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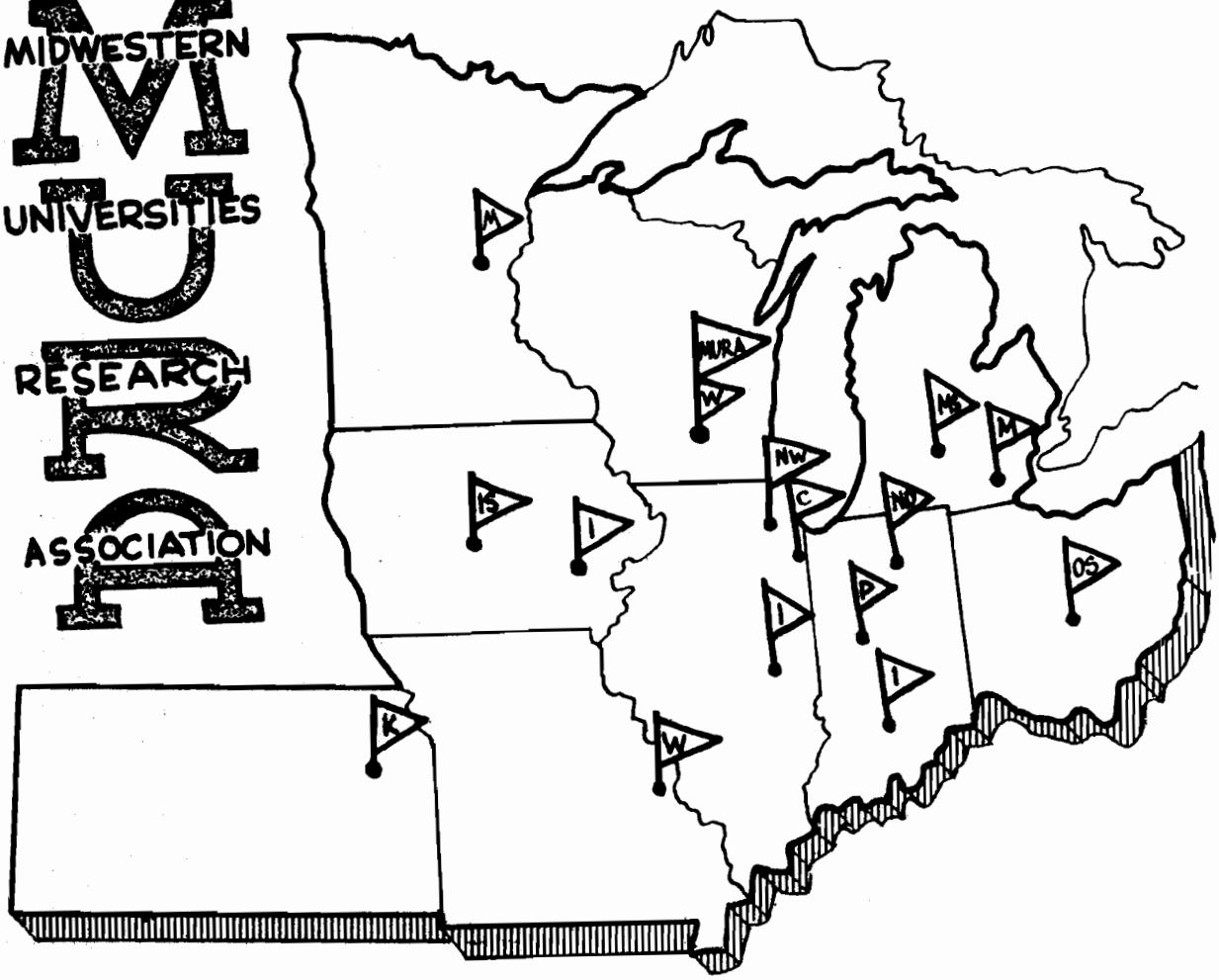

REPORT

COILFINDER
March 21, 1962

NUMBER 636

Computer Program
(Internal)

COILFINDER

George Bush

PURPOSE

This is a program designed to remove some of the drudgery associated with coil design. That is, it will perform all pertinent calculations needed, but will not do any optimizing. Given ampere turns, slot and pole dimensions, insulation and clearance allowances, water temperature, headloss range, and conductor and hole size ranges, this program will increment conductor width, conductor height, and hole diameters, calculating for each incremental change the resultant pancake size (turns), number of pancakes that can be fitted, total turns of this configuration, current required, current density, pancake dissipation, total dissipation, total copper weight, flow rate required to carry this power away, and finally the headloss required to achieve this flow rate. This final headloss is then checked and if it is within the pre-specified limits, it and all above quantities are printed out and the next incremental value of conductor and hole configurations are selected and this process is repeated again.

ACCURACY

The accuracy of this program can be considered to be that of the computer, or approximately seven digits for all quantities except the final one headloss, which cannot be considered to be more than 10%. There are two sources of error in this calculation, a minor one resulting from approximations used in calculating total pancake length, and a major one due to the approximations used in calculating headloss per foot. Minor wall imperfections and other deviations make agreement of theoretically and empirically derived headloss at best to within 10%.

The specific method used to determine headloss was the evaluation of engineering table D.D. #10, U.C.R.L. 3687.

METHOD

Some calculations are made as the various input parameters are being incremented. These are quantities that need calculating only once, or only when a parameter is changed and consequently are not in the inner loop with the main calculations. There are four of these preliminary calculations, they are;

Average Length per turn = 2(Pole Length & Pole Width + 2 Slot Width)

Conductor Area = (Wire Width x Wire Height) - Hole Area

$$\text{Turns per Pancake} = \frac{\text{Slot Width} - (2 \times \text{Clearance})}{\text{Wire Width} + \text{Turn to Turn Insulation}}$$

$$\text{Layers} = \frac{\text{Slot Depth}}{(\text{Wire Height} + \text{Layer to Layer Insulation}}$$

In the inner loop, with all parameters properly incremented, and the above quantities pre-calculated the program then continues on and makes the following main calculations.

Total Turns = Turns per Pancake x Layers

Pancake Length = Length per Turn x Turns

$$\text{Current} = \frac{\text{Ampere Turns}}{\text{Turns}}$$

$$\text{Current Density} = \frac{\text{Current}}{\text{Conductor Area}}$$

Power per Pancake = Pancake Length x Current x Current Density x Restivity of Conductor

$$\text{Flowrate} = \frac{.0038 \times \text{Power per Pancake}}{\text{Water Temperature Rise}}$$

$$\text{Headloss per ft. (turb.)} = \frac{\text{Flowrate}}{.00105 \times (10 \times \text{Diam. of Hole})^{4.105}}$$

$$\text{Headloss per ft. (Lam.)} = \left(\frac{\text{Flowrate}}{.0074 \times (10 \times \text{Diam. of Hole})^{2.601}}\right)^{1.87266}$$

Headloss per Coil = Headloss per ft. (lam. or turb. whichever is greater) x (Pancake length + 2 x Turns per Pan)

After which the calculated Headloss per Coil is compared with the headloss limits set on input and if it falls within these limits, then the following quantities are also calculated.

Total Power Dissipated = Power per Pancake x Layers

Total Conductor Weight = Conductor Area x Pancake Length x Layers x Conductor Density

And all results are printed out.

INPUT

A standard agendum sheet is included on p.6. The first card is read in with the name of run as a standard Hollerith field FORTRAN input, and must be included, even if no run name is desired. After this the rest of the input data is read in with the standard MURCD2 input subroutine. All the restrictions as to format, signing of numbers, exponentiation, and magnitude that apply to MURCD2 apply to COILFINDER agenda. Briefly these are;

1. Decimal points omitted only if understood to follow the rightmost digit.
2. Factors may not contain more than 8 digits.
3. Exponents may not contain more than 2 digits.
4. Exponents may be omitted if zero, if not they must be signed.

Since most of the parameters entered probably will be small in magnitude, the agendum sheet is set up for non-exponentiated numbers. Numbers with exponents can also be entered for any parameter if so desired.

The limits indicated on the agendum sheet are mainly of two types, one imposed by the printout format, and the other imposed by logic of looping and the range of the calculations. The limits imposed on the

first ten parameters are due to printout format limitations and these can be exceeded if necessary if the consequent loss of accuracy due to rounding-off of printout can be tolerated. Exceeding the stated limits on the rest of the parameters will probably result in the program ignoring the run and going on to the next run, but in some cases could cause a miscalculation.

Most input parameters are self-explanitory, but some might be sligtly confusing or ambigious. A description of these parameters follows. Slot Length refers to the azimuthal dimension of the slot across the pole face. Pole Width refers to the radial width of the pole enclosed by the coil being calculated. Clearance is the clearance from coil to slot face, on either side of the coil. No clearance is allowed at bottom of coil because of the possiblity of additional coils at the bottom of the slot. The submittor must consider all of these problems himself and subtract these special clearance limitations from the real slot depth and submit this figure for Slot Depth. No allowance is made in the calculations for change in conductor restivity due to heating of the coil, so this effect must be considered when the submittor specifies the Water Temperature Rise and Conductor Restivity for that expected temperature. The Increment parameter sets the looping indices for Conductor Height, Conductor Width and Hole Diameter.

SUCCESSIVE RUNS

Successive runs may be entered if separated by End Data cards. Parameters are remembered and unchanged from run to run and only those parameters that change need be re-entered. This can be accomplished by completely filling out one coilfinder agendum sheet and stapling to this sheet additional sheets, one per run with changed parameters marked. The use of the name card on successive runs is optional, except that where it is omitted, a blank card must be substituted.

OPERATION

1. No sense switches used.
2. Output on tape #9, no others used.
3. Place program deck in card reader.
4. Place data decks on top, each deck followed by an END DATA card, with three END DATA cards last.
5. Press clear, then LOAD CARDS.
6. Program will stop on HPR 0 at location 4061_8 (MURCD2 normal END OF DATA stop).

OUTPUT

The non-incremented input parameters are first printed out and then the column headings and units for the inner-loop calculation results are printed. Next any incremented quantity is printed whenever it is changed, and finally the inner loop calculation results are printed. There are four lines of these results corresponding to the four coil combinations. The first is a coil with one layer removed and the remaining layers with one turn removed. Secondly, a full number of layers of one turn removed from each layer. Thirdly, one less layer and full number of turns, and finally the results for the full coil. This was done to help the submitter evaluate the proper coil configuration incorporating correction coil space allowances. Successive runs will start on fresh pages if new run names are also entered.

COILFINDER AGENDUM SHEET

(Program F-68)

Instructions:

Enter all parameters for first run and then only enter parameters that change for successive runs. Put all successive runs on separate COILFINDER agendum sheets Name of run should be 52 characters maximum. Decimal points may be omitted only if understood to follow the rightmost digit. Eight digits maximum permitted. No sense switches used, output on tape #9.

NAME OF RUN (Coil Designation, etc.) 1 _____

Parameter	Limit	Address	Value	Units
Ampere Turns	>0 to $<10^{10}$	1		Amps.
Slot Width (radial)	>0 to $<10^{5}$	2		Inches
Slot Length (Azimuthal)	>0 to $<10^{5}$	3		Inches
Slot Depth	>0 to $<10^{5}$	4		Inches
Pole Width (radial)	>0 to $<10^{5}$	5		Inches
Turn-to-Turn Insulation	0 to $<10^{3}$	6		Inches
Layer-to-Layer Insulation	0 to $<10^{3}$	7		Inches
Clearance	0 to $<10^{3}$	8		Inches
Conductor Resistivity	>0 to <10	9		μOhm - $\frac{in^2}{ft}$
Conductor Density	>0 to $<10^{2}$	10		lbs/in^3
Water Temperature Rise	>0 to $<10^{-4}$	11		Deg. C.
Conductor Height (Max.)	Slot Depth	12		Inches
Conductor Height (Min.)	Twice Increment	13		Inches
Conductor Width (Max.)	Slot Width	14		Inches
Conductor Width (Min.)	Twice Increment	15		Inches
Hole Diameter (Max.)	Conductor Height or width	16		Inches
Hole Diameter (Min.)	Increment	17		Inches
Head Loss (Max.)	1000	18		lbs/in^2
Head Loss (Min.)	0	19		lbs/in^2
Increment	1,.1,.01, etc.	20		Inches
Program will halt on HPR 0 at 40618				END DATA