain advantages in analysis, documentation, and man - to - man communication.

Regardless of the documentation format, the main theme of ADE systems design is the identification of a unique design logic, and the implementation of this logic into an operating engineering system which is far more effective and efficient than those in existance today.