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POWER CONSUMPTION OF SMALL BELTS AT LOW TEMPERATURES

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ABSTRACT

A description is given of two series of tests conducted over a temperature range of -30°C to + 20°C: (a) tests of four different belts at a single speed, (b) tests of one belt at three different speeds. The results show that the most serious factor in belt power consumption at low temperatures is high-speed operation. Furthermore, a motor with high starting torque is absolutely essential for low-temperature operation.

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PURPOSE

This series of tests was initiated as a result of the failure of a piece of belt-driven equipment to operate satisfactorily at -30°C. It was evident that a considerable amount of power was being absorbed by the belt itself and that knowledge of this power absorption would be valuable in future work. The original test was run using an "A" section V-Belt, but the scope of the experiment was later extended to include various types of belts at three different motor speeds.

EXPERIMENTAL PROCEDURE

The tests were run in a small cold chamber using dry-ice vapour and a thermostatically-controlled blower and valve to regulate the temperature. In all tests two pulleys of the same pitch diameter ($2\frac{3}{4}$" approximately) were used, one mounted on the motor shaft and one on a ball-bearing-mounted idler shaft. An a-c wattmeter was used for power measurement. The power absorbed by the motor and idler shaft only, was determined by coupling the shaft directly to the motor and taking readings over the full temperature range. Power consumption for a given belt running over a single pulley may then be found by subtracting the "idler shaft and motor" power from the "belt and pulley" power and dividing the answer by two.

The first series of tests was carried out using a 400-cycle 6000-rpm 110-volt $\frac{1}{2}$-hp induction motor, since it was felt that the high speed would represent a good upper limit for most applications. Four different types of belts were tested over the full temperature range -30°C to + 20°C, readings being taken at 5-degree intervals:

1) "A" section V-Belt
2) 3/8" V-Belt
3) 1/4" Rubber O-Ring
4) Timing Belt (rated 3/4 hp).

The results of this series of tests are shown in graphical form (Fig. 1), but it is necessary to explain exactly what the plotted values represent. The equipment was left to "soak" overnight. In the case of the two larger belts, the motor failed to start owing to its low starting torque. In addition to this, the belt was "moulded" to the pulley contour. After being turned over a few times by hand the motor finally succeeded in coming up to speed, but even then the starting load was in the neighbourhood of 1000 watts. As soon as full speed was reached the power dropped suddenly to about one-third of its peak value and then fell slowly to a fixed point some 30% lower again. The reason for this slow fall was that the energy input to the belt heated it to the point at which energy input equalled dissipation losses; after this the meter reading remained constant. Following each reading, the motor was shut off and the temperature was raised 5°. The equipment was allowed to soak at the new temperature for half an hour before the next reading was taken.

The motor was not run continuously for two reasons:

a) The cold chamber was incapable of handling the energy input.
b) The energy input to the belt itself would have heated it to a temperature well above that of the cold chamber, thus giving false readings.

Taking everything into consideration, it was felt that the most suitable wattage value for plotting purposes was that which occurred just before the last slow fall. This is the value which appears in the graphs.

Two other tests were run, both with the 3/8" V-Belt — the first at 3600 rpm and the second at 1800 rpm. The results thus obtained are shown in Fig. 2., together with the original curve obtained with the 3/8" V-Belt at 6000 rpm.

CONCLUSIONS

It is evident from the above that belt losses are caused by four factors:

1) small pulley diameter,
2) high-speed operation,
3) low ambient temperature,
4) heavy belt sections.

Under normal conditions the loss may be negligible (10-20 watts), but under adverse conditions it may run as high as 140 watts for a 3/8" V-Belt running on a single pulley of $2\frac{3}{4}$" diameter. It should be remembered that this is for the belt alone and does not include the motor or the bearings on which the pulley is mounted.

One observation of major significance was that after the equipment had been left to soak overnight at -30°C, the 6000-rpm motor was incapable of starting until it had been turned over several times by hand. It is therefore emphasized that unless the belt is readily accessible for manual operation, the starting characteristics of a motor to be used at low temperatures are of prime importance.

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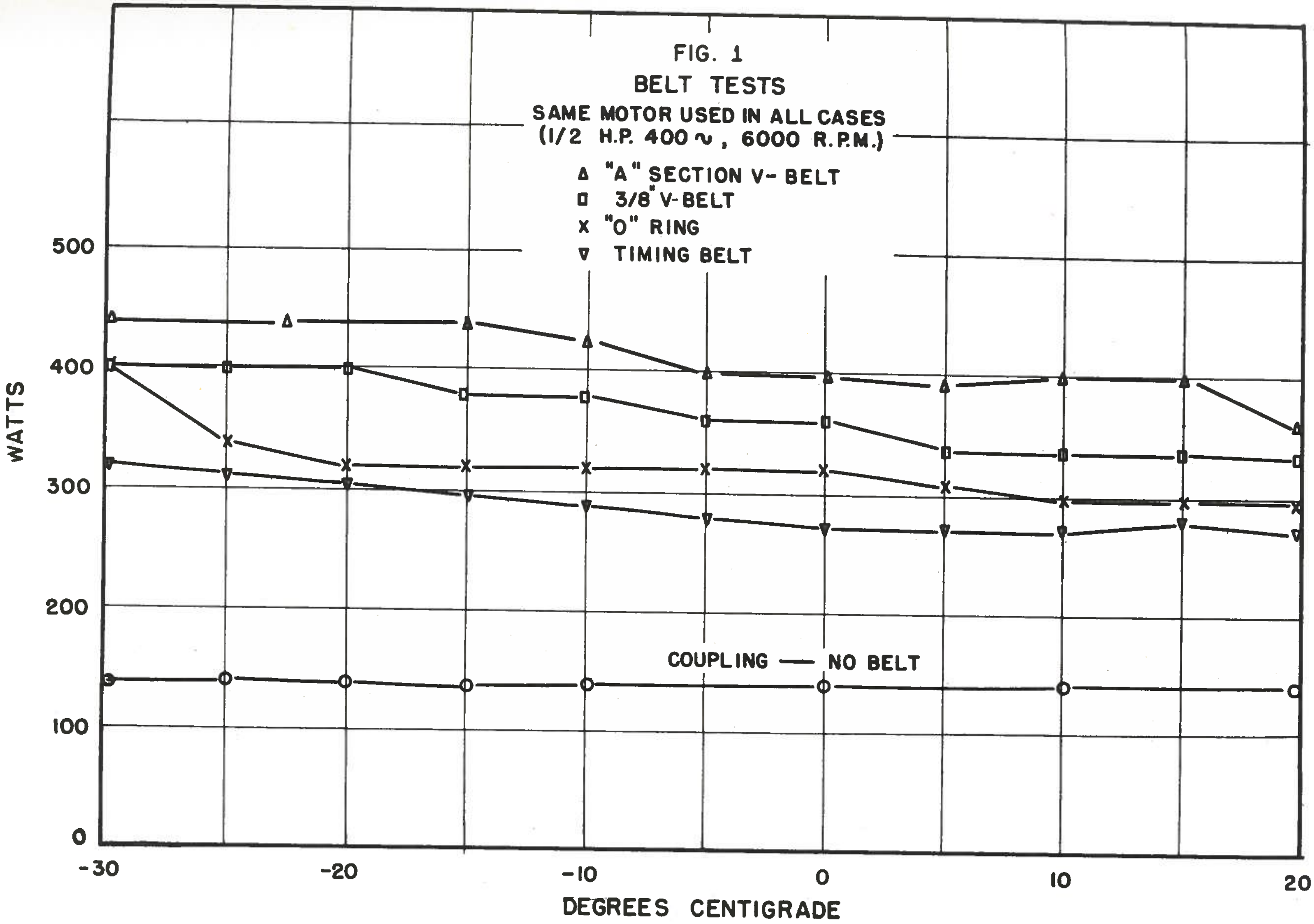
FIG. 1
BELT TESTS
SAME MOTOR USED IN ALL CASES
(1/2 H.P. 400 ∿ , 6000 R.P.M.)
Δ "A" SECTION V- BELT
□ 3/8" V-BELT
X "O" RING
▽ TIMING BELT
COUPLING — NO BELT
WATTS
0
100
200
300
400
500
-30
-20
-10
0
10
20
DEGREES CENTIGRADE

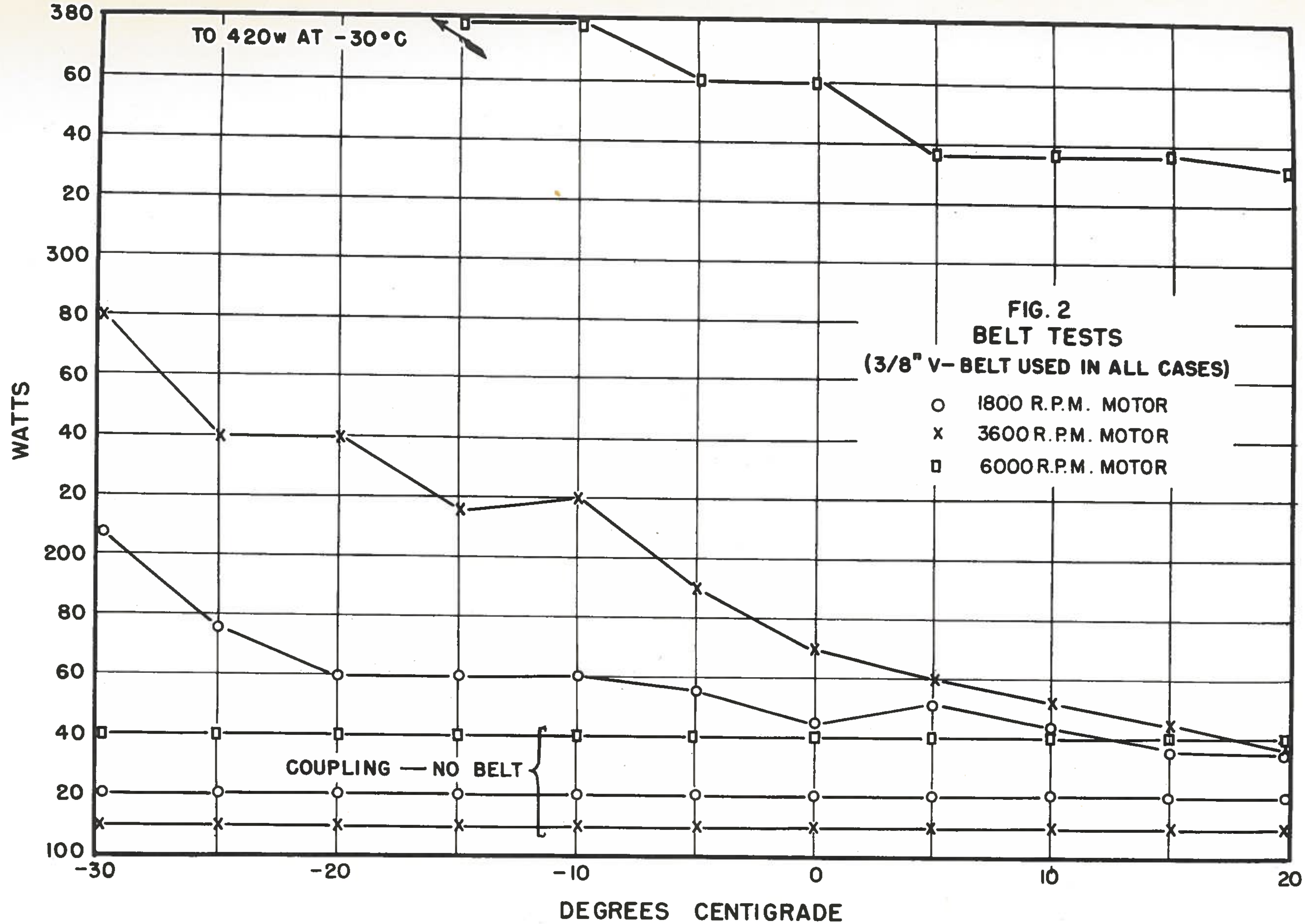

FIG. 2
BELT TESTS