MILITARY TECHNICAL COLLEGE

CAIRO - EGYPT

NOISE OF GEARS OF DOUBLE CIRCULAR-ARC TOOTH-PROFILE

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ABSTRACT

The paper embodies the results of an experimental investigation carried out to study noise of a relatively new type of gearing of double circular-arc tooth- profile. More than 300 magnetic tape recordings were taken and analysed, for gears 4 mm module running at different speeds and loads in a direct drive gear test rig installed in free field. Experimental results revealed that the largest single frequency component is double the tooth contact frequency and that patterns of the generalised generated noise are uniform in all directions. Generally, as either speed or load increases, overall noise levels increase from 95 dB at speed 400 r.p.m. and load =15kp to 115 dB at speed 2250 r.p.m. and load= 40kp.

INTRODUCTION

Gears are widly used in machinary in a large variety of sizes and over a wide range of speeds and loads. Quieter gears are always needed and their maximum sound levels should comply with the values recommended by the national standards. Many investigators 1-6 have studied the sources of gear noise and its propagation and means of its reduction. They nearly agreed that the main source of gear noise is errors in action caused by manufacturing inaccuracies, deformations of gears, shafts and attached masses together with the torsional vibrations of the geared system. In this investigation, noise of gears of circural-arc tooth-profile is studied.

TEST RIG AND MEASURING EQUIPMENT

Gear noise ismeasured in a direct power transmission test rig shown diagramatically in Fig. 1. It is composed of two shafts each is supported on two roller bearings and carries one of the

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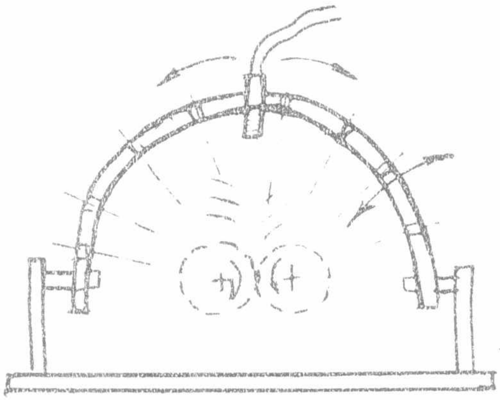

Fig. 2. Microphone carrier.

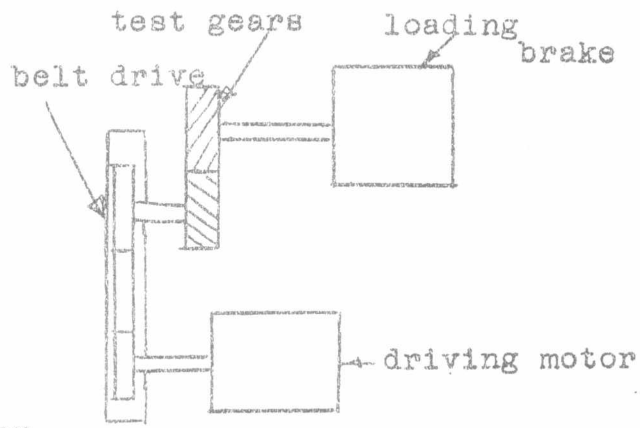

Fig. 1. Layout of test rig.

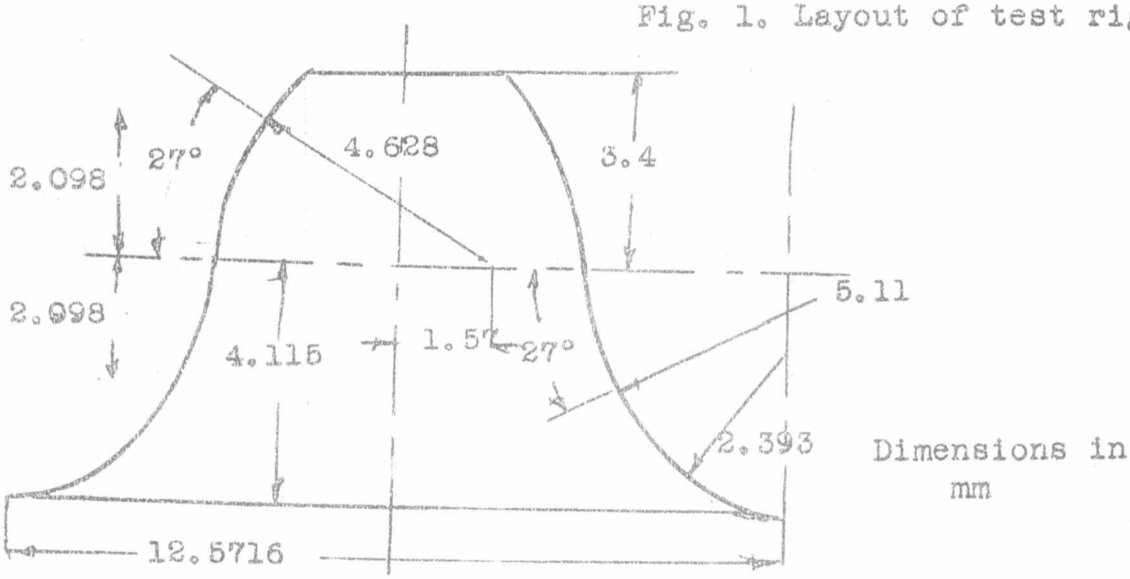

Fig. 4. Profile of test gear tooth.

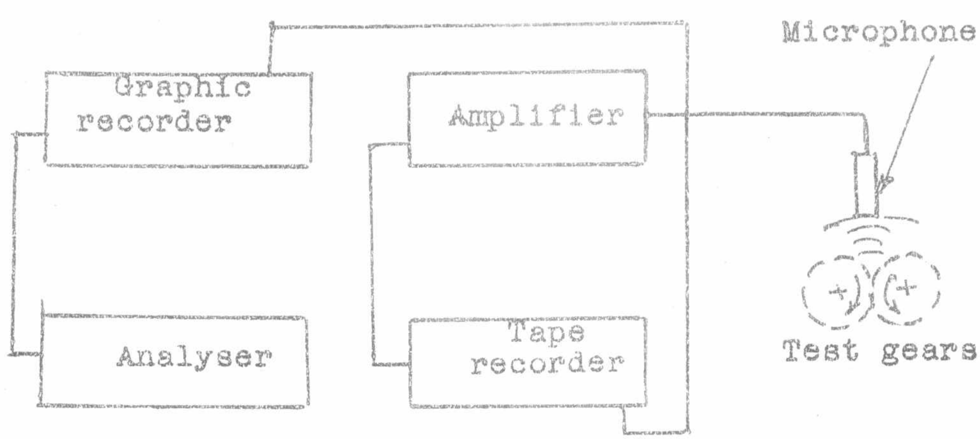

Fig. 3. Measuring circuit.

the test gears. The test rig is driven by 12.5 HP-2900 r.p.m. induction motor. The test gears are loaded by 33 KW-5000 r.p.m. electric brake, and calibrated on a differential balance to indicate load with accuracy ± ½% . Test gear noise is picked by a microphone placed on a carrier shown diagramatically in Fig.2. The microphone could be placed in grooves in the carrier placed at 30° apart around the test gears. The carrier with the microphone could be angularly displaced thus enabling noise measurements to be recorded at any point on a spherical surface with the point of contact as its centre.

Noise is measured by ½ in. B and K condenser microphone cartridge type 4165 mounted to microphone preamplifier type2619 of attenuation smaller than 0.03db. Noise is amplified by audio frequency amplifier type 2069 with frequency response 20 Hz to 20 KHz ± 0.05 db. Test gear noise is recorded by tape recorder type 7003 and analyzed by 1/3 octave and octave band bypass filter type 1618. Noise level is displayed on graphic level recorder type 2307 with frequency range from 2Hz to 100 KHz. Fig.3 shows the electric connections of the measuring circuit.

TEST GEARS

Test gears are of a relatively new type of helical tooth composed of concave and convex form of the profile shown in Fig. 4. Contact occurs consecutively at two points on the addendum and dedendum of the tooth. Under load the points become ellipses sweeping the tooth facewidth and trace two lines parallel to the helix direction.

The test gears are 4 mm normal module, 27° pressure angle, 28.5° helix angle, 20 teeth and 30 mm facewidth. For purpose of comparison between noise of double circular- arc gears and involute helical gears, all tests are repeated on a pair of involute helical gears of the same parameters. All test gears are made of CSN 14220 steel.

EXPERIMENTAL PROCEDURE AND RESULTS

Noise is recorded when test gears are running under different tooth loads ranging from 15 to 105 kp and at different speeds ranging from 400 to 2250 r.p.m. Overall noise levels were displayed on strip charts from the graphic level recorder connected to the tape recorder . Records were then analysed through the 1/3 octave band bypass filter on the graphic level recorder. Calibrations were performed before and after each test by a pistonphone type 4220-124 dB. The same experiments were repeated to record and analyze noise of involute helical gears running at the same speeds and transmitting the same loads. Fig.5 shows a sample of these records of overall noise level spectrum when the gears were running at 2250 r.p.m. and 15 kp tooth load. Fig.6 shows the 1/3 octave analysis of the same spectrum which reveals that the main noise generation harmonic is of double that of the tooth contact frequency.

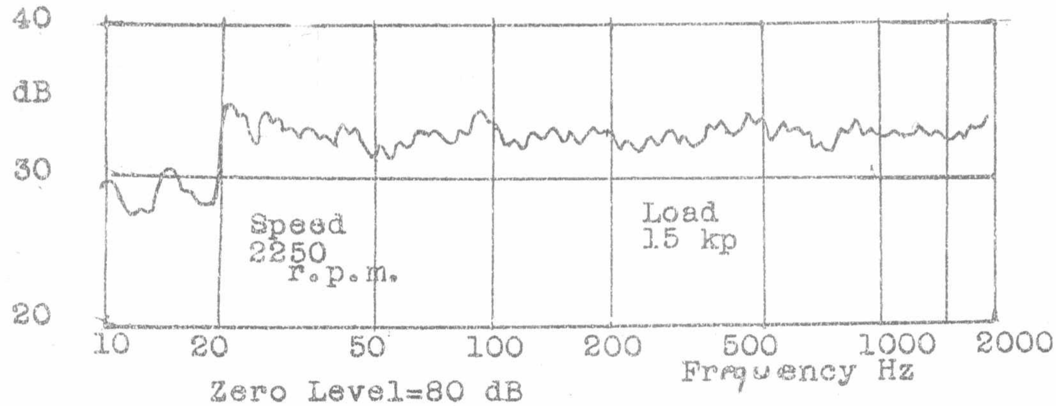

Fig. 5. Overall noise level spectrum.

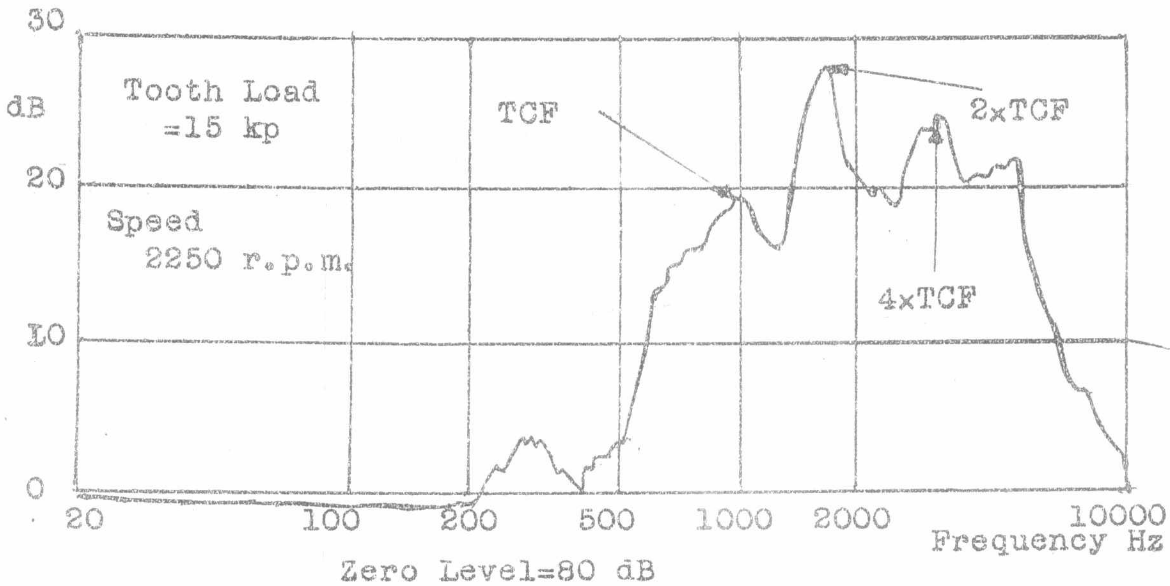

Fig. 6. 1/3 Octave analysis.

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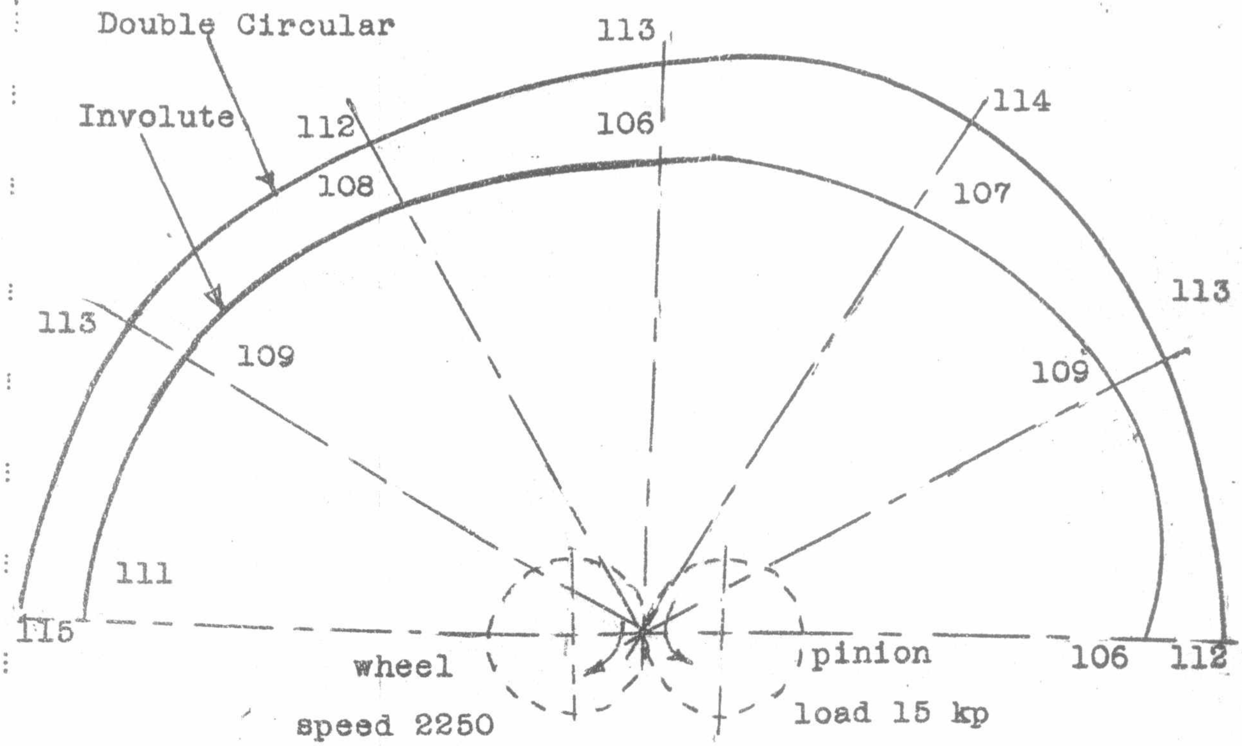

Fig. 7. Overall noise patterns in transverse plane.

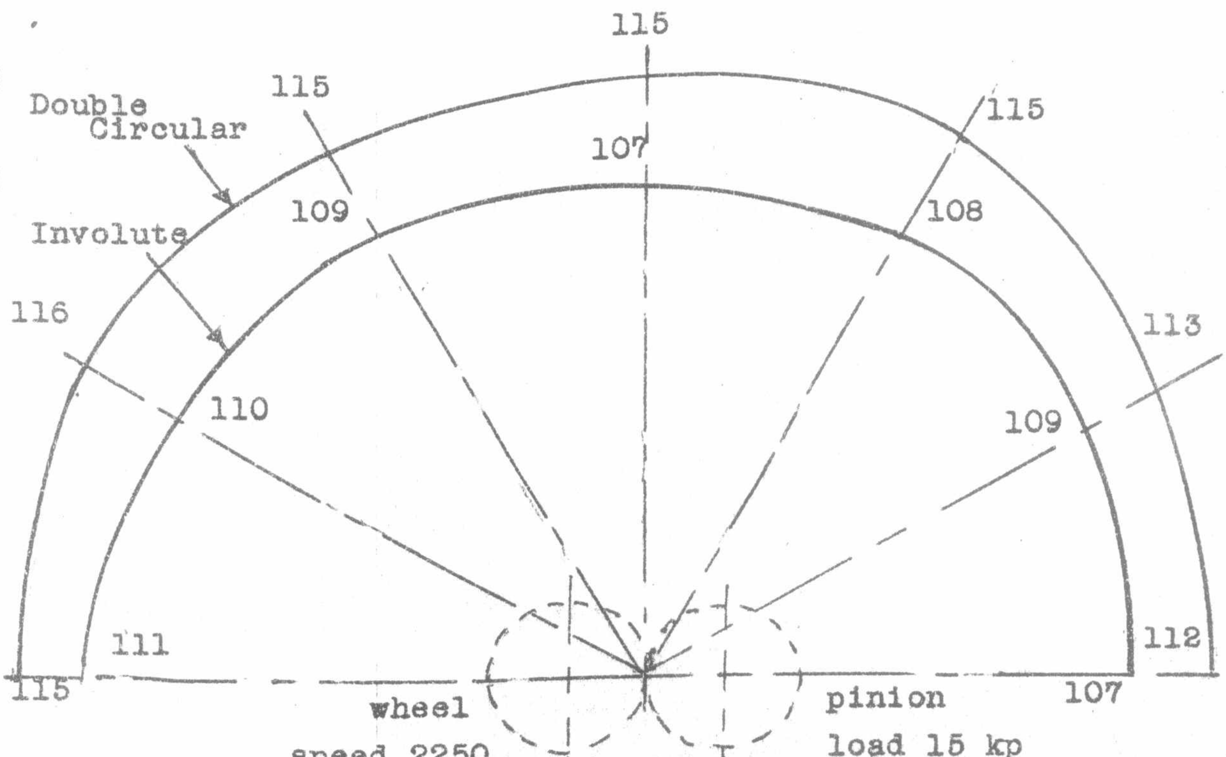

Fig. 8. Overall noise patterns in a plane inclined -30° to transverse plane

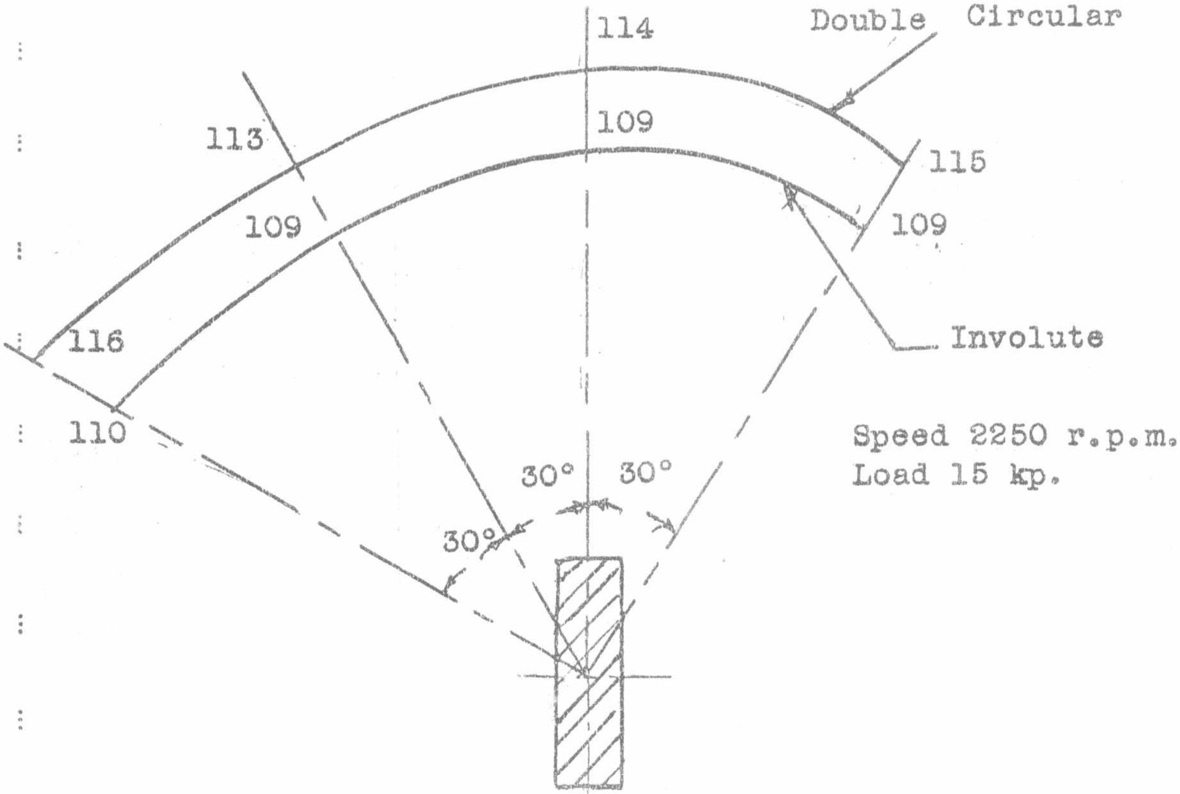

Fig. 9. Side distribution of noise around driving gears.

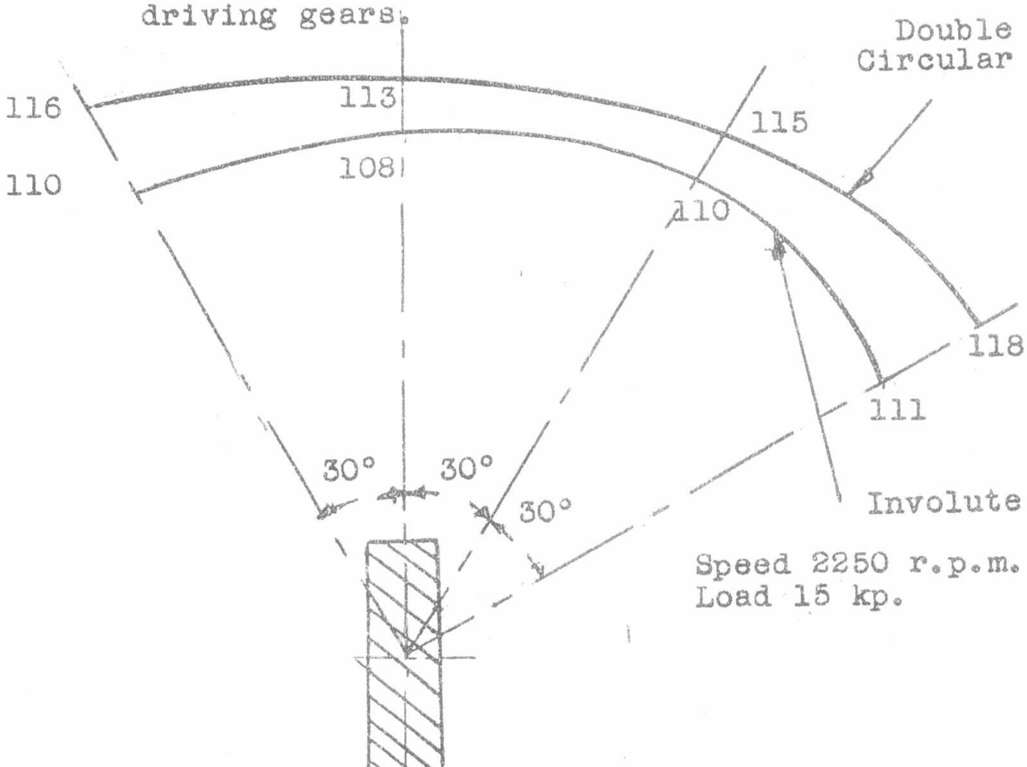

Fig. 10. Side distribution of noise around driven gears.

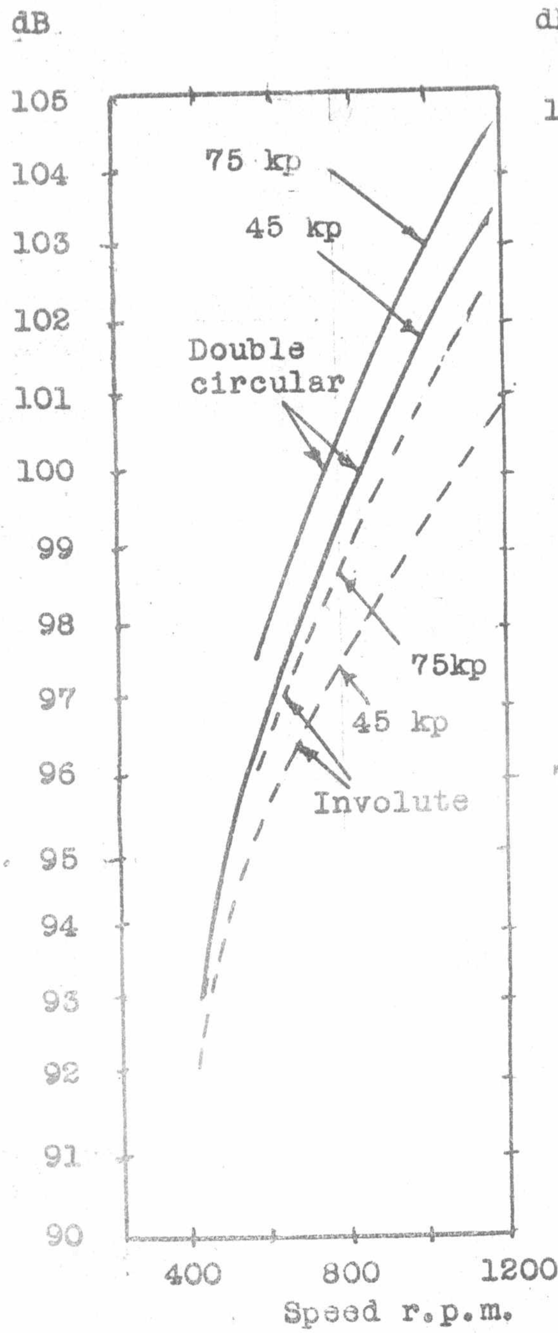

Fig.11 Change of overall noise level with speed at different loads.

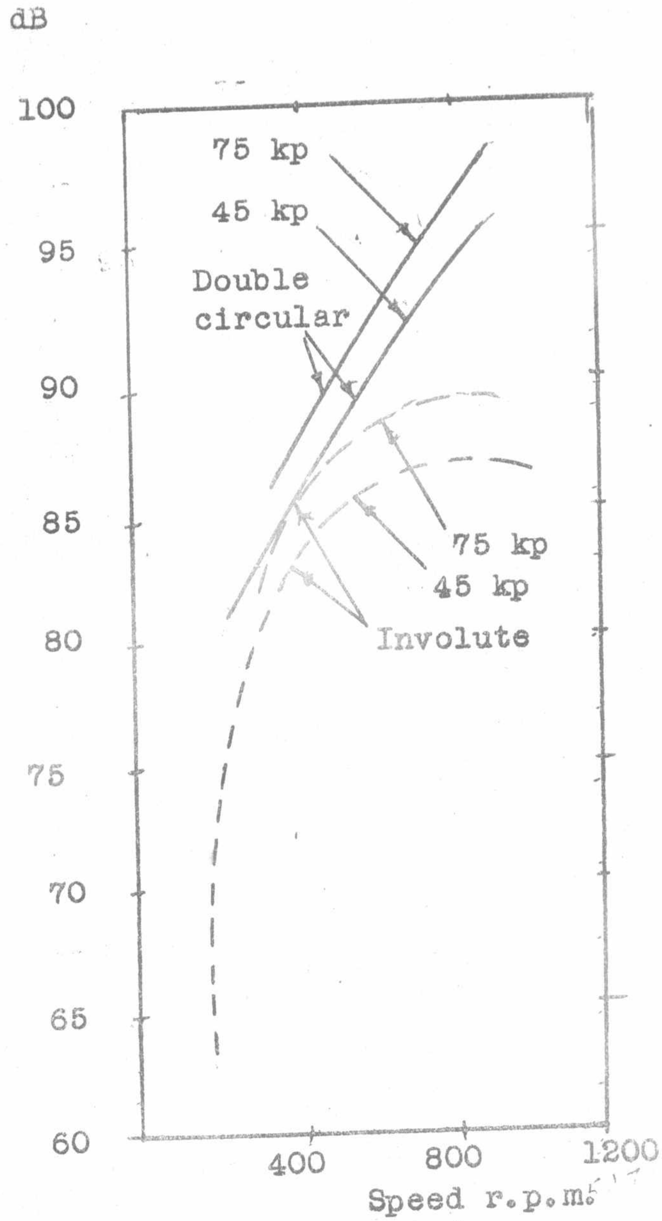

Fig.12. Change of noise level of largest single frequency component with speed at different loads.

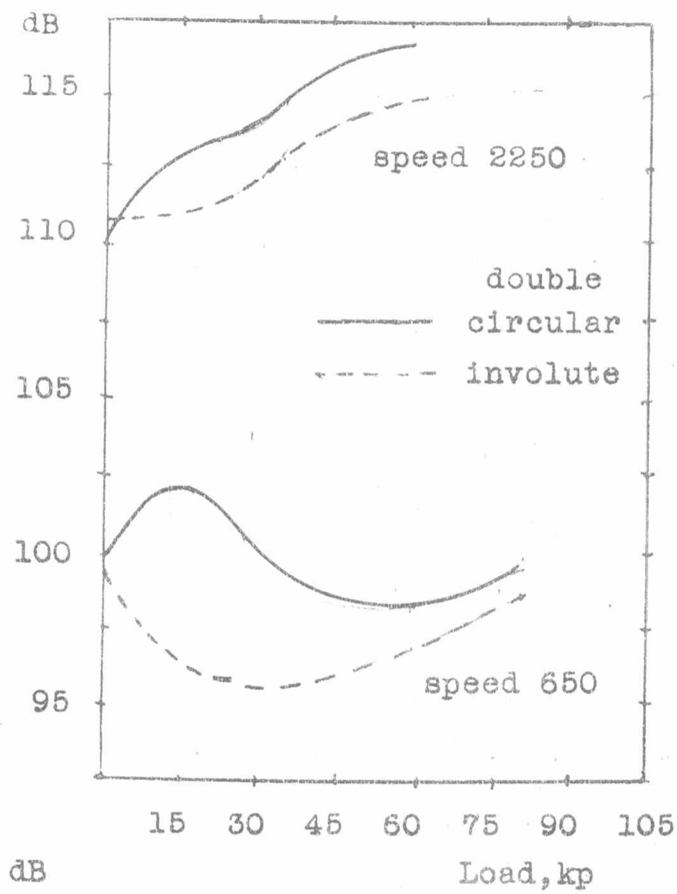

Fig. 13. Change of overall noise level with load at speed=650 and2250 r.p.m.

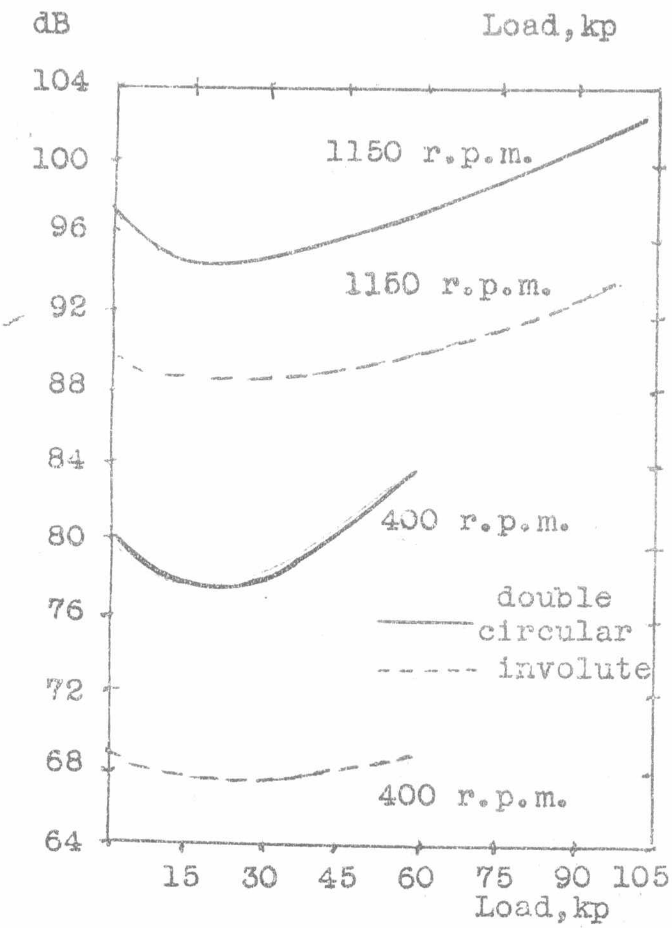

Fig. 14. Change of noise level of largest single frequency component with load at speeds 400 and 1150 r.p.m.

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Fig.7. shows the overall noise patterns around the double circular arc and involute helical test gears at speed 2250 and load 15 kp in the transverse plane. Fig.8. shows these patterns in a plane inclined 30° to the transverse plane. Fig.9 and Fig. 10 show the side distribution of overall noise level around driving and driven gears respectively at speed 2250 r.p.m. and load 15 kp. Fig. 11 and Fig. 12 show the changes of overall noise level and the largest frequency component respectively with speed at loads 45 kp and 75 kp. Fig. 13 and 14 show these changes with load at speeds 400 and 1150 r.p.m.

CONCLUSIONS

1. The noise main frequency harmonic is double the tooth contact frequency for double circular-arc gears and the tooth contact frequency for involute helical gears.
2. Noise of double circular arc gears is generally 6 to 8 dB higher than the corresponding noise of involute helical gears of the same parameters and running conditions.
3. Recorded space noise patterns show uniform noise distribution which should be considered in the design of gearbox cover.
4. Noise of test gears increases at higher rate with increase of speed than with increase of load tending to reach a maximum value.

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