Depot

PRE-HEATING OF A BISMUTH COOLED PILE.

August 12, 1942

Since the melting point of bismuth is around 270°C, it is obvious that the operating pile must be brought to a temperature of around 300°C before any power can be taken from it. We calculate in this report the quantity of nichrome wire which would be needed in order to radiate 2000 kw of energy at a temperature of 800°C.

The amount of energy radiated per sec, q, equals $\sigma T^4 = 8.3$ watts per cm^2 for T = 1100° absolute. ($\sigma = 5.7 \times 10^{-5}$ ergs/cm^2/degree^4/sec.) Thus, in order to radiate 2000 kw, we require an area of $\frac{2 \times 10^6}{8.3} = 0.24 \times 10^6$ cm^2. If we take nichrome wire of 2 mm diameter, circumference is approximately 0.6 cm, and the length of wire required is then $\frac{.24}{0.6} = 0.4 \times 10^6$ cm, or 4000 m. Since the x-sectional area of this wire is 0.03 cm^2, the volume of 4000 m would be 12 liters, and for a density of 8 this gives a weight of 96 kg.

If we have 4000 m in which to radiate 2000 kg we must radiate 500 watts/m, and since the resistivity of nichrome is 100 micro ohm--cm, one meter of 2 mm wire has a resistance of 1/3 of an ohm and will thus require a current of 40 amperes. If we divided nichrome wire into 6 m lengths, the voltage required is 2 x 40 = 80 volts.

Thus, what one might do, would be to construct a steel frame around the top and bottom of the pile and string the nichrome wire from one frame to another around the pile, applying 80 volts across the frame. Since we have 4000 m of wire and it is divided into 6 m lengths, the total number of lengths of wire is about 670, and spreading it around the length of 24 m gives a distance of 3.6 cm between wires.

Time to heat pile to a temp of 300°C by putting in 2000 kW $\leq$ 15 hrs.

however: from Strong:

$q = k T^m$ and for Nichrome $k = 1.8 \times 10^{-5}$

$m = 4.1$

so $q = 1.8 \times (1100)^4 (1100)^{0.1} = 5.3$ watts/cm^2

this is 1.6x worse than the above and gives a wt

of 154 kg

The temperature can probably be raised to

1000°C. This, now gives a factor of

$\left(\frac{1.3}{1.1}\right)^{4.1} = 1.99$ in our favor

and requires a weight of 78 kg