

PATENT SPECIFICATION

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1338 610

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DRAWINGS ATTACHED

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(54) SERIES OF GEAR SPEED REDUCERS

(71) We, S. A. HANSEN TRANSMISSIONS INTERNATIONAL N. V. formerly known as Machinery and Gears Hansen, Société Anonyme, a body corporate organized and existing under the laws of Belgium, of Boerenlegerstraat, 2520 Edegem, (Antwerp—Belgium), do hereby declare the invention for which we pray that a patent may be granted to us, and the process by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a set of gear speed reducers.

According to the invention there is provided a set of gear speed reducers each comprising an input gear, an output gear and at least one intermediate gear intercoupling said input and output gears, the distance centres of the output gear and the gear meshing gears considered from the input to the output gear, the distances between the centres of the output gear and the gear meshing therewith in the set of speed reducers forming a progression of which the r^{th} term is defined as

$$a_r = a_{r-1} \times h_r \times p^{(r-2)} \quad (1)$$

wherein a_{r-1} is the preceding term and h_r and p are constants.

An embodiment of the invention is described hereafter, with reference to the accompanying drawings, in which:

figures 1 to 3 are schematic front views of three successive reducers in a set of speed reducers according to the present invention; and

figure 4 shows a table giving the selection of centre distances in the reducers of the set.

Definitions

The centre distance a of a pair of meshing gears is the distance between the axes of rotation of the gears of said pair.

The facewidth b of a pair of meshing gears

[Price 25p]

is defined as the narrowest effective toothed width of the meshing pinion and gear at the pitch circle.

The characteristic torque T of a speed reducer is the maximum permissible output torque of the reducer, for 8 hours continuous running per day under steady load conditions.

The horsepower rating of a reducer is defined as the product of its characteristic torque and its output speed.

The specific centre distance of a speed reducer in a set according to this invention is the largest of its centre distances and it determines the characteristic torque of the reducer.

In a set of gear speed reducers according to the present invention, each reducer comprises an input gear 10; 10a; 10b, . . . , an output gear 11; 11a; 11b, . . . intermeshed by intermediate gears 12, 12a, 12b . . . The centre distances between intermeshing gears are indicated as: a_{00} , . . . , a_1 , a_2 , a_3 , a_4 , . . . and such distances in each reducer increase from the input to the output gears.

The specific centre distances a_1 , a_2 , a_3 , a_4 , . . . in a set of speed reducers increase according to a progression of which the r^{th} term is defined as

$$a_r = a_{r-1} \times h_{r-1} \quad (2) \quad 75$$

where a_{r-1} is the preceding term and the value of h is given by

$$h_r = h_1 \times p^{r-1} \quad (3)$$

where h_1 and p are constants.

Combining (2) and (3):

$$a_r = a_{r-1} \times h_1 \times p^{r-2} \quad (1)$$

and

$$a_r = a_1 \times h_1^{r-1} \times p^{\frac{(r-1)(r-2)}{2}} \quad (4)$$

The face width b of a meshing gear pair is

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preferably a function of the centre distance a of that particular pair, what the reduction ratio. This is expressed by the relationship

$$b = K_1 \times a^e \quad (5)$$

- 5 in which K_1 and e are constants. A suitable value for e has been found to be 0.9 and for K_1 , 0.58 if a and b are expressed in millimetres.

- 10 The characteristic torque T , calculated according to A.G.M.A. (American Gear Manufacturers Association) may be expressed by the relationship

$$T = K_2 \times a^{1.98} \times b^{0.9} \quad (6)$$

- 15 in which K_2 is a coefficient which is a function of material properties and reduction ratio.

Taking into account (5)

$$T = K_3 \times a^{2.77} \quad (7)$$

- 20 as it appears from the given equations (5) and (6)

$$K_3 = K_2 \times K_1^{0.9} \quad (8)$$

- 25 In the following calculation of the characteristic torques the same reduction ratio and material of the gears for all specific centre distances is supposed. As a result K_3 has the same value for all specific centre distances. The series of characteristic torques T is

$$T_r = T_{r-1} \times k_{r-1} \quad (9)$$

the value k is given by

- 30 $k_r = k_1 \times q^{r-1} \quad (10)$

Comparing (9) and (2) and taking into account (7) we find:

$$k_r = k_r^{2.77} \quad (11)$$

From (10), (3) and (11):

- 35 $q = p^{2.77} \quad (12)$

Combining (9) and (10), the value of any one characteristic torque T_r can be written

$$T_r = T_1 k_1^{r-1} \times q^{\frac{(r-1)(r-2)}{2}} \quad (13)$$

- 40 The characteristic torque T_n of the last unit in the set is

$$T_n = T_1 \times k_1^{n-1} \times q^{\frac{(n-1)(n-2)}{2}} \quad (14)$$

and

$$q = \sqrt[n-1]{\frac{T_n}{T_1 \times k_1^{n-1}}} \quad (15)$$

From (10)

$$q = \sqrt[n-1]{\frac{k_{n-1}}{k_1}} \quad (16)$$

whereas (15) and (16) allow to write

$$k_1 k_{n-1} = \sqrt[n-1]{\frac{T_n}{T_1}} \quad (17)$$

In practice, the values of T_1 , T_n , k_1 , k_{n-1} are chosen before hand, in function of the requirements to be met by the contemplated set of speed reducers. 50

The value of n is then calculated from (17). As this last formula will usually give a fractional number, the nearest full number is chosen and k_{n-1} is readjusted accordingly. 55

A particularly interesting set of speed reducers is obtained when choosing $T_1 = 90$ mkg. (7.800 in lbs), $T_n = 7000$ mkg (610.000 in lbs), $k_1 = 2$, $k_{n-1} = 1.3$.

The number n of units in the set is then 10 and the exact value of k_{n-1} is 1.316. 60

Equation (15) gives

$$q = \sqrt[36]{\frac{T_{10}}{T_1 \times 2^9}} \quad (18)$$

The values of the other parameters may be calculated by the equations given above. 65

In a set according to this invention, the centre distances—other than the specific centre distances—between pairs of meshing gears in any reducer of the set except the first are chosen from those used in smaller reducers of the set. A suitable choice is illustrated in figure 4 of the accompanying drawings. The horsepower ratings of said pairs of meshing gears are chosen to be substantially equal. 70 75

The input shafts of the units of a set can be the shaft of a motor. The output shafts of the units may be hollow.

WHAT WE CLAIM IS:—

1. A set of gear speed reducers, each com- 80

preferably a function of the centre distance a of that particular pair, what the reduction ratio. This is expressed by the relationship

$$b = K_1 \times a^e \quad (5)$$

- 5 in which K_1 and e are constants. A suitable value for e has been found to be 0.9 and for K_1 , 0.58 if a and b are expressed in millimetres.

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the value k is given by

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and

$$q = \frac{\frac{(n-1)(n-2)}{2}}{\frac{T_n}{T_1 \times k_1^{n-1}}} \quad (15)$$

From (10)

$$q = \sqrt[n-2]{\frac{k_{n-1}}{k_1}} \quad (16)$$

whereas (15) and (16) allow to write

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The input shafts of the units of a set can be the shaft of a motor. The output shafts of the units may be hollow. 75

WHAT WE CLAIM IS:—

1. A set of gear speed reducers, each com- 80



prising an input gear, an output gear and at least one intermediate gear intercoupling said output gears, the distance between the centres of the successive meshing gears considered from the input to the output gear increasing from the input to the output gear, the distances between the centres of the output gear and the gear meshing therewith in the set of speed reducers forming a progression of which the r^{th} term is defined as

$$a_r = a_{r-1} \times h_1 \times p^{(r-2)} \quad (1)$$

wherein a_{r-1} is the preceding term and h_1 and p are constants.

2. A set of gear speed reducers according to claim 1, in which the face width b of any pair of meshing gears is obtained by the relationship

$$b = K_1 a^{0.9}$$

in which K_1 is a constant and a represents the centre distance between the pair of meshing gears.

3. A set of gear speed reducers, as claimed in any one of the preceding claims, in which the characteristic torque as herein defined of the smallest reducer in the set equals 90 mkg (7,800 in lbs) and the characteristic torque of the largest reducer in the set equals 7000 mkg (610,000 in lbs).

4. A set of gear speed reducers, as claimed in claim 3, in which, for a set of 10 reducers, the relationship between the characteristic torque T_r as herein defined of any one reducer in the set and the characteristic torque T_{r-1} of the preceding reducer in the set, is obtained by one of the terms of a progression defined by

$$T_r = T_{r-1} \times k_1 \times q^{r-2}$$

of which the constant q is

$$q = \sqrt[36]{\frac{T_{10}}{T_1 \times 2^9}}$$

T_1 and T_{10} being respectively the first and the last characteristic torque, the ratio k_1 of the second to the first characteristic torque being equal to 2 and the ratio of the last characteristic torque to the penultimate characteristic torque being approximately equal to 1.3.

5. A set of gear speed reducers as claimed in claim 1, in which the centre distances, other than the specific centre distances as herein defined, between pairs of meshing gears in any reducer of the set except the first reducer in the set are chosen from those used in smaller reducers in the set, in such a way that the horsepower ratings, as herein defined, of said pairs of meshing gears are substantially equal.

6. A set of gear speed reducers as claimed in any one of the preceding claims, in which the input shaft of at least one unit is a shaft of a motor.

7. A set of gear speed reducers as claimed in any preceding claim in which the output shaft of at least one of the reducers in the set is hollow.

8. A set of gear speed reducers, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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