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NEW METHOD FOR THE MANUFACTURE OF HIGH PRESSURE HOLLOW VESSELS

By Schierenbeck

I. Multi-layered Method of the Firm Smith in America

A number of these sheets 6 - 7 mm in thickness are wound around a thin core, so that the sum of the layers equals the required thickness.

The sheets are cylindrically rolled and pushed over the previously prepared core tube, abutted and the butt joints electrically welded. The connection between the multi-layered jacket and the flanges, or the body and the head pieces is done with electrically welded circular beads.

Multi-layered vessels can be used, however, only for less important requirements, because alloy steels must be used in hydrogenation and similar purposes, and it is very difficult to weld and requires many costly after treatments.

II. Proposals of Large German Firms

Three offers made by Large German firms present executions which differ but little from the original Smith process.

Four other large German firms shrink or roll upon each other cylinderical sheets into different thicknesses and shapes which must be welded together to the required length of the jacket out of several lengths.

The connection between the jacket and the flange is again produced in all of these proposals by means of electrical circular beads. These processes are all so complicated and expensive as not to come into consideration. There are principally two experimental vessels which have been ordered for execution. From December 1927 and until today all seven firms have made altogether only two small experimental vessels, while Leuna has itself made a 500 li multi-layered vessel and put it in operation as a catchpot.

III. High Pressure Wickel Process of Dr. Schierenbeck

In this process small, profile steel bands are bound upon a core tube with grooves which are wound with a pitch corresponding to the width of the bands in multi-layers and without welding at about 800°C. The bands of the different layers are displaced for about 1/3 or less of the width of the band against each other to have the butts of the individual layers covered by the bands of the layers above them, and they are locked with keys. The flanges are shrunk upon the jackets so prepared either in the same way as in a forged construction with solid wall bodies or else are wound by individual layers in exactly the same way as the jacket.

So far, around fifty smaller vessels up to about 200 mm inside diameter and up to 2 m in length have been made and about twenty large containers up to 800 mm clear inside diameter and 12 m long. Several of the larger Wickel vessels have already been placed in operation or else are being constructed. The greatest number of the so prepared containers were pressure tested to bursting, with an exact determination of the axial and tangential elongations. The results showed:

1. The locking obtained with the profile bands is so outstanding that the actual strength of the Wickel bodies met all requirements.

2. It is possible to increase the axial strength of the Wickel bodies up to the solid body vessels by a displacement of the bands by less than 1/3 the width of the band.

3. TheWickel vessels stand considerably higher pressures than the solid wall vessels of equal wall thickness and of the same material, because of the annealing of the bands during the winding as well as because the elasticity of the layers result in a uniform distribution of stress over the whole cross section

4. Advantages resulting from the elasticity of the Wickel vessels increase with the cross section ratio $d_{outside} : d_{inside}$ and amount to 18 percent with a ratio $d_o : d_i = 1.4$, and with an annealing to 38 - 45 percent. As a result the Wickel vessels can be made thinner in the future.

5. The contact of the bands is so good that the heat conduction coefficient of the Wickel vessels is 80 - 90 percent of the solid wall vessels.

6. In spite of the good contact the winding is permeable to gases so that no openings for de-gasing are required.

7. Rolling and winding of the band material makes it so uniform that a perfectly homogeneous structure can be guaranteed in all parts of the Wickel vessels.

8. The use of the Wickel process permits a considerable saving of chromium and molybdenum, so that only the core tube must be made from a high alloy steel.

9. The use of the Wickel lathe developed in Oppau makes the Wickel process so simple that only three operators are required, and the time of manufacture is only about 1/5 of that required for the manufacture of solid body vessels.

10. As a result of 9, Wickel bodies of the same wall thickness cost 20 - 30 percent less than solid wall vessels.

11. The manufacture may be divided into the preparation of the core tubes, rolling of the bands and the actual winding. The processes of manufacture can be carried out side by side and may also be done by different firms.

12. When the core tubes are welded, which can be done readily because of the small thicknesses of the wall, the cover alone remains as a single forged piece. As a result the large forging presses costing as much as 2,000,000 marks and more can be omitted.

13. The required Wickel lathes can be made over with a small effort from old lathes so that the conversion offers no difficulties and means of production are correspondingly suitable for wider uses.

14. There is a very great loss during the preparation of the solid wall vessels, because of the necessity of starting with the 3-fold weight of the finished goods; on the other hand the waste in Wickel vessel is entirely insignificant. This permits the manufacture of Wickel vessels with lighter cranes and other installations, or with the same installation considerably larger vessels can be manufactured than could be done in the past. There even is presented the possibility of making the Wickel vessels at the plant site, and their size is not limited by the transportation requirements. The individual steps are shown in the photographs of a Wickel lathe and of the winding itself with the aid of a short colored movie.

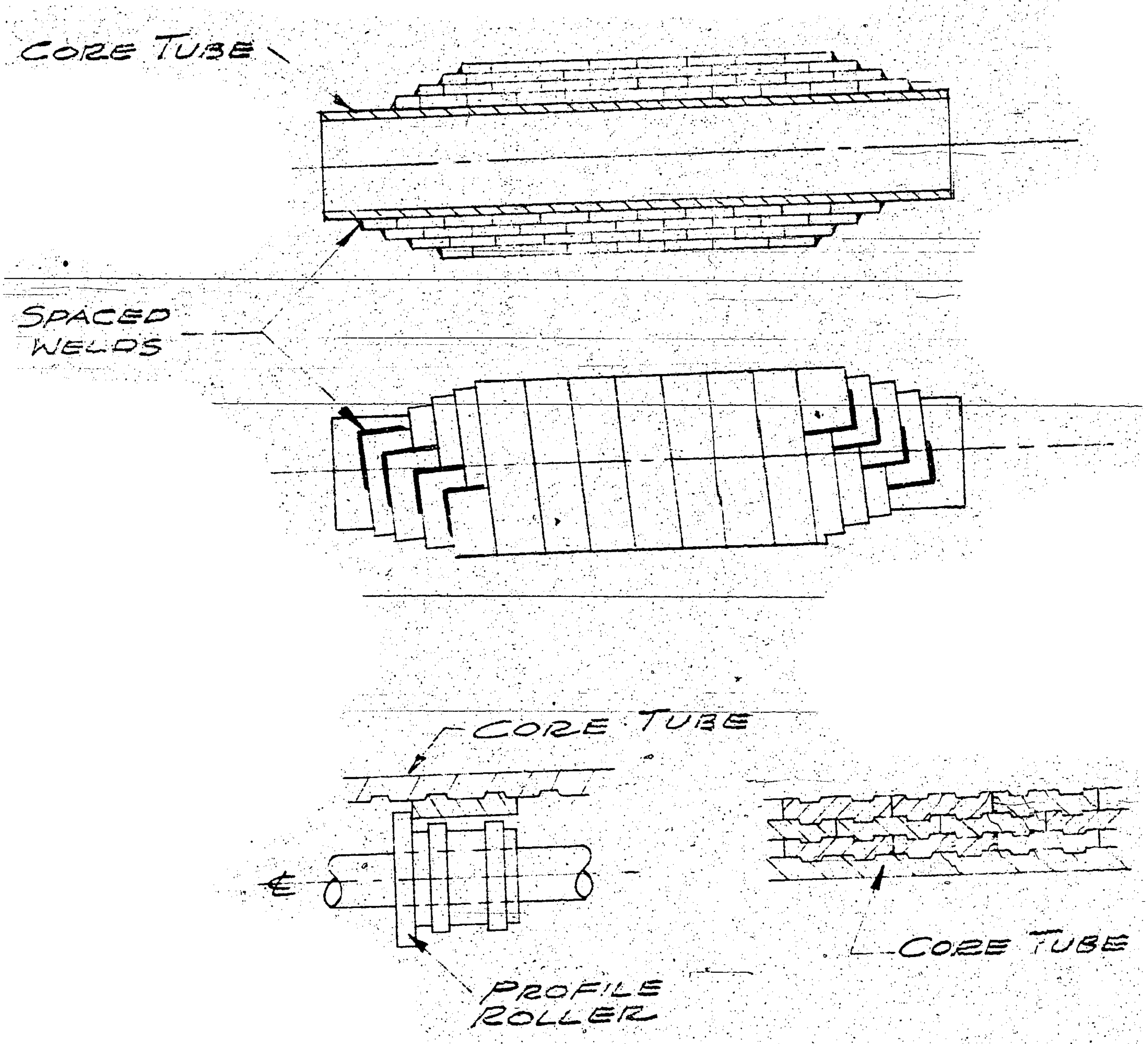
Krupp has converted two heavy lathes to conform with the Oppau Wickel lathe and this firm is now in position to manufacture Wickel vessels up to 2-1/2 m in diameter and 20 m in length. The vereinigten Stahlwereke also intended the manufacture of Wickel vessels on four lathes.

$$g = \frac{\text{bursting pressure of Wickel body}}{\text{bursting pressure of solid body}}$$

$$g = \frac{2\sigma \, 2 \, \frac{u - 1}{u + 1}}{\sigma \frac{1}{1.73} \times \frac{u^2 - 1}{u^2}} = 3.46 \left(\frac{u}{u + 1}\right)^2$$

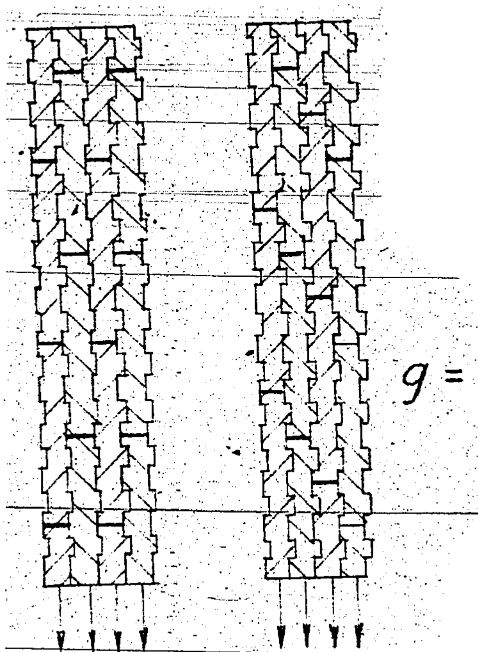
$$s = \frac{d_o - d_i}{2} = \frac{u - 1}{2} \times d_i$$

Ratio of Diameters $u = d_o : d_i$	Quality Factor g		Thickness of walls s
	g	g in %	
1.1	abt .1	0	0.05 d_i
1.2	1.03	3	0.1 "
1.3	1.11	11	0.15 "
1.4	1.18	18	0.2 "
1.5	1.25	25	0.25 "
1.6	1.31	31	0.3 "
1.7	1.37	37	0.35 "
1.8	1.43	43	0.4 "
1.9	1.49	49	0.45 "
2.0	1.54	54	0.5 "



SCHEMATIC PRESENTATION OF EXPERIMENTAL VESSEL

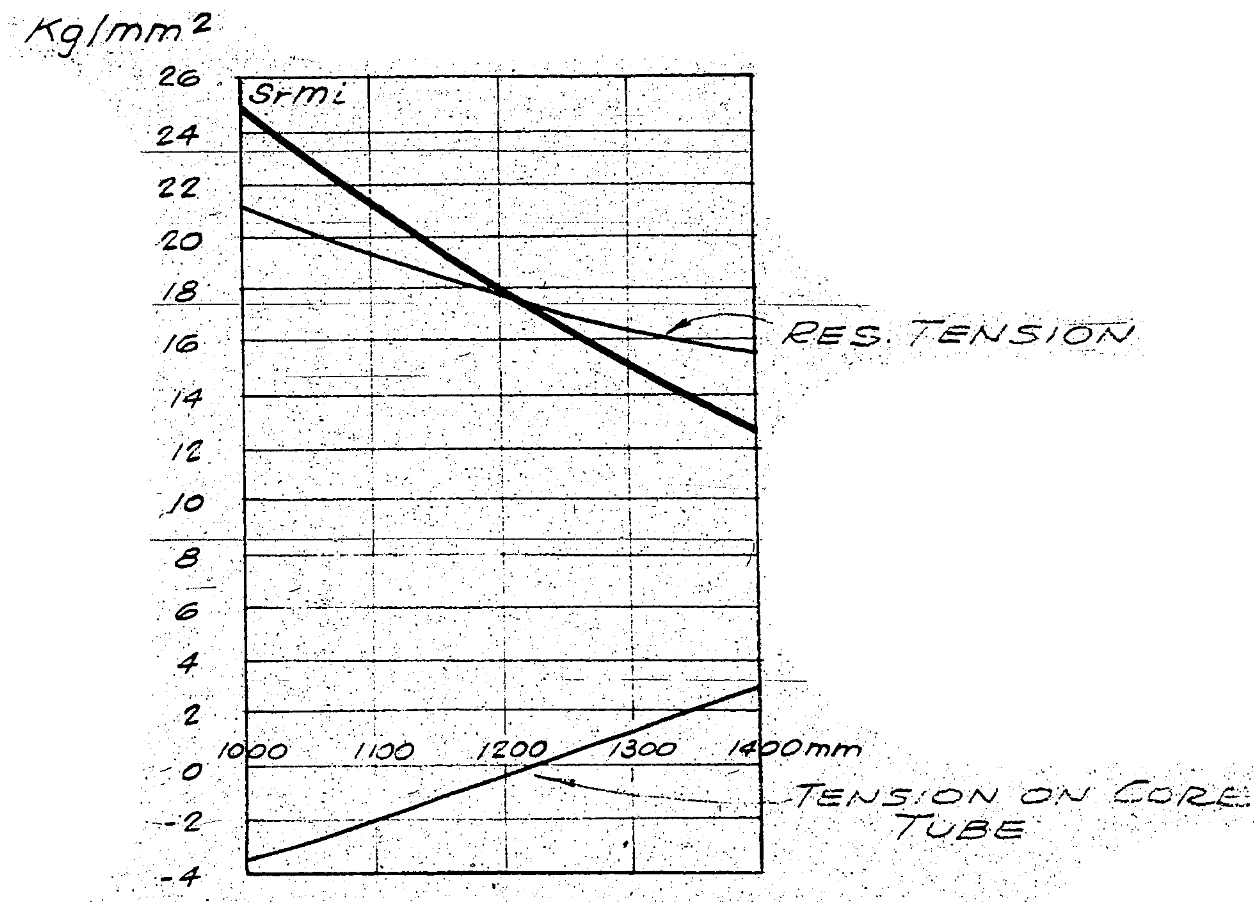
FIG. 4



$$g = \frac{\text{EFFECTIVE ACTUAL CROSS SECTION}}{\text{TOTAL ACTUAL CROSS SECTION}}$$

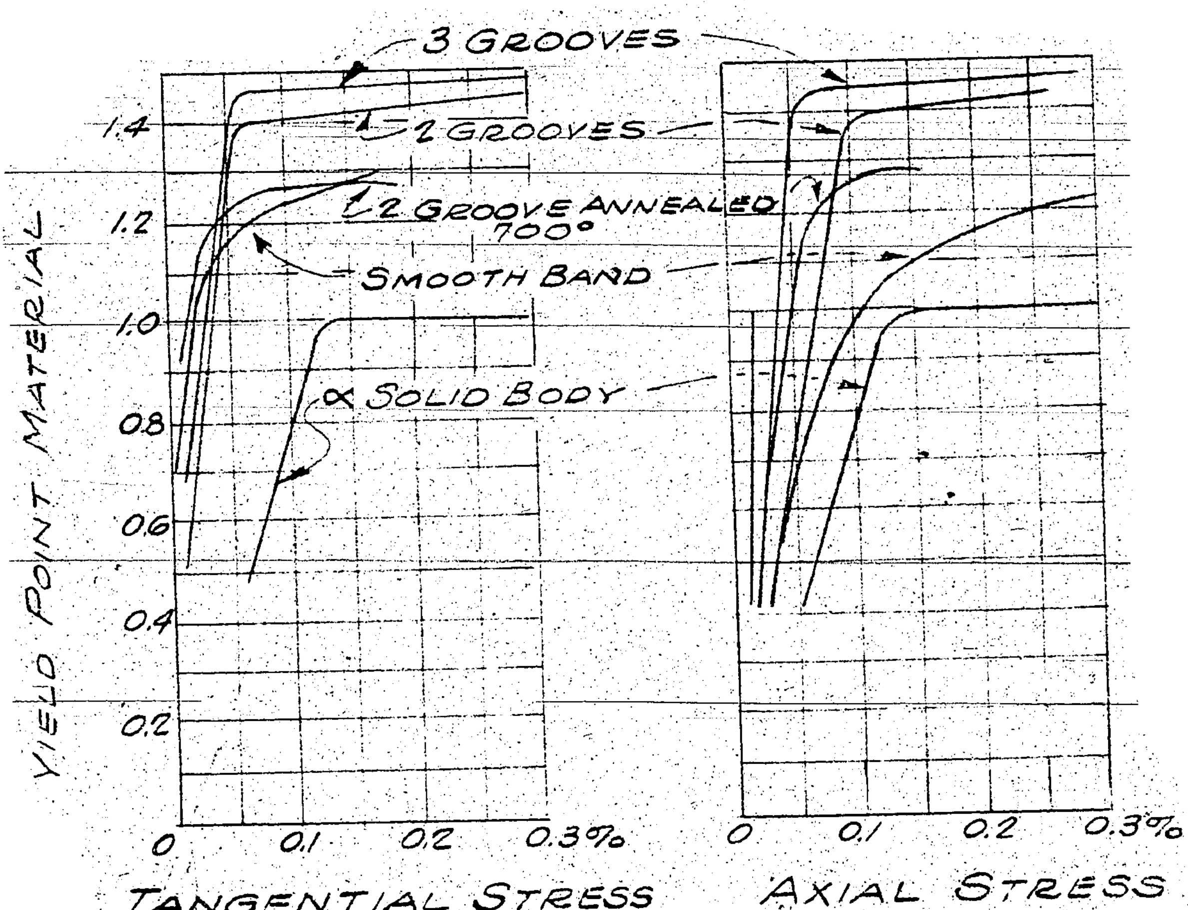
$g = 50\%$ $g = 75\%$

FIG. 6



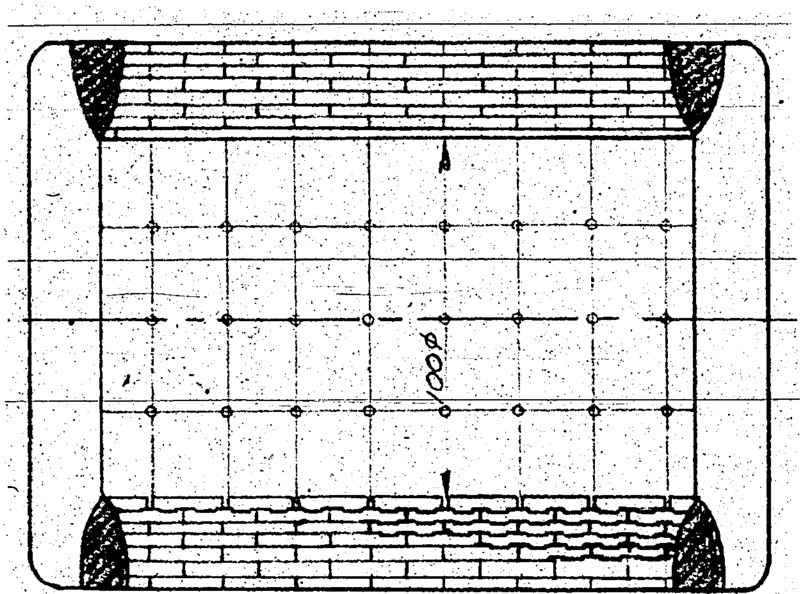
STRAINS ON A SOLID WALL TUBE
1000/1400 AT 700 ATM. AND 300°C

FIG. 7



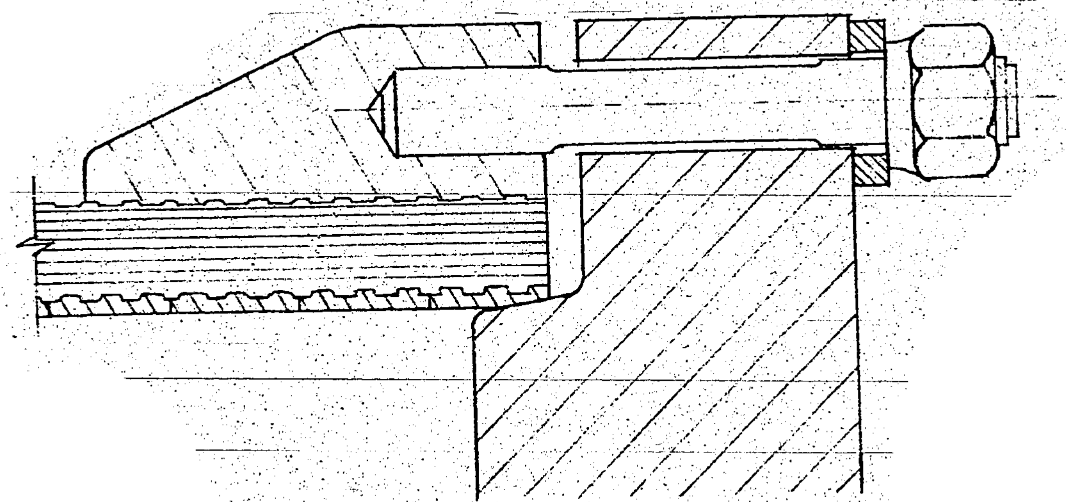
MEASUREMENTS OF STRESSES AND ELONGATIONS OF WICKEL BODIES

FIG. 9

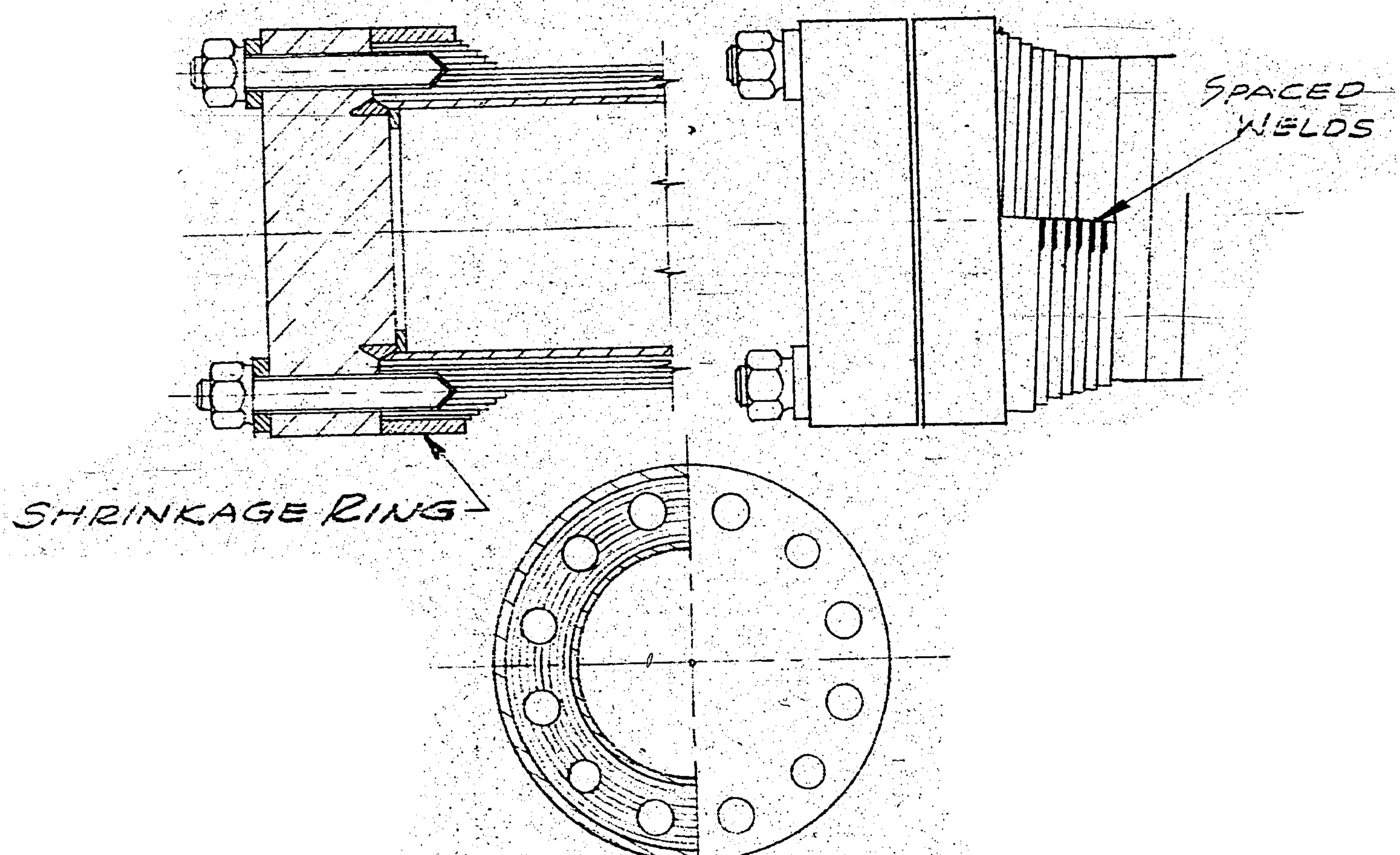


WICKLE TUBE WITH GAS OUTLET HOLES

FIG. 10



SHRUNK FLANGE
FIG. 11



WICKEL FLANGE
FIG. 12

METAL BAND WINDING UNIT FOR WICKELOFEN

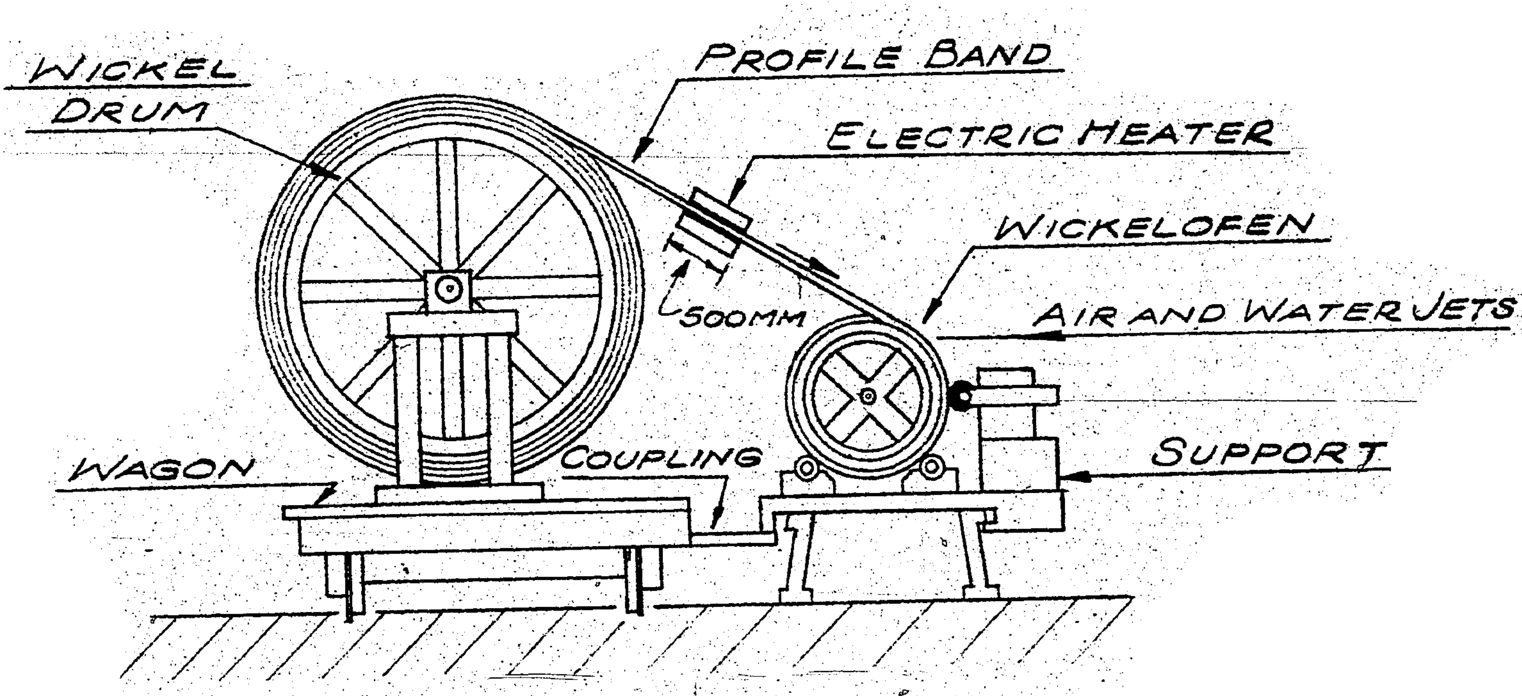


FIG. 14