





CITROËN GEARS

SEPTEMBER 1914

THE CITROËN GEAR CO LTD

27, QUEEN VICTORIA ST LONDON, E.C.

TELEPHONE TELEPHONE AND THE CENTRAL LISTS WAS A B C., SEN ENTERN.



HISTORICAL

the creators, for instance, having hit on something which has immediately taken the popular fancy. But when success is due to exclusive specialisation on a good product, the use of the best methods of manufacture, supported by a sound commercial and technical organisation, then the creators of the business may indeed congratulate themselves upon their success.

We are proud of our success, because we have worked hard for it; and have only attained it by excellence in every department of our business.

It was in 1901 that the first machines were laid down in a small works at Essonnes, near Corbeil, France, and for a period our operations took the shape of experiments in improving the machines and the gears turned out by them. Gradually our experiments were crowned with success, for the first gears supplied to enterprising clients proved satisfactory.

In those days, Machine Cut Double Helical Gears were a comparatively new venture, and as the price was also far above that for ordinary gearing, it was some time before manufacturers and users adopted them generally.

Three years after the first plant was laid down, viz.: in 1904, the number of orders received necessitated larger manufacturing accommodation, and we removed to Paris, in order to benefit by the better manufacturing facilities offered by a large city.

During the next few years, the reception accorded to our speciality by French engineers encouraged us in the belief that



British engineers would give Citroen Gears an even more cordial welcome, and we opened our first office in London in 1907. How rapidly the British branch of our business has grown, is probably known to most of our many friends and clients. The name "Citroen" has in these seven years become almost a household word amongst engineers, and it is a name of which we are justly proud, for wherever it is pronounced, it conveys the impression of "quality."

It was mainly due to the great support received from our British and Colonial friends that we again found it necessary to extend our factory, and our present modern works, which are described on a subsequent page, were officially opened in 1911. In the same year, our office in London was transferred to larger and more commodious premises, capable of accommodating our increased technical and clerical staff.

In 1913, a further development occurred when our French house was converted into a limited company, with a capital of frs. 3,000,000, and the British branch was constituted a separate limited company.

Our British organisation now consists of Head Offices in London, with nine sub-offices in the principal centres of the United Kingdom, and agencies in South Africa, Australia and Canada. The gears for all these parts are made at our central factory in Paris, and other portions of the world are served from our factories in Russia and Austria.

The scope of application of Citroen Gears has equally broadened. Some of the first gears supplied were for Mining and Pumping Machinery, Shaft Transmissions in factories, etc., and they gradually found their way into Rolling Mills, Ships, Electric Locomotives, etc., whilst our latest developments are in connection with Motor Car Drives and Aeroplanes.



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THE EVOLUTION OF CITROEN GEARS

of straight toothed gears, even when cut with the utmost precision, is that it is impossible to obtain a continuous engagement of the teeth. As the result, an appreciable portion of the transmitted pressure is suddenly applied to the whole length of one tooth at the commencement of engagement, and the same proportion of the pressure is suddenly withdrawn at the end of engagement. These periodical and

sudden variations of pressure entail flexions and shocks, and it is on account of these that it is necessary to allow a certain amount of back lash between the teeth. Straight-toothed gears cannot therefore be silent unless made of soft materials, such as wood or raw hide, to the obvious sacrifice of strength.

When single helical teeth are substituted for straight teeth, the resulting engagement may be considered as that of an infinitely large number of infinitely thin, straight teeth, the pressure being applied progressively and continuously and each tooth being withdrawn in a like manner. There is no jerkiness in the transmission of power—hence the silent running of single helical gears.

But it is recognised that single helical gears cause axial thrusts, rendering them unsuitable for drives of any importance.

In order to overcome this objection, double helical gears were used, the teeth of which consist essentially of two single helical teeth opposed to each other. The side thrust originating from one half of the combined tooth is counteracted by the other, leaving only the tangential force.



These double helical gears were first produced either by moulding—giving a solid tooth—or by fitting together two separate rings, in each of which half of the tooth had been cut.

Neither of these methods gave satisfactory results, but they were tolerated owing to the absence of any suitable machines or methods for cutting double helical gears from the solid. It will be evident that moulding is bound to introduce inaccuracies, so that back lash is not eliminated, and also the inclination of the tooth could not be more than 25° (see page 11 under "High Efficiency"). Further, casting is a rather rough process, and hence the teeth were uneven, causing noise and vibration. The apices of moulded teeth are rarely in the same plane, and the two branches are not always symmetrical. As a consequence, side-thrust is set up in addition to the vibration caused by the irregularities in the profile of the tooth.

In the case of assembled rings, the angle of the two branches had also to be small, owing to the nature of the cutters used, and the accurate assembling of the two rings was very difficult to obtain and maintain, and also, a gear of this type would not be as strong as a solid gear.

The growth of any particular industry is always that from imperfection to perfection, from primitive methods of manufacturing to highly specialised and scientific methods, and this is the case with the manufacture of double helical gears.

The Citroen method of cutting double helical gears obviates all the troubles dealt with in the preceding paragraphs, and realises the aim of the early makers of double helical gears: for Citroen Gears are cut with one tool, in one operation, from the solid, with an angle of inclination of 45°.

A full description of the Citroen method of manufacture is given on pages 16-21, to which we would refer those who are interested in this subject.





ADVANTAGES OF CITROËN GEARS

There are a variety of means of transmitting power—ropes, belts, chains, gears, etc. For the sake of argument, let us imagine each in its class to be as perfect as possible:

Now, of these various kinds of drive, it is acknowledged that the geared type is the most mechanical and direct, because it is positive.

In the article, "Evolution of Citroen Gears," on pages 8 and 9, we have shown that of the various types of gear, the Machine Cut Double Helical is the best. We believe amongst engineers generally this is an accepted fact.

Our unrivalled experience in the manufacture of Machine Cur Double Helical Gears, and our special methods of manufacture, have placed Citroen Gears in the premier position as the best Machine Cut Double Helical Gears obtainable.

This statement is endorsed by prominent engineers the world over, as will be seen by reference to the section "Citroen Gears at Work," pages 23 to 56.

From the foregoing argument, it naturally follows that we are justified in claiming the Citroen Gear to be THE FINEST DEVICE FOR THE TRANSMISSION OF POWER.

The paragraphs on the following page show in detail the basis on which we make this claim.



High efficiency, owing to continuous engagement, theoretically correct shape of the teeth, and the choice of an angle of inclination of 45° for the two spirals (see Reuleaux Formula, from which can be deduced the ideal angle of inclination for Double Helical Gears). The efficiency obtained by Hopkinson tests, for ratios of reduction ranging from 1:1 to 10:1 has never been below 98%, and has reached 98.7% ("Bulletin de la Societé Industrielle de Mulhouse," Novembre, 1908).

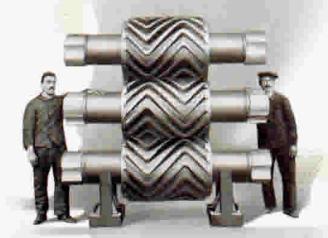
Noiseless running up to highest speeds, owing to total absence of back-lash, shocks and vibration. The running of Citroen Gears is at least as silent as that of gears made of soft materials, such as raw hide, compressed paper, etc., which are used for the sole purpose of securing silent running. With Citroen Gears this silence is obtained without the sacrifice of either strength or durability.

Great strength on account of the tooth being double helical, continuous, and of relatively small height. It is also largely due to the pressure being equally divided over the whole length of arc of contact.

Great durability owing to entire absence of back lash, and almost entire absence of friction.

High ratios up to 20:1 for single reductions. The continuous engagement obtained with Citroen Gears enables us to cut pinions with a minimum of four teeth. For this reason, wheels of high-ratio gears can be kept within a reasonable size.

As compared with Worm Gears, High Ratio Citroen Gears run as silently, but have a much higher efficiency.







OUR WORKS



E should only bore our readers if we attempted a technical description of our Factory, and, as we wish these paragraphs to be read, we shall avoid doing so. This article is only a brief description covering the salient features of our Factory and Offices, and is inserted for the purpose of indicating the ideal conditions under which

Cirroen Gears are designed and manufactured.

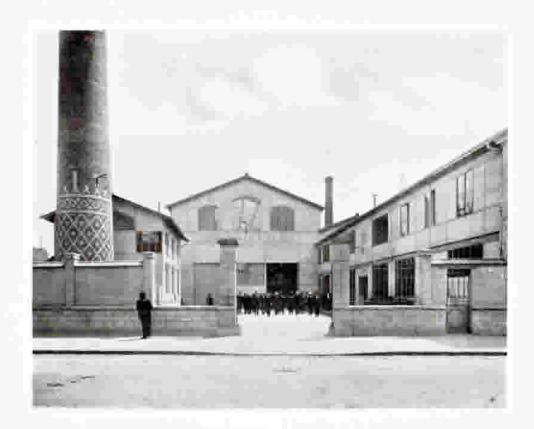
The first view of the Factory, when walking along the Quai de Grenelle. Paris, is a pleasing one: the entrance being through impressive iron gates, beyond which can be seen the large wood-paved yard with the buildings on three sides, against the walls of which are beds of shrubs and flowers. The walls are of a light grey colour relieved from monotony by an ornamental design. In fact, our Works impress the observer as being of the Garden City type, and smoke and soot are entirely absent.

From a commercial point of view, the factory is in an ideal position, being on the banks of the River Seine and close to the Champs de Mars Railway Station, thus facilitating land and water transport, both for heavy and light goods. Within two minutes walk of the Works is the Grenelle Station of the Paris Metropolitan Railway, from which easy access is obtained to all parts of Paris.

When the Works were built, the aims we had in view were to obtain a factory suitable for our purpose from the economic standpoint, and one that would also be an ideal and pleasant working place for our staff and workmen. As can be seen from a foregoing paragraph, this latter aim has been achieved so far as



external appearances and situation are concerned, and internally, the same degree of success has been obtained. There is brightness throughout; the light in workshops and offices is abundant, both by day and by night, and the heating is on the most modern system. Elaborate washing and sanitary conveniences are provided, and each worker has a locker in which to keep his belongings.



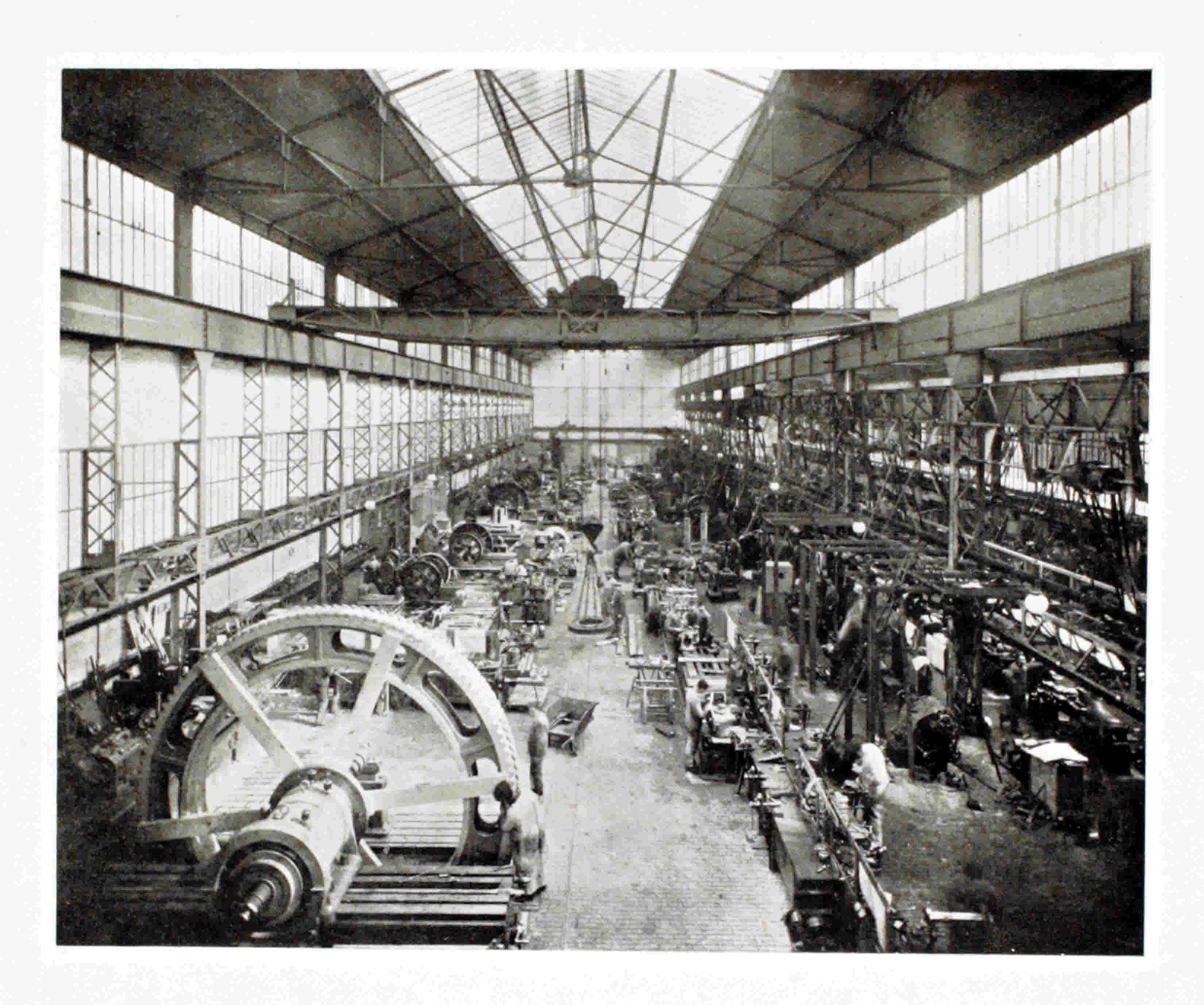
The whole of the factory is wood paved. There are three bays, of which the centre one is the largest. The latter is served by a 20-ton travelling crane, and the two others each by a 10-ton travelling crane.

The machinery is distributed in groups of lathes, general machine tools, and large and small gear-cutting machines.



Throughout the Factory electric motors are extensively used, in many cases the machines being individually driven. Thus the light is not obscured by overhead belting.

At the end of the centre bay is the testing room, the clearing house of all our gears before despatch. (See separate description on page 21.)



The shop buildings are of steel framework with brick walls, plastered on the inside; the roof is partly tiled and partly glazed, the tiled portion being lined with wood to facilitate the heating of the shops during the winter.

The buildings, apart from the factory itself, are situated on both sides of the courtyard. On the left is the power house, with



a 200-h.p. horizontal uniflow condensing steam engine, coupled to a direct current electric generator. Here are also the boilers, coal storage and chimney.

On the right are the offices. Through a double set of swing doors, access is given to the large entrance hall, which reaches to the top of the building. This hall is also used as a reception room for visitors, who will there find many models and photographs to interest them. A double flight of stairs leads from the hall to the first floor, where the spacious and modern drawing offices are to be found. The general offices and private offices of the directors and chief engineer are on the ground floor.

There is a weighbridge in the courtyard, registering inside the offices.

In view of future extensions, ground is available at the rear of the shops.

We believe that a large measure of our success is due to the ideal conditions under which our employees work, and to the scientific manner in which the works and machinery are laid out.

This must be our apology for including this description, for without it, the list of reasons for the success of Citroën Gears would be incomplete.





HOW CITROËN GEARS ARE CUT

The action of the Citroën Gear-cutting machine is based on the milling process. An end-cutter formed to the normal tooth contour is used, the main cut being taken by a single pass of the tool. The rounded portion at the apex of the tooth is effected by a subsequent cut.

Our end-cutters are not standardised, but are specially designed and made to suit minutely the requirements of each particular case. They are manufactured with the greatest accuracy in a special department of our works which has been brought to the highest pitch of organisation and efficacy.

The main advantages of the cutters are:

- 1.—They render it possible to retain the apex of the tooth which in other methods of cutting is interrupted in the centre.
- 2.—They give the teeth an accurate profile without any "flats" or irregularities.
- 3.—They admit of the shrouding of the teeth either to the top or to the pitch line.

We have availed ourselves of the progress made of late years in high speed steels, and, as a consequence, the wear of even our roughing cutters may be said to be negligible. We use, moreover, a finishing cutter which only removes an extremely thin layer of metal.

This discriminate choice of high speed steels, and our experience in their treatment, enables us to cut successfully the hardest materials used for gearing purposes, and we do not, therefore, need to sacrifice durability to cutting facilities.

The inclination of the tooth can be chosen at will without modification of the machine, and we have adopted an angle of 45° for Spur Gears and $52\frac{1}{2}$ °



for Bevels as being the most suitable for this type of gearing. Owing to the special nature of the Citroën Gears, these angles can be varied without altering the profile of the tooth.

The Citroën Machine consists essentially of two beds set at right angles to each other, one carrying the faceplate and the blank to be cut, the other being provided with a saddle upon which the cutter-carrier and cutter are

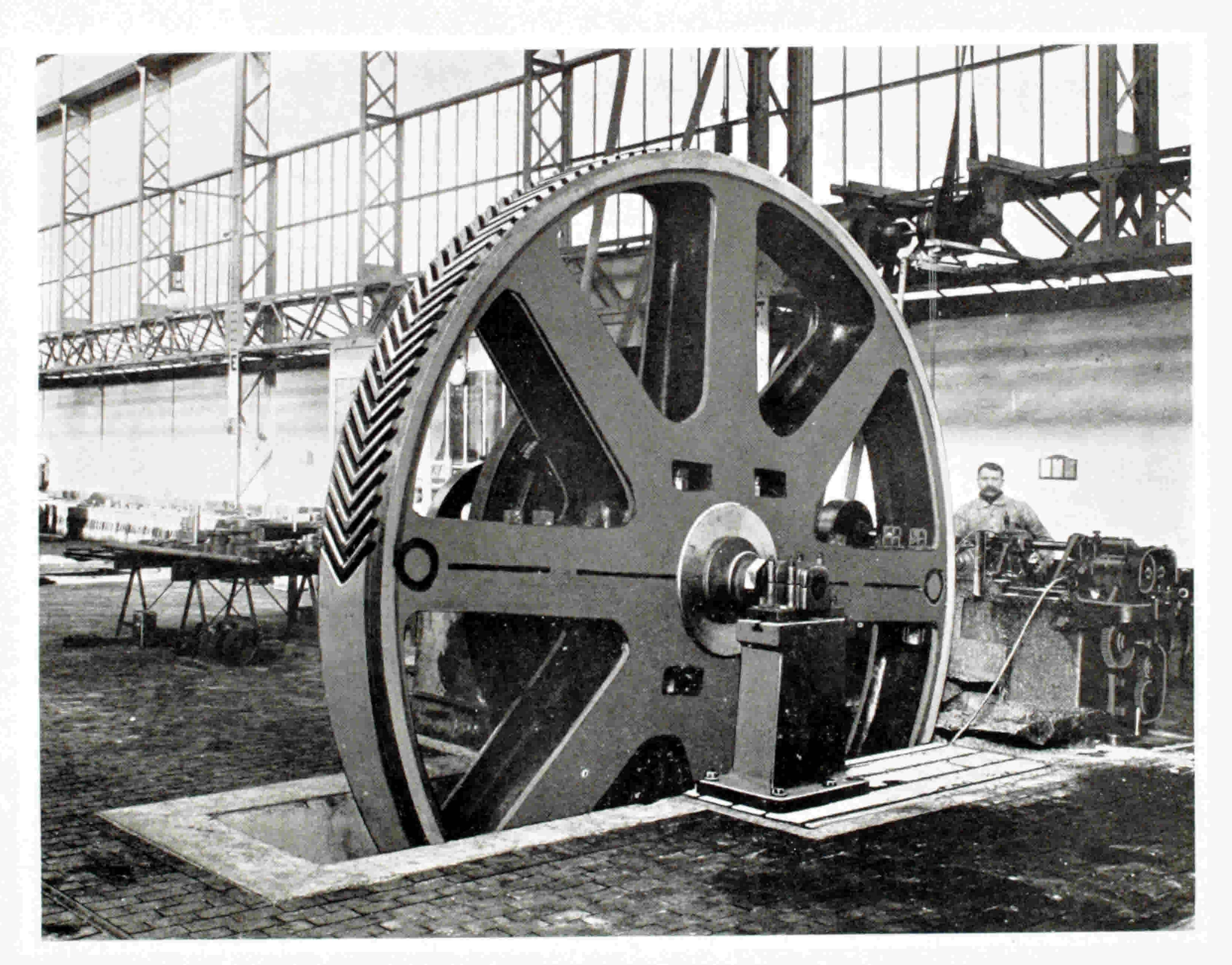


Fig. 1.—Large Citroën Spur Wheel being cut.

supported. The blank is adjusted on the faceplate by exactly the same method as adopted on a lathe, the centering being obtained by the mandrel.

The cutter-carriage is automatically traversed along its bed in a longitudinal direction and parallel to a generating line of the wheel to be cut, by means of a feed-screw.

Depth of cut is obtained by a hand-feed-wheel, screw and graduated plate, thus allowing the exact depth to be readily and accurately gauged.



The cutter is rotated by the driving shaft, through suitable helicoidal gearing, its axis of rotation being perpendicular to the work.

The movement of the faceplate and blank are co-ordinated with those of the cutter-carrier. This combination of movements is obtained from the feed-screw of the carriage, through change wheels, cams, reversing gears and dividing wheel (in which are as many teeth as are to be cut on the blank), worm and worm wheel to the blank. This arrangement permits simultaneous and corresponding movements of the cutter-carriage and the blank, making it possible to cut on the latter either straight or helical teeth of any required shape, and either double helical or double herringbone.



Fig. 2.—Citroën Bevel Wheel partially cut.

For cutting ordinary double helical teeth, the blank is slowly rotated and the cutter-carrier moved in a direction parallel to the generatrix of the wheel being cut, so that the tool generates on the rim a helix, the height



and inclination of which are regulated by the previously determined rates of speed of the cutter and the blank.

As soon as the cutter has cut half the tooth, the reversing gear is automatically brought into operation, the blank being thus rotated in an opposite direction to that in which it was previously moving and at the same speed. In the second half of the cut, the tool therefore develops a helix exactly similar, but inverse in direction to that generated in the first half.

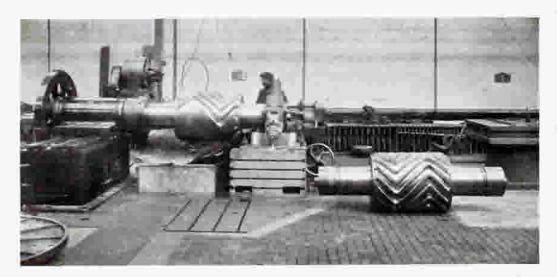


Fig. 3.—The cutting of a 3-ton Citroen Rolling Mill Pinim.

It will thus be seen that the tooth is composed of two helices cut in one continuous stroke without stoppage.

The tool having taken a cut over the whole width of the face, the cutter is brought back into its starting position by the quick return mechanism, the blank at the same time rotating first in a backward and then in a forward direction to allow the free passage of the cutter.

As soon as the latter has reached its original starting point, the blank is rotated through a distance corresponding to the pitch, and the operation is repeated until the whole circumference has been cut. (Figs. 1, 2 and 3 show machines in operation with blanks partially cut.)

The machines of the smaller pattern cutting up to 61 feet in diameter, and those of the larger pattern cutting up to 30 feet are of a similar type.



The larger machines are capable of cutting gears with any width or pitch of tooth.

BEVEL GEARS. The cutting of helical teeth in bevel wheels introduces a more difficult problem, which we have solved successfully.

Theoretically, two methods present themselves, which may be distinguished by the type of spiral given by the teeth when projected on a plane perpendicular to the axis of the wheel.

This spiral may take one of two known forms: the logarithmic or the archimedian. The former develops a tooth profile analogous to that of a straight tooth of an ordinary bevel gear. It is a known property of this spiral that the tangent, at any of its points, makes a constant angle with its radius vector, and it follows that the inclination of the teeth to the generatrix of the cone will be constant in any gearing designed on this basis. The tooth profile at each point of the generatrix is that of a straight tooth multiplied by the cosine of the angle of inclination of the tooth, which, according to the foregoing, is a constant co-efficient. The thickness of the tooth at the pitch circle will, therefore, increase proportionately to the distance from the apex of the cone, as in the case of ordinary bevel teeth.

Although it is possible to generate straight teeth converging towards the apices with mathematical precision by means of a planing process, this cannot be done with helical teeth, as, in addition to the motion generally employed in cutting bevel teeth, a further motion is necessary in this case, viz.: a rotary movement of the gear being cut, which, having to follow the logarithmic law, would be extremely difficult to realise.

It is because of the difficulty thus involved, that the Citroen process is based on the archimedian spiral, the realisation of which in practice only necessitates angular movements of the blank proportionately to the linear displacements of the tool along the generatrix of the cone. The machines based on this principle are practically similar to those used for cutting double helical spur gears, the essential difference being that the two beds, the one carrying the cutter and the other the blank, are so mounted as to be capable of being placed at any desired angle in relation to each other.

To effect this, the tool slide and its bed are so constructed as to be capable of movement round a vertical axis, hence all positions necessitated by the angle of any particular gear face can be given to the cutter, the axis of which can always be placed perpendicular to the surface to be worked.



In the smaller machines, viz.: those for dealing with blanks up to 6) feet, the tool bed is fixed, and the headstock is adjustable in two ways: in a direction perpendicular to the travel of the cutter, and round its own vertical axis.

In the larger machines, the whole of the tool bed swivels on a turntable, while the headstock carrying the blank has a sliding movement in the direction of the axis of the mandrel.

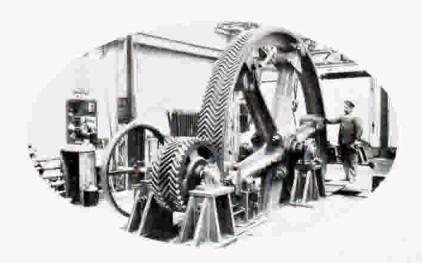
TESTS.—From our clients' standpoint, the Testing Room is the most important department in our Factory.

It is an absolute and strictly observed rule that each set of gears must be tested, and none are allowed to be despatched unless they have satisfactorily passed our standard tests.

We have facilities for accurately testing all gears we make, from the smallest to the largest

They are fitted to the exact centres at which they will be called upon to work, and are run at the number of revolutions of the drive for which they are intended.

The illustration below shows a large set of Spur Gears under test.







CITROEN GEARS AT WORK

The following section of this album is indicative of the wide range of application of Citroen Gears. Should there be no illustration representative of your own requirements, kindly let us know what these are, and there is no doubt we shall be able to refer you to applications of a like nature.



MINING

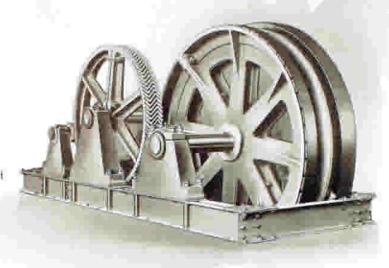
The large power often required for driving Mining Machinery, such as Winding and Hauling Engines, etc., has led to the wide adoption of Citroën Gears, for the saving it is possible to effect by their use means a very considerable reduction in the running costs. But Efficiency is not the only factor which has contributed to the success of Citroën Gears in this sphere, the following are also important considerations:—

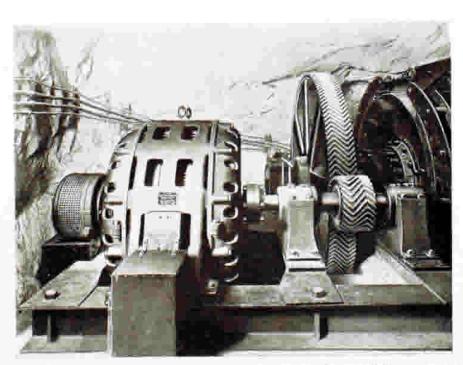
Reliability. This is of primary importance to any mining enterprise, as breakdowns and stoppages are matters of serious import. Citroen Gears possess an ample factor of safety, and can be relied upon under the most severe working conditions.

Noise. Owing to the comparatively small section of the underground ways, any noise is greatly magnified and becomes a serious nuisance. Citroen Gears are noiseless, and are therefore to be preferred to any other type of gearing.

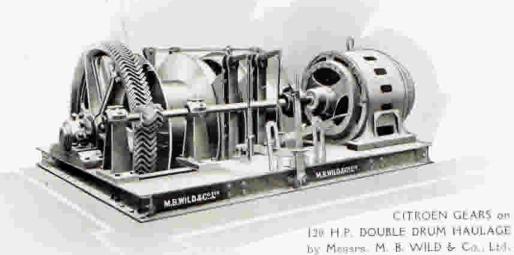
The South African Gold Mines, large Collieries in the South Wales and Newcastle districts and in other mining centres of Great Britain have adopted Citroen Gears to a large extent, showing conclusively that their value is well recognised by mining engineers.

CITROEN GEARS ON
ELECTRICALLY DRIVEN
HAULAGE ENGINE by
MESSIE, CLARKE, CHAPMAN
100 H P.
RATIO 7 : L
WHEEL IN HALVES
DOUBLE HERRINGBONE TEETH

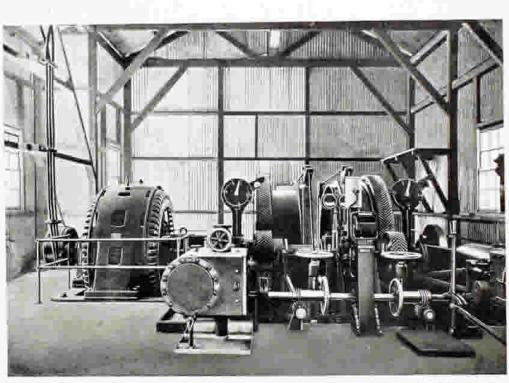




CITROEN GEARS OF ELECTRICALLY DRIVEN HAULAGE ENGINE, SUPPLIED by THE BRITISH WESTINGHOUSE ELECTRIC & MANUFACTURING Co., Ltd., for SOUTH AFRICAN MINE



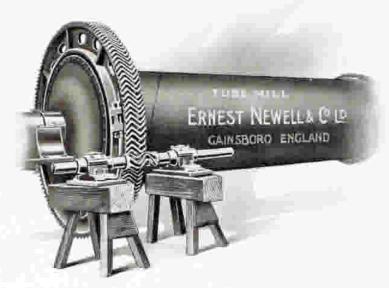
RATIO 10 1 WHEEL IN HALVES. DOUBLE HERRINGBONE TEETH.

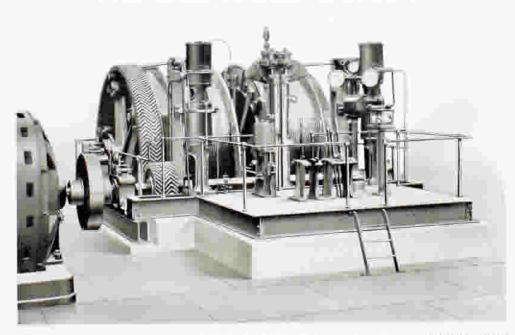


2 Sets of CFTROEN GEARS transmitting 2000 H.P. maximum, fitted to WINDING ENGINE in SOUTH AFRICAN GOLD MINE converted from STEAM to ELECTRIC DRIVE by THE BRITISH WESTINGHOUSE ELECTRIC & MANUFACTURING Go., Ltd.

Lange numbers of similar gears have been supplied.

CITROEN GEARS ON
ELECTRICALLY DRIVEN
TUBE MILL by
MUSSES ERNEST NEWELL & CO., Ltd.,
MUSSES ERNEST NEWELL & C





CITROEN GEARS on 1200 H.P. ELECTRICAL HAULAGE, supplied for an INDIAN MINE by Messes SANDYCROFT, Ltd. THE LARGE CITROEN WHEEL IS BUILT UP IN 5 PARTS (centre in halves and rint to 3 segments) AND WEIGHS # TONS.



PUMPING

The adoption of gas and oil engines and highspeed electric motors for pumping purposes has led to a demand for better gearing, and hence to the increasing use of Citroen Gears.

Unevenness of load, especially with Single Acting Pumps, causes shocks and vibrations with ordinary gears on account of their back-lash, and hence detrimental effects are experienced on the machinery and foundations. These troubles are not encountered where Citroen Gears are used, owing to their freedom from back-lash.

The great pressure on the teeth due to slow speeds often causes excessive wear of ordinary teeth. With Citroen Gears, this pressure is distributed evenly over a number of teeth, and wear is practically non-existent.

Citroen Gears are specially recommended for pumping stations in residential districts, owing to their perfectly silent and smooth running.

Most of the Waterworks in this country have adopted Citroen Gears, and are specifying them for their new plant. STEEL CITROEN GEARS

ON ELECTRICALLY DRIVEN

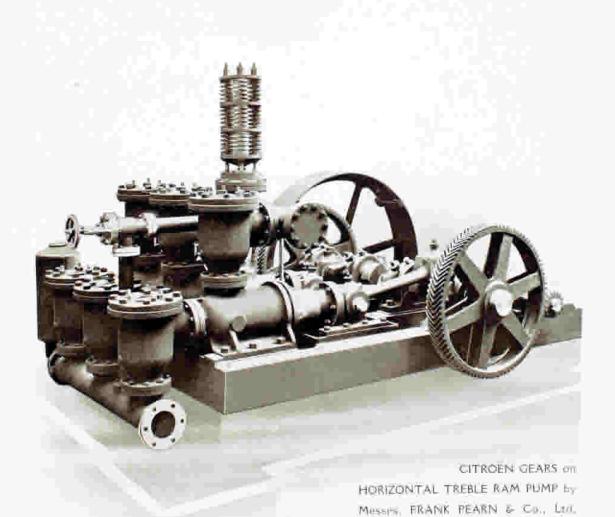
THREE-THROW FUMP by

THE USKSIDE ENGINEERING Co., LUL.

100 H P.

RATIO W. L.

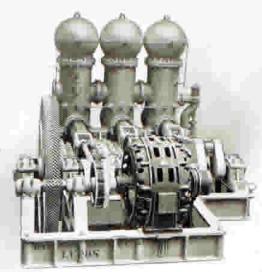
WHEEL IN HALVES.

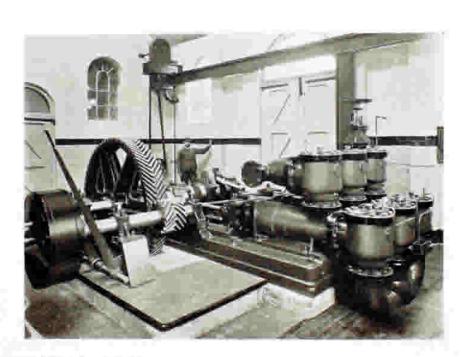


145 H.P. transmitted through

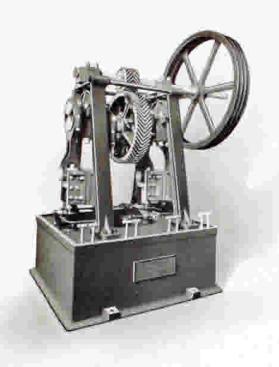
2 SETS OF GEARS

CITROEN GEARS on
ELECTRICALLY DRIVEN PUMP by
Mesens. HATHORN, DAVEY & Co., Lut.,
for the LEEDS WATERWORKS.
400 H.P.
SINGLE RATIO IN I

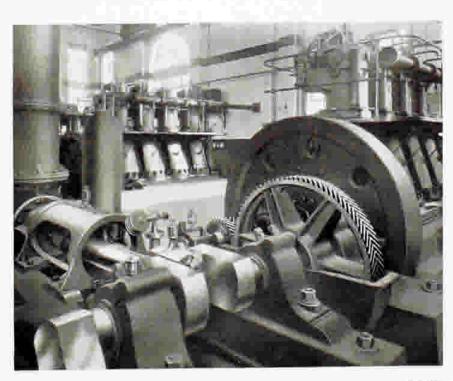




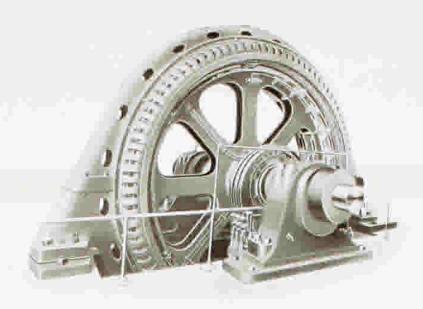
CITROEN GEARS driving PUMP from GAS ENGINE, supplied to Messas, HUNTER & ENGLISH, Ltd., for the SOUTH ESSEX WATERWORKS.



CITROEN GEARS ON
HYDRAULIC PUMP
FOR OIL MILL
WHEEL IN HALVES.
Several similar sets
supplied to
Masses ROSE DOWNS
6 THOMPSON, Lt.L



CITROEN GEARS supplied to Mesons, GLENFIELD & KENNEDY Ltd., for PUMPS drived by MIRRLEES DIESEL ENGINES for THE METROPOLITAN WATERBOARD. A SETS.



ELECTRICAL

The introduction of the Electric Motor with its high speed brought about the necessity for either the re-designing of existing machines or the provision of a suitable speed-reducing device.

The chief objections to most of the speedreducing devices that have been used hitherto have been noise and vibration, and loss of efficiency. Each of these points is directly opposed to the advantages claimed for the electric motor, and where the speed has to be reduced by such means, the reputation of the motor naturally suffers.

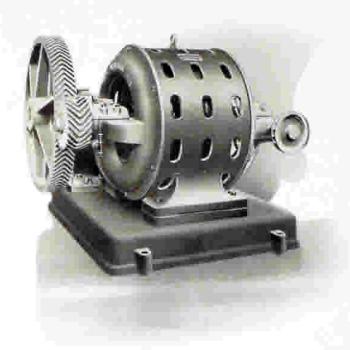
With the advent of Citroen Gears these objections were swept away, for they are noiseless and vibration-less, and have an efficiency of 98 % for ratios up to 10:1, and for ratios up to 20:1 the efficiency is only slightly lower.

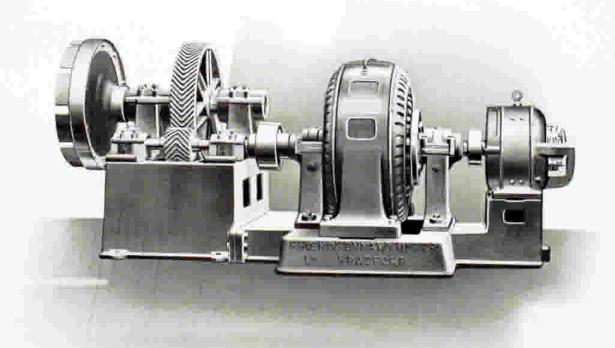
As the price of Citroen Gears is not materially affected by the ratio, for a given speed on driven side, it follows that by using Citroen Gears, a high-speed motor (more efficient and costing less) can be used.

(See other sub-sections for Electrical Applications)

CITROEN REDUCTION GEAR on "DERLIKON" MOTOR.

For small powers the gears may sometimes be sverthing, but for larger powers outside bearings should be provided.

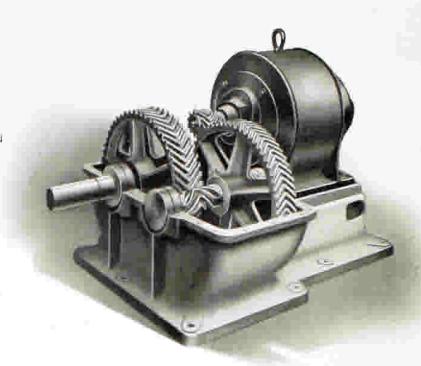


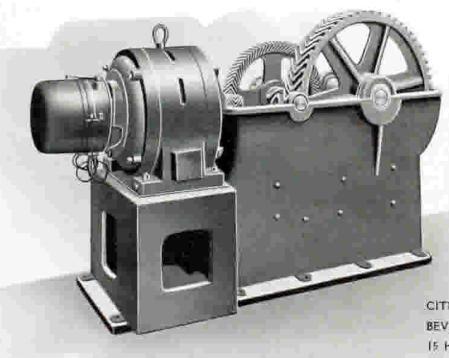


CITROEN SPEED-INCREASING GEAR driving 150 K.W. "PHŒNIX" DYNAMO from LINE SHAFT.

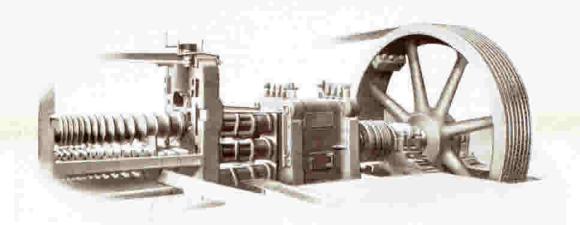
120 & 500 REVS. EFFICIENCY, 98 L.

CITROEN DOUBLE REDUCTION
SPUR GEARING.
40 H.P. 800 & 18 REVS.
TOTAL RATIO, 44.5.: I
OVERALL EFFICIENCY, 96%.





GITROEN DOUBLE REDUCTION
BEVEL AND SPUR GEARING.
15 H.P. 715 & 9 REVS.
TOTAL RATIO, 80 I.
OVERALL EFFICIENCY, 94%.



ROLLING MILLS

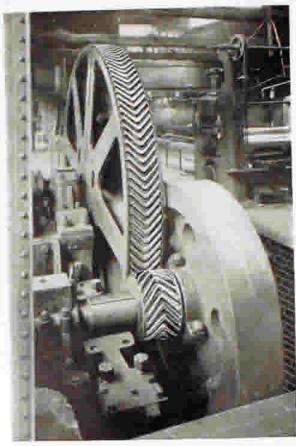
The severe conditions under which Rolling Mill Gearing operates call for gears of exceptional durability and strength, and proprietors of Rolling Mills have recognised the superiority of Citroen Gears in these respects.

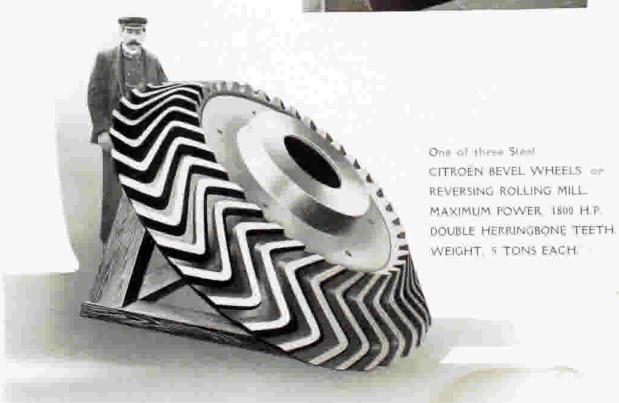
The efficiency of Citroen Gears is an additional reason for their adoption, for owing to the high powers used in Rolling Mills, the saving in cost of power by using our gears is considerable. We suggest that manufacturers compare the 98 the efficiency of Citroen Gears with that of ordinary gears, and then reckon up the saving they would effect by adopting the former.

Rolling Mill Pinions. Cirroen Rolling Mill Pinions last from three to four times as long as ordinary pinions, enabling the manufacturer to considerably reduce the item of labour in replacements, and reducing proportionately the risk of stoppage at an inopportune moment.

The absence of back-lash, and hence of vibration, in Citroen Pinions prevents the marking of the work, and further, the elimination of vibration lengthers the life of the housings.

STEEL CITROEN GEARS divising
LARGE ROLLING MILL.
MAXIMUM POWER. 2500 H P.
PINION SPEED. 240 REVS.
RATIO OF GEARING 7 II.
WEIGHT OF WHEEL. 17 TONS.
TEETH SHROUDED TO MITCH LINE.

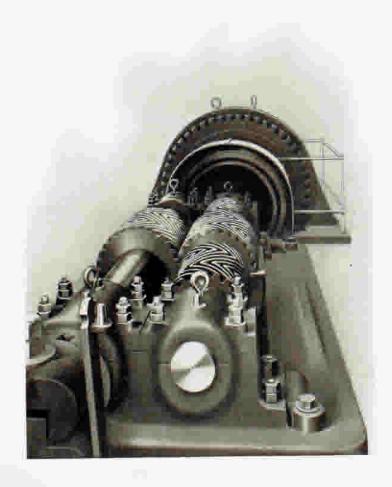




A large set of CITROEN ROLLING MILL PINIONS with DOUBLE HERRINGBONE TEETH for reversing purposes.

These pinions will lead from 3-4 times as long as smillnery pinions.





LARGE CITROEN PINIONS used as CHANGE SMEED GEAR IN ELECTRICALLY-DRIVEN ROLLING MILL INSTALLED BY THE BUTTISH WESTINGHOUSE CO. For the DISTRICT IRON & STEEL Co., Ltd., POWER TRANSMITTED 2000 H.P., DOUBLE HERRINGBONE TEETH.

There are 2 spars pinions
Le pair with the outer punions.



SHIPPING

Preceding sections have shown that Citroen Gears are the most reliable and durable of all gears, and as reliability is of such paramount importance on board ship, it naturally follows that Citroen Gears are the best for this purpose.

The absence of noise and vibration, combined with their reliability, render Citroen Gears by far the most suitable for Steering Gears, Winches, Refrigerating Machinery, etc., especially on passenger ships.

We have supplied sets of Steering Gears for a great number of large ships built by Messrs. Harland & Wolff, and the French Admiralty have adopted them almost universally for geared drives on their ships and submarines.

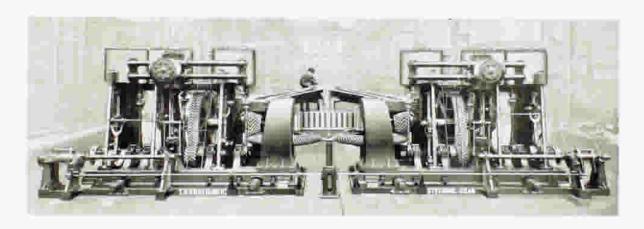
The following are some of the ships built by Messrs Harland & Wolff, in which the Steering Engines are fitted with Citroen Gears: — OLYMPIC — OXFORDSHIRE — ARLANZA — CERAMIC — BRITANNIC — ALCANTARA — ANDES — STATENDAM — KATOOMBA — ALMANZORA — ORCA — MINNEKAHDA.

Citroen Gears have been very successfully employed in the Melbourne Dredgers of the "John Stewart" type. The adoption of Citroen Gears in these Dredgers has reduced the power required from the engines to 200-h.p., as against 510-h.p. with ordinary gears.

CITROEN DOUBLE HERRINGBONE SPUR GEARS, as supplied in large quantities for STEERING ENGINES to Messes, HARLAND & WOLFF, Ltd.

These Spur Geers form doubte reduction with the Bevels depinted below.





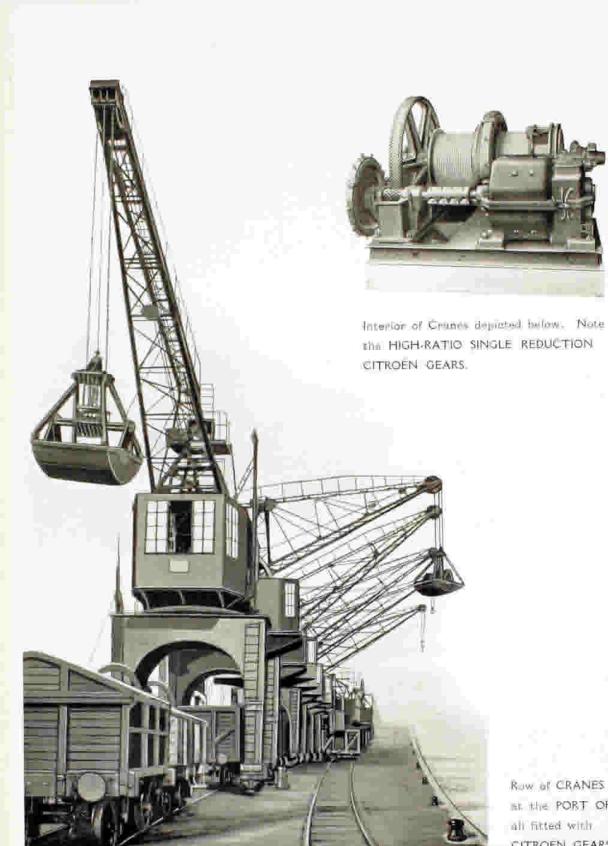
STEERING ENGINES of the T.S.S. "BRITANNIC," erected in the shieps of Messrs. HARLAND & VVOLFF, Ltd., fitted throughout with CITROEN GEARS.



CITROEN DOUBLE HERRINGBONE BEVEL GEARS, as supplied in large quantities for STEERING ENGINES to Messes HARLAND & WOLFF, Ltd.

These Bayel Wheels form double reduction with

These Boyel Wheels form double reduction with the Spors depicted above:



Row of CRANES IN THE PORT OF ROUEN. air fitted with CITROEN GEARS.



TEXTILE

Trouble experienced with main drive gears in the early mills led to the adoption of the rope drive, but the recognised superiority of Citroen Gears is leading manufacturers back to gearing for main drives.

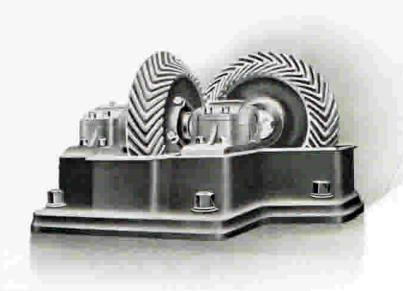
Citroen Gears are specially suitable for textile installations, and have been extensively adopted by manufacturers who have realised their advantages, both for individual drives and for line shaft drives.

The most important reasons for the adoption of Citroen Gears are -

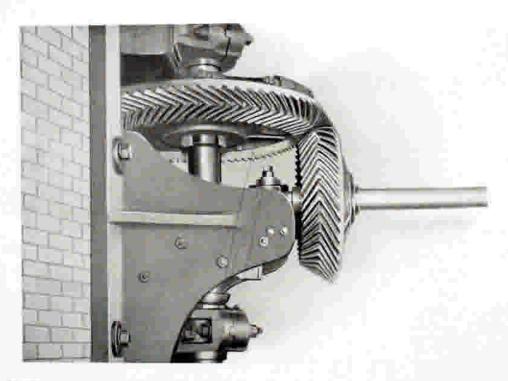
They have no back-lash, and consequently the drive is as smooth and continuous as from a direct connected electric motor.

Once installed, they give the mirumum of trouble, and do not need the constant attention of the main-tenance staff; and

The high efficiency of Citroen Gears renders them a necessity wherever the individual electric drive is employed owing to the large number of motors, and consequently the big aggregate loss that would be experienced with ordinary gears.

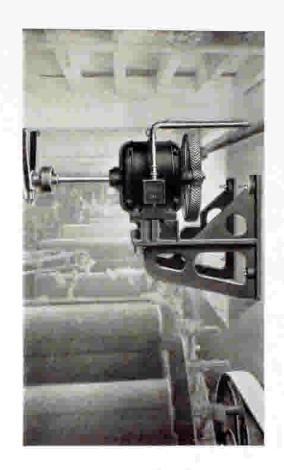


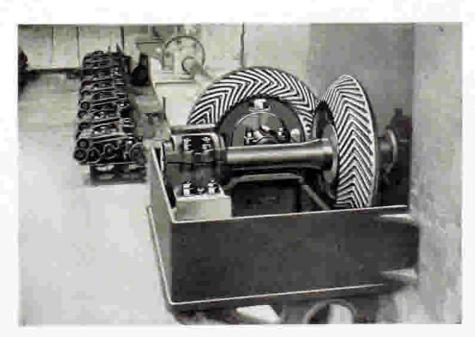
A typical set of CITROEN BEVEL GEARS For driving RIGHT ANGLE LINE SHAFTING.



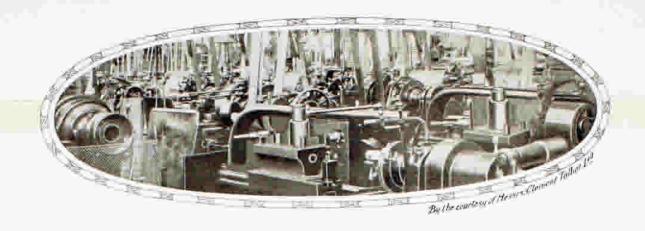
CITROEN BEVEL GEARS on VERTICAL SHAFT DRIVE, supplied to Messes. WM. MORRIS & SONS, List.
100 H.P. 98 & 156 REVS. LARGE WHEEL IN HALVES.

One of savarral sets of
CITROEN REDUCTION GEARS
driving LINE SHAFTING
from WRIGHT & WOOD MOTORS
at the George Street Mills of
Messes JAMES SHIRES & SONS Little
20 H.P. enach.
SINGLE RATIO, 8:1





300 H.P. CITROEN BEVEL GEARS at W. C. GAUNT'S VALLEY MILLS. supplied to Messirs, CROFT 6 PERKINS, Ltd.



MACHINE TOOLS

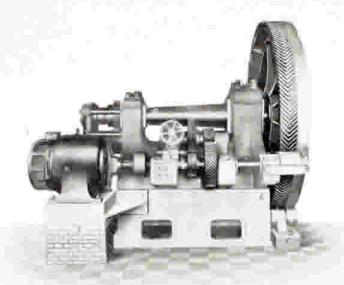
Citroen Gears are peculiarly adapted for Machine Tools on account of their entire freedom from backlash and the perfect shape of the teeth.

As a consequence inaccuracies in the various transmissions are avoided, the different drives of a machine are positive, and there is no possibility of creepage.

The chief advantage following the use of Citroen Gears as face-plate gears on large lathes is the absence of the markings on the work so often experienced when ordinary gears are used.

As a typical application of this type we may mention that large gun lathes made by the leading armament firms are fitted with Citroen Gears, ensuring that perfect work which is so essential in the manufacture of big guns.

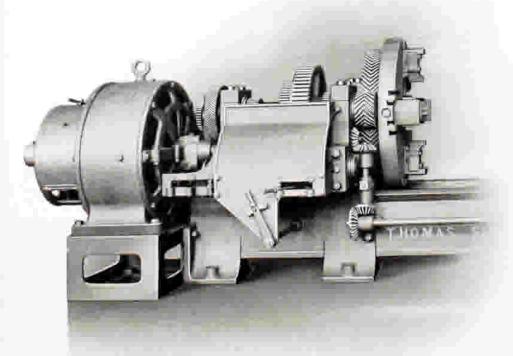
The individual driving of large machine tools by electric motors has been an important factor in the adoption of Citroen Gears, because they ensure a minimum loss of power.



CITROEN GEARS on
LARGE LATHE made by
Megara, JOHN STIRK & SONS, Ltd.
The FACE PLATE WHEEL and
PINION have a
SINGLE RATIO OF 18:11.
The two smaller sets of
Citroen Gears form
CHANGE SPEED GEAR.

CITEGEN CEARS ON PACE PLATE
OF LANGE GUN LATHE HIGH W
MARKETHONG WESTWORTH & CO. LIST
THE PERCOT RING SHARED WHEEL
IN BURNING FORGED STERL





CITROEN GEARS ON LATHE MAJE by Messey. THOS. SHANKS & Co.
As MOTOR REDUCTION GEARS they PREVENT NOISE, and as FACE PLATE GEARS
They OBVIATE BACK-LASH.

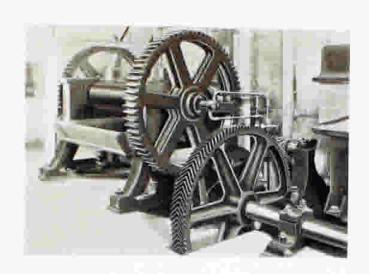


RUBBER MACHINERY

The adoption of Citroen Gears by the leading rubber manufacturers, such as DUNLOR, MACINTOSH, MICHELIN, BERGOUGNAN, etc., and the satisfaction they give to these firms, is sufficient evidence that Citroen Gears have special advantages over other types of gearing for this class of drive.

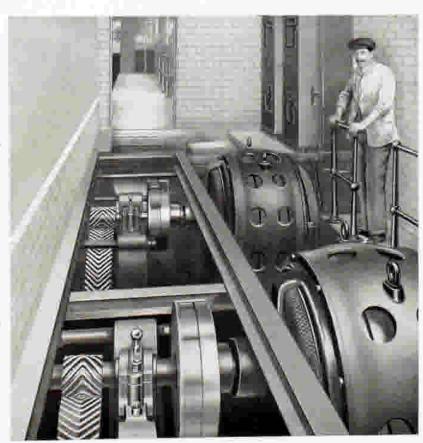
Citroen Gears are employed for rubber machinery owing to the great strength required for this purpose in order to successfully withstand the shocks and vibrations set up by processes such as "masticating," rolling," etc. Ordinary gears are liable to wear quickly and develop excessive back-lash. The life of Citroen Gears under these conditions especially is much longer than that of ordinary gearing, and for this reason alone it is more economical to use Citroen Gears.

The advantage of being able to use high-ratio Citroen Gears with no appreciable loss of efficiency is also a deciding factor owing to the rapid adoption of the electric drive, as smaller motors can be used—with better overall efficiency—than would be possible with other types of gear.



CITROEN GEARS (RATIO, 8:1) supplied to The AVON INDIA RUBBER Co., Ltd., for RUBBER WASHING MACHINE.

2 mets of STEEL CITROEN GEARS
driving WARMING-UP ROLLERS
and CALENDERS respectively.
One set 150 H.P.
SINGLE RATIO. 16 1.
One set 200 H.P.
SINGLE RATIO, 14 1.
Both philodys solid with about.
Messes, CHAS, MACINTOSH
& Co., Ltd.





COMPRESSORS

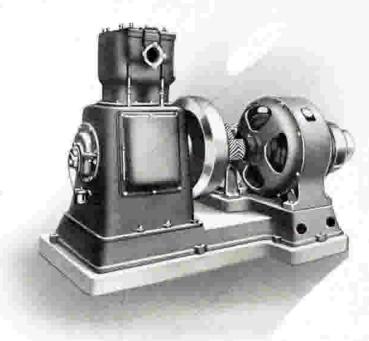
In gears for driving Compressors, even more than in the case of pumps, great strength and durability are required in order to successfully withstand shocks, great pressures and uneven loads.

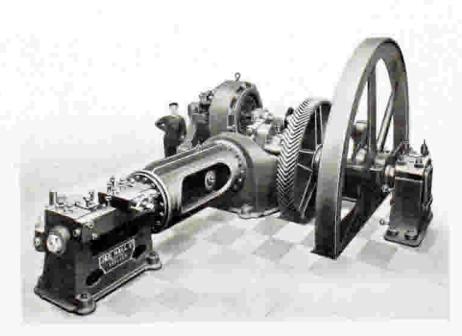
The superiority of Citroen Gears in these respects renders them specially suitable for gear-driven Compressors. The shock and vibration at the end of compressing stroke is sufficient in many cases to strip the teeth of ordinary gears, especially when the back-lash has been increased owing to wear. With Citroen Gears, the absence of back-lash eliminates shocks on the teeth due to this strain, and the inherent strength and durability of Citroen Gears is sufficient to withstand excessive sudden pressures of this nature without breakage or wear.

As in the case of almost every type of machinery, the introduction of the electric motor with its high speed has made necessary the provision of high-efficiency silent gears, so that compressing plants may benefit to the utmost extent from the advantages of the electric drive.

Citroen Gears here meet the need in every possible respect, and, indeed, their advent has removed all the objections that formerly existed to the use of gearing for Compressor drives.

CITROEN GEARS on ELECTRICALLY-DRIVEN AIR COMPRESSOR by Messrs BROOM & WADE, Ltd.





CITROEN GEARS ON CO. COMPRESSOR by Messes J & E. HALL, Ltd., for the BREWERY of Messes TRUMAN, HANBURY, BUXTON & Co., Ltd., 300 H.P. SINGLE RATIO, 7.5.11.

Several simular sets supplied.

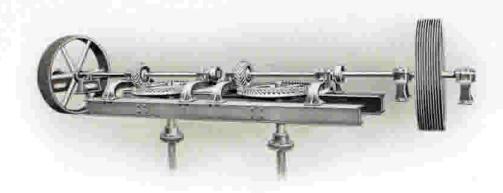


TURBINES

Citroen Gears are extensively used in connection with Water Turbines for Hydro-Electric installations, for speed increasing.

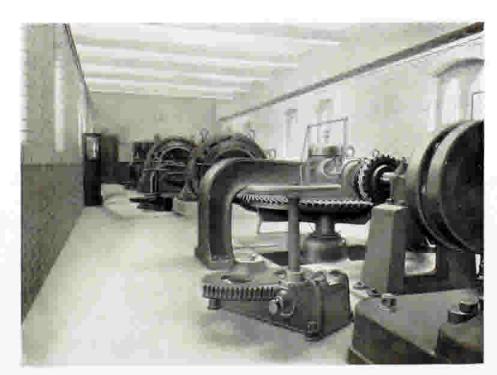
Efficiency is of paramount importance, as the gears constitute the main drive, the whole of the power necessary for the generation of the current passing through the gears. Citroen Gears are second to none on the score of efficiency, and consequently they are exceptionally suitable for this class of drive.

An electricity supply works on which depends the lighting of a town, and the operation of many factories, must be equipped with machinery that can be relied on to give continuous service for long periods without attention from the break-down gang, and hence the choice of Citroen Gears for transmitting power from water turbines to generators is a judicious one, for Citroen Gears are as reliable as they are efficient.

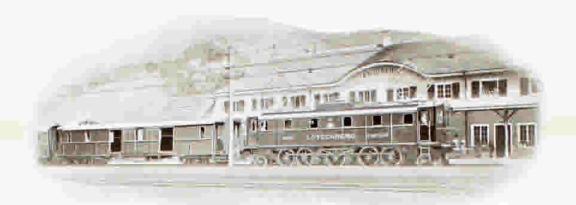


2 bets of 150 H.P. CITROEN BEVEL GEARS supplied to Messes, JAMES GORDON & Co.

Top the HYDRO ELECTRIC POWER STATION in PATIALA (India).



3 sets of 300 H.P. CITROEN BEVEL GEARS supplied to Messes, JAMES GORDON & Cu. for the CHESTER HYDRO-ELECTRICITY WORKS.



ELECTRIC TRACTION

With the adoption of Electric traction arises the need for satisfactory gearing—a need which is in every respect filled by Citroen Gears.

Citroen Gears are noiseless. This is a particularly desirable feature, and ensures that quality of quieter running claimed for electric traction. Ordinary gears cannot run silently owing to the high peripheral speeds.

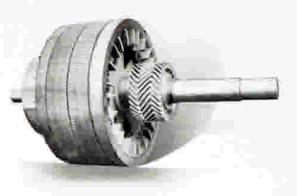
Citroen Gears do not introduce vibration, and hence the life of the motor is lengthened, and the services of the repair man are seldom required.

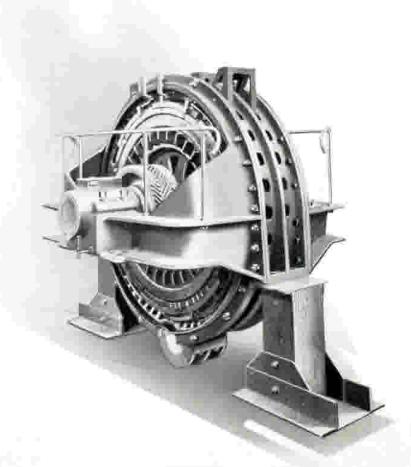
Citroen Gears have an efficiency of 98%, and as all of the power required at the wheels must be transmitted through the gears, it follows that their adoption results in a considerable reduction in power consumption.

Reliability and durability are special features of Citroen Gears, and hence they are exceptionally suited to withstand the severe working conditions, and the excessive wear and tear to which railway gearing is subject.

Citroen Gears run for long periods without attention, and the teeth are practically unbreakable.

For the above reasons. Citroen Gears have been adopted by the Loeischberg, Paris Metropolitan, and other Railways. The gears on the former run silently at peripheral speeds up to 5,000 feet per minute. CITROEN DOUBLE HERRINGBONE PINION
on ROTOR of "OERLIKON" MOTOR
used in the ELECTRIC LOCOMOTIVES of the
LOETSCHBERG (Switzerland) RAILWAY.







One of the large

"OERLIKON" ELECTRIC LOCOMOTIVES used on the LOETSCHBERG RAILWAY, and fitted with CITROEN GEARS.



MOTOR CARS

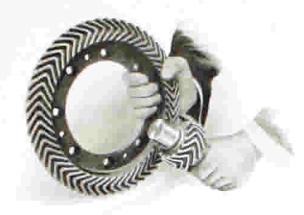
The quest of the silent car has led to the elimination of noise in almost every part, leaving the back axle as the chief creator of noise.

Every maker is aware of the continuous humming sound produced by straight cut bevel gears as chiefly used for back axles. When the brakes are suddenly applied this humming changes to a rumbling, and shocks and vibrations occur which are greatly detrimental to the life of the other running parts of the car.

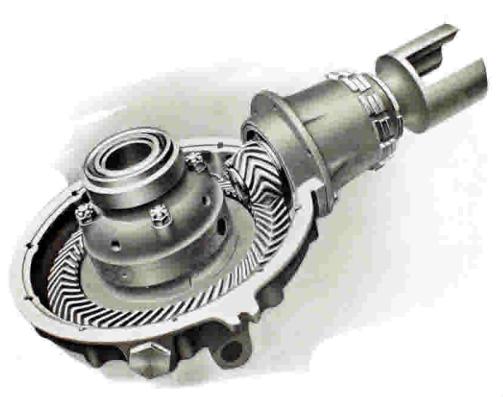
With the worm gear back axle, greater silence is obtained, and the car drives better—when new. But there are inherent defects in the worm gear which can be briefly summarised as: considerable loss of power due to friction; excessive wear as the result of this friction, irreversibility or back thrust, specially noticeable in running down hill, when the worm gear acts as a brake, causing loss of power and of time, and distortion of the teeth when the brakes are suddenly applied.

Citroen Gears have no thrust; have an efficiency of 98 %; give absolutely silent and smooth running; have practically no wear; are stronger than ordinary gears; and being supplied ready for immediate use they require no "fitting" or "running in."

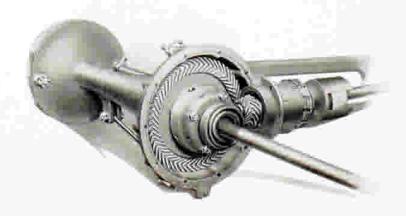
That is why many of the chief motor car manufacturers in England and France are making them standard on their cars.



CITROEN BEVEL GEARS HERE TOP BACK-AXLE DRIVES IN MOTOR CARS.



MOTOR CAR BACK-AXLE



For those Engineers who have been interested in the foregoing information and photographs, and who wish to obtain further particulars regarding Citroen Gears, we have included the following pages containing

"Useful Information"

This section will be of assistance in obtaining a more detailed knowledge of our gears, and will be useful when sending enquiries and orders.



USEFUL INFORMATION

PITCHES AND SIZES.

One of the main advantages of Citroen Gears is that the pitches are not standardised. The cutters we use enable us to introduce any pitch to suit a given centre distance. This is why Citroen Gears are equally satisfactory for every installation in which they are used, because there is never a question of approximation.

This also accounts for the fact that we do not make gears to stock sizes, nor can we issue Price Lists.

Owing to the special nature of our cutters, our pitches are limited to certain minima, which are approximately \S'' for cast iron and gun metal, and \S'' for steel. On the other hand, we are in no way limited so far as the maximum is concerned.

With regard to diameters, our largest machines are capable of dealing with wheels up to 30° in diameter, whilst the width of face is practically unlimited.

The usual proportion adopted between pitch and width of face is as follows:

For Spur Gears the face should be at least 3½ to 4 pitches wide. For Bevel Gears the face should be 2½ pitches wide.

MATERIALS.

As Citroen Gears run silently at all speeds the use of soft materials is not necessary and they are, therefore, always made in hard materials. These are Cast Iron, Steel and Gun Metal or Bronze.

We have given our serious attention to the question of materials used in the manufacture of our Gears, and we have restricted our sources of supply in such a manner as to be certain that we obtain the very best quality only.

Our long experience has shown us what are the most suitable steels for cutters and the method of treating these so that we can cut the



USEFUL INFORMATION Continued

hardest materials. The following are our usual combinations of materials for wheels and pinions:

Cast Iron Wheel with Forged Steel or Gun Metal Pinion.

Cast Steel Wheel with Forged Steel Pinion.

Our Rolling Mill Pinions are made either of Cast Steel or Forged Steel

For our Motor Car Gears we use heat-treated Steel, such as B.N.D.

DOUBLE HERRINGBONE GEARS.

Double Helical Gears should run with the apices of the teeth in the direction in which the load is being transmitted, as the pressure is first

transmitted at the strongest part of the tooth of the pinion, viz.: the apex. They will last longer in this way than if run in the opposite direction.

It follows, therefore, that if gears are called upon to transmit the same load in both directions, the teeth will wear out sooner on one side than on the other. To overcome this, Citroen Gears can be made with Double Herringbone teeth with three sections, which present an apex on both sides, and thus equalise the wear in reversing gears.

Citroen Double Herringbone Gears are now being used to a great extent in Winding Engines, Steering Gears, Rolling Mills and other installations necessitating frequent reversal.



SHROUDED TEETH.

Thanks to our method of cutting we can produce Citroen Gears with shrouded teeth when considerations of strength demand.

The shrouds are solid with the teeth, so that maximum strength is obtained.



USEFUL INFORMATION Continued

Citroen Gears can be shrouded either to pitch line or to the top of the teeth



The latter method is adopted in the case of pinions having a small number of teeth or if the pinion-bore is large as compared with the diameter.



The shrouding of teeth to pitch line is almost always adopted in the case of Rolling Mill Pinions, and frequently in Rolling Mill drives and other transmissions where shocks and heavy pressures are encountered. (See Rolling Mill Section, pages 35 to 37.)

PINIONS SOLID WITH SHAFTS.

When using high-ratio single-reduction Citroen Gears, excessive diameters of the wheels can be avoided by making the pinions solid with their shafts, thus considerably reducing their size.



The minimum diameter of such a pinion will generally depend upon the shaft diameter required to transmit the given horse-power at the given speed.

Our pirion-shalts are supplied machined to our clients' specifications.



USEFUL INFORMATION Continued

WHEELS IN HALVES.

To suit certain installations and to overcome the difficulties of transport where very large wheels are concerned, Citroen Gears can be made in halves. In this respect they have a distinct advantage over



straight-toothed gears, because the joint in the rim of Citroen Gears has the exact shape of a double helical rooth, which causes the two halves to interlock. Thus the strain on the assembling bolts, which is so prominent in straight-toothed Spur Gears, is greatly relieved in the case of Citroen Gears.

In the case of railway transport, users of very large gears will have experienced the difficulty in obtaining special trucks for gears of large diameter, and many railway companies will not even take gears over 10' in diameter, on account of the limits imposed by bridges and ninnels.

Citroën Gears in halves have in all cases machined joints and turned and fitted bolts and their erection offers no difficulty

For the purpose of cutting facilities, our wheels in halves should preferably have an even number of teeth.

RACKS.

The latter point is of great

Citroen Gear cutting machines are adaptable to the cutting of Racks for large Planing Machines, Tilting Machinery, etc.

Their advantage lies in greatly increased strength greater durability, and, last but not least, their continuous and smooth running. importance in Planing

Machines and other large tools, where the vibration set up in ordinary racks is very detrimental to the quality of the work turned out



USEFUL INFORMATION-Continued:

ERECTION OF CITROËN GEARS.

In other parts of this Album we have demonstrated with what accuracy and care Citroen Gears are manufactured, and it naturally follows that if the great advantages which clients have the right to expect from our gears are to be realised, their erection should be carried out with equal care.

The following suggestions will be of assistance to clients who appreciate this fact.

HINTS COMMON TO SPURS AND BEVELS:

Meshing of the Teeth. The pinion and the wheel should be meshed together according to the marks which will be found on one side of the teeth, viz.: tooth No. I on one wheel should drive tooth No. I on the other. The teeth should be engaged without back-lash, but jamming must be avoided.

Bearing of the Teeth. The teeth should bear on their whole length.

Shafts. The shafts must be a good fit in the bores, so that the wheels will run true.

Lubrication. Lubrication by grease is sufficient for peripheral speeds up to 1,600 feet per minute, but above this speed it is advisable to run the gears in oil.

HINTS PARTICULAR TO SPUR GEARS.

Shafts. Must be level and parallel. If at all possible, they should be supported by bearings on both sides of wheel and pinion. The centre distance should be adjustable.

Teeth. The surface of the teeth must be level.

Side Play. End play in the shafts should be eliminated, as it tends to rapidly wear the teeth.

HINTS PARTICULAR TO BEVEL GEARS.

Side Thrust. This must be taken up by means of substantial collars or side-thrust ball bearings, fitted right against the corresponding bearings, so as to allow of no side play in the shafts.

Bearings. Whenever possible, bearings should be fitted immediately behind the wheels. Overhanging of gears should be avoided.



USEFUL INFORMATION Continued.

PACKING.

We do not use packing cases except for small gears and for pinions. The machined parts of our large wheels are suitably protected by woodwool and straw plaiting, even for shipment abroad. We find from experience that owing to the shape of gear wheels this method of packing is preferable to using cases.





PARTICULARS REQUIRED FOR QUOTATIONS

We invite our clients to give careful attention to the following paragraphs, for by so doing, their transactions with us will be greatly facilitated.

Under the heading "Pitches and Sizes" on page 57, we have given the reason why we carry no stock and have no price lists. After 14 years' experience in the exclusive manufacture of Citroen Gears for all purposes, we are fully aware of the requirements in every case. For this reason we strongly recommend our clients, whenever possible, to leave us a free hand in our proposals for Citroen Gears, whilst giving us as much information as possible regarding the drive they have under consideration.

In this respect we draw our clients' attention to the fact that the formulæ used in the calculation of the proportions of Citroen Gears vary according to the nature of the drive, which shows how essential it is, when sending us their enquiries, that our clients should always mention for what purpose the gears are wanted.

With regard to the material to be used for the gears, this also should preferably be left to our judgment, as it does not only depend upon the nature of the drive, but also upon the advisability of having well-proportioned gears.

We are aware that we are often called upon to quote for gears which are to replace existing ones. In such cases we are always glad to know the sizes and proportions of the existing gears, but here again the nature of the drive and full particulars should be given us, if a suitable and economical proposal is to be expected.

Apart from the Nature of the Drive, we invariably require the following particulars:

The Horse-power (both normal and maximum in the case of variable loads).

The Number of Revolutions and Ratio. With regard to the latter, our clients should bear in mind that it is very often possible to use a single set of high ratio Citroen Gears, where a double-reduction ordinary gear would be necessary.



- The Centre Distance (if fixed). If the centre distance is in no way limited, our clients are recommended to leave us entirely free to determine it ourselves.
- The Bores. Although during the enquiry stage an installation may not be sufficiently definite for the exact bore of wheels and pinions to be decided, yet an approximation is desirable, as the bores may play an important part in the calculation of our gears. This refers particularly to the pinion, the bore of which may completely govern the sizes and proportions of the whole of the gears.
- Arrangement of Drive. It is advisable that we should know how it is intended to fit our gears, or, in cases where our gears are to replace others, how the old ones were fitted, and for this purpose it would be of great assistance if clients would send us drawings showing how the gears are erected. Our experience in this respect is always at the disposal of our clients and if faced with installations which are not quite satisfactory, we will gladly advise as to alterations, or, if no alterations are possible, we should design our gears in such a manner as to obtain the best possible results under existing conditions.





PARTICULARS REQUIRED FOR ORDERS.

When sending us their official orders, our clients are requested to supply us with the following information:

- The exact sizes of the bores. For these, accurately machined gauges should be sent us as soon as possible. (See further remarks below.)
- 2. The number and sizes of keyways.
- A sketch showing the direction of rotation and also showing the side from which the keys are to be driven.

GAUGES.

With regard to the above-mentioned Gauges for the bores, we cannot too strongly emphasise the necessity of these being of the greatest accuracy. In fact, it would not be possible to obtain the high efficiency, the silent running and the long life which we claim for our gears, unless they run perfectly true on their shafts, and the latter condition can only be achieved by the use of perfect gauges



We illustrate above the type of gauge which we have found most suitable for this purpose and which we have therefore standardised in our works: of all gauges sent us by our clients, duplicates are made by us for future reference, and they are made of this type, which we consider more reliable in use than gauges of the pin type.

It will therefore be to the advantage of all parties if our clients will supply us with gauges as illustrated.





TERMS AND GUARANTEES.

ORDERS.

Orders are only put in hand on receipt of official order containing full information (See page 65).

GUARANTEE.

All our gears are covered by a twelve (12) months' guarantee against faulty material, workmanship and construction, and we undertake to replace or make good all gears found defective for any of these reasons. Our guarantee is, however, strictly confined to the gears themselves and on no account do we undertake contingent liability.

DELIVERIES.

Our delivery period starts from the date on which we are in possession of full particulars enabling us to put orders in hand. In cases where manufacturing drawings must be submitted for approval, the delivery period will take effect from the date on which our drawings have received approval. The delivery period terminates on the day of despatch from our Works.

It is our aim to supply our goods within the promised period, but we do not undertake any responsibility for late deliveries, nor do we accept orders containing a penalty clause for late delivery.

Delays caused through strikes, faulty castings and other cases of force majeure will on no account justify the cancellation of an order.

All goods are forwarded at client's risk, even if sent carriage paid.

PACKING

We make no charge for packing either for Home or Export Orders (see page 62).

PAYMENTS.

Our accounts for home orders are payable at end of month following delivery, less 25% cash discount. Overdue accounts are strictly net.

For export orders, payments are to be made cash against shipping documents.

REPRESENTATIVES.

Arrangements entered into by our representatives will become binding only after our official acceptance.



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