FINAL REPORT No. 251
ITEM No. 25

GERMAN LANDING GEAR, DESIGN AND TESTING

BRITISH INTELLIGENCE OBJECTIVES
SUB-COMMITTEE

LONDON - H.M. STATIONERY OFFICE

GERMAN LANDING GEAR DESIGN, AND TESTING

Reported by

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BIOS Target Numbers
C25/554, 25/203, C25/560,
25/110.

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TABLE OF CONTENTS

Personnel of Team

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1 Object of Investigation

The object of the trip was to ascertain German experience of aeroplane undercarriages and their methods of design, testing and manufacturing them. Enquiries were also made about their methods of testing wheels for strength. The design and testing of wheel brakes will be covered in a separate report from the Wheel Brake Team. During the trip preliminary information was obtained about the German aeroplane tyre industry in order to decide the targets for the aeroplane tyre team which will submit a separate report.

2 Summary of Conclusions

2.1 General. The relations between the aircraft and undercarriage firms and the German Air Ministry developed in much the same way as in this country. Their experience, generally, was similar to our own except for the troubles due to higher landing speeds described in the next paragraph.

2.2 Outstanding troubles. Their outstanding trouble had been due to the very high landing speeds - up to 150 m.p.h.- which caused large drag forces due to spinning up the wheels at touch down which in turn caused the shock absorbers to jam, so making the tyres "bottom" and collapse. The trouble was overcome by a combination of fairly small changes but it led to serious proposals to spin up wheels before touch down.

2.3 Design requirements. The German design requirements specified higher standards of energy absorption and strength than those used in this country. For some time they have had a requirement specifying that the energy to be absorbed between proof and ultimate conditions is to be at least 50% of that absorbed at proof conditions.

2.4 Structure. German methods of construction followed orthodox practice generally except for their much wider use of welding including flash welding. In this respect they were much more advanced than British practice and probably as much so as American.

3. Targets and Personnel visited

3.1 The main targets visited were:

Date	Firm	Personnel	
25/10/45 and 31/10/45	V.D.M. Luftfahrtwerke, A.G., Grossauheim, Near Hanau.	Dr. Waibel Dr. Tonges	C25/554

Date	Firm	Personnel
27/10/45 and 29/10/45	Elma G.m.b.H., Waiblingen, Near Stuttgart.	Dr. Michael 25/203

3.2 Short visits and enquiries were made at the following targets:-

25/10/45	V.D.M. Heddernheim	Herr Pleimes C25/560
26/10/45	Hutchinson Gummi Werke, Mannheim.	Dr.F.Huslacher
29/10/45	Elektron G.m.b.H., Bad Canstatt, Stuttgart.	Ch.Ing.Burkhardt 25/110
30/10/45	Veith Gummi Werke, Höchst in Odenwald.	Herr Turner
1/11/45	Deutsche Dunlop, Hanau.	Dr.Kramer Herr Fitjer(Late Landing Gear Specialist of Rechlin).

4. General. Design and Development Procedure

4.1 Undercarriages. In Germany the relations between the Air Ministry, the official technical establishments and the aircraft and undercarriage firms developed on very similar lines to those in England. The aircraft firms relied on specialist firms to design and make the landing gear shock absorbers, the three specialist firms being V.D.M. at Grossauheim, Elma at Waiblingen and Kron Prinz at Solingen. V.D.M. and Elma designed and produced the prototype shock absorbers, generally of the oleo pneumatic type and each had several subcontractors which put them into production, the workshops of the parent firm concentrating on the production of one or two types only. V.D.M. and Elma also designed and produced components for aircraft hydraulic systems. Kron Prinz specialised in the "ring spring" types of shock absorber which were heavy but were popular among operators because no maintenance was required. Towards the end of the war, however, Kron Prinz started to develop oleo pneumatic shock absorbers but their experience was limited. In principle, aircraft firms were free to choose their specialist firm but from about 1943 the Air Ministry directed new designs to particular firms.

As in England, the aircraft firms produced layouts for their undercarriages. The detail design and particularly that of the shock absorber was developed by the specialist firms.

4.2 Aircraft Wheels. The design, testing and production of aeroplane wheels was done by V.D.M. and Elektron of Bad

Canstatt, from which Elma, Waiblingen was an offshoot in 1942.

4.3 Aircraft Tyres. The design and development of aircraft tyres was done by three firms, viz. Continental at Hanover, Dunlop's at Hanau and Phoenix at Harburg. Several other firms made aeroplane tyres but they worked to drawings or instructions from these three firms.

5 V.D.M., Grossauheim, Near Hanau

5.1 General. This firm was also known as Continental Metal, A.G., and it made landing gear shock absorbers, wheels, brakes and hydraulic equipment. The factory was started in 1942 when the firm separated from the parent organisation, V.D.M. at Heddernheim. The Director was Dr. Waibel and his Chief Technical Assistant was Dr. Tönges, both of whom were interrogated.

The technical staff comprised 25 draughtsmen and 12 technicians employed on stressing or testing work, 10 or 12 fitters were engaged on testing work. All the design work and testing was done at Grossauheim where all prototypes were made; there were 8 or 10 subcontractors producing components to their designs. Apart from hydraulic equipment the production at Grossauheim was concentrated chiefly on Ju.88 undercarriages of which 450 were made per month; nose wheel units for He.219 and Me.162 were also in production there.

V.D.M. designed landing gear for the following types of aircraft:-

Main undercarriage and tailwheel unit

Me.110
Fieseler Storch

Main undercarriage and nosewheel unit

He.219 (night fighter tricycle)
He.280 (jet tricycle limited number)

Main undercarriage

Ju.88, 188 and 388 (Kron Prinz ring spring tail-wheel unit)
Ju.52 and 252
Me.210 and 410 (Elma and Kron Prinz tailwheel units)
Me.163 (skid undercarriage)
F.W.189
He.111 (tailwheel unit was Heinkel with Kron Prinz rings).
He.177 Shockabsorber unit

Nosewheel Unit

He.162 (jet fighter, main undercarriage was Elma unit as for Me.109)

5.2 Plant

5.2.1 General. The workshops were well equipped with machine tools of general purpose types; there were not many special purpose machines. The plant included heat treatment, welding and chromium plating equipment and material testing and chemical laboratories in addition to equipment for testing hydraulic components, wheels and undercarriages.

Little damage was caused by bombing but the hydraulic machine-shop, the development shop and part of the design offices, comprising roughly 40% of the plant were wrecked by American artillery fire at the crossing of River Main. Some of the remaining machine tools have been removed and American Army is taking over part of the plant for vehicle repair work.

5.2.2 Welding. The plant was well equipped for welding and there was a Siemens flash welding machine which had been in use for production of Ju.88 main undercarriage units for about six months. The flash weld joined two portions of the outer cylinder of the shock absorber and the production time per joint was five minutes compared with one hour 20 minutes per joint when this was made by arc welding previously. The steel was stated to have an ultimate strength of 57 to 67 tons per square inch and [illegible] to have been of the chromium manganese type (without molybdenum). They had tried a stronger steel having an ultimate strength of 76 tons per square inch but the welding was found to be too difficult.

The maximum force which could be exerted by the machine was 20 tons and the sectional area which could be welded was stated to be about 15 square inches for soft steel and about one-half that area for high tensile steel.

According to the chief engineer very extensive tests had been made on flash welded specimens before the method was adopted for production and they had had no troubles with it in service. The records of the firm were badly damaged so that it will probably be impossible to obtain the results of their tests. It is not known whether their welding specialist could be traced.

The plant included X-ray equipment which, according to the chief engineer, was used at earlier stages for radio examination (photographic) of welds made. Towards the end of the war, however, only 40% of the welds were X-rayed.

5.2.3 Test Equipment. They had had two drop testing machines of the vertical slider type; the larger had a capacity of 16 tons. Both had been destroyed and only the wreckage was seen. The machines were equipped with air cylinders which could be used to simulate wing lift, but frequently these were not used and the weight was corrected to represent airborne conditions as in British practice.

It was stated that wedges were used to simulate drag loads, but Herr Waibel, whom we interrogated, was uncertain what angles were used. He said that it depended on characteristics of the aircraft but he did not know what these were.

Measurements made were:-

(i) Total travel through a pulley (reducing) system by a direct pencil record on a rotating drum.

(ii) Axle travel by a similar method, when required.

(iii) Vertical reaction by a hydraulic pressure unit or by a piezoelectric unit (with Cathode ray recorder) when finer measurements were required. These measurements recorded the reaction direct by placing the units on the ground or between the undercarriage and the mass above it.

Another machine was being constructed by Schenk of Darmstadt which would permit drops on to a rotating drum.

5.3 Shock Absorbers

5.3.1 Design of shock absorber. The early type of shock absorber made by this firm was the "Faudi" or V.D.M. type which uses air only as in the Avro Anson type of unit (see Fig.1). A unit of this type was designed recently for the He.177 main undercarriage. Generally, however, the typical design of this firm was as shewn in Fig.2, and is similar to some British types. The orifices were originally in the form of slots in the ram, (e.g. Me.110), but latterly a plain drilled orifice was used as this was found satisfactory for most purposes and eased production.

Another type of shock absorber used was an alternative design for the He.177 main undercarriage and is as shown in Fig.3. Grease was used in place of the more conventional hydraulic fluid in this unit chiefly because the latter was in short supply. It was also stated to leak less under the conditions of zero pressure which apply to this type of unit under static conditions.

Compression ratios were 3 or 4 to 1 for main undercarriages and 8 or 11 to 1 for nosewheel units. Normal pressures, fully extended were in the region of 12 to 20 ~~atmos~~ atmospheres but for articulated units pressures as high as 70 to 80 ~~atmos~~ atmospheres had been used.

Oil compression units had been considered but not pursued due to gland troubles and lack of time for development. Orifice sizes were generally determined empirically and confirmed by drop testing.

5.3.2 Shock absorber construction. Apart from the use of welding mentioned in paragraph 5.2.2 their methods of construction are orthodox by British standards. Towards the end of the war they received considerable pressure from the German Air Ministry to simplify the job in order to cut down production times. The use of hard chromium plating for sliding tubes was maintained however. Generally their landing gear units appeared to be heavy by British standards.

6. Elma G.m.b.H., Waiblingen, Near Stuttgart

6.1 General. This firm made landing gear shock absorbers and hydraulic equipment; it was originally a part of Elektron G.m.b.H., at Bad Canstatt, from which it separated in 1942-1943 when it moved to Waiblingen. The Director was Herr Michael who was interrogated.

Their design staff numbered 40 - 50. All the design work and testing was done at Waiblingen where all prototype units were made. There were several subcontractors producing components to their designs but apart from hydraulic equipment the production at Waiblingen was concentrated chiefly on F.W.190 and the F.W.152 which was developed from it by Professor Tank. The production rate at Waiblingen was 1,000 undercarriage units per month and 500 tailwheel units per month which was achieved by 198 men.

The design and production of wheels and brakes remained at Elektron, Bad Canstatt where the responsible technical staff were the Director Dr. Eisemann and Ing. Burkhardt.

The most recent units designed at Elma were:-

Main Undercarriages	Nosewheel Units	Tailwheel Unit
Me.109	Do.335	Me.210-410
FW.190	Me.262	
FW.152	Ar.234	
Do.335		
Me.262		
Ar.234.		

The firm's policy was to install ample test equipment.

6.2 Plant.

6.2.1 The workshops were well equipped with machine tools of general purpose types. There were not many general purpose machines. The plant included heat treatment, welding and chromium plating equipment and testing laboratories. The plant is undamaged but the records have been looted. The factory is under the control of the Military Government at Waiblingen and the German management has been turned out.

6.2.2 Welding. The plant was well equipped for welding and there were two A.E.G. flash welding machines, the smaller of which was stated to have been in use for production jobs since 1939-1940. For some time it had been used regularly for FW.190 main undercarriage units for which the steel was stated to have an ultimate strength of 57 - 67 tons per square inch (Specification No.1604) and was of the chromium manganese type (without molybdenum). The maximum force of the smaller machine was about 15-20 tons and the sectional area which could be welded was 8-10 square inches for soft steel and 4-5 square inches for high tensile steel. The larger machine was stated to be one of the three largest flash welding machines in Germany; it was installed but not quite ready for use. Its maximum force was 50 tons and the nominal rated capacity was 31 square inches for soft steel.

According to the chief engineer very extensive tests had been made on flash welding before it was adopted for production, particularly to ascertain the best timing sequence and "squeeze"; they had had no troubles with it in service. They found that generally pressures required were about 1.9 tons per square inch for soft steel and 3.8 tons per square inch for high tensile steel.

As already stated the records of the firm were looted so that it will probably be impossible to obtain reports of their tests. It is not known whether their welding specialist could be traced.

6.2.3 <u>Test Equipment</u>. The only machine in use up to the end of the war was a small machine of 2-3 tons capacity. It is of the vertical slide type and was not equipped for wedge drops as there was very little bracing. It was used for development work only, and when Elma were satisfied with the performance of a unit it was sent to Rechlin for official tests.

Provision was made for fully airborne tests with air cylinders.

The only measurements made were reaction (by a hydraulic unit on the ground) and total travel by a rack and pinion device. The records were made on a rotating drum driven by a synchronous motor. No electronic measuring apparatus had been tried and Dr. Michael was not in favour of this type of measuring apparatus.

The new test building had been constructed to contain two drop testing machines, a 150 ton press and a pulsator for fatigue tests. The two drop testing machines were to be arranged on [redacted]carriages so that either could be used to drop test units on to a central rotating drum of 3 metres diameter or on the ground. The machines were made by Karl Schenk of Darmstadt; the largest drop mass of the smaller machine was 5 tons and of the larger machine 20 tons. The 5 ton machine had been delivered but not assembled. The 20 ton machine was stated to be under construction. Its height was said to be about 12 metres. The 150 ton press was being made by M.A.N. of Nuremburg. The pulsator was being made by Losenhausen of Dusseldorf.

A testing machine was used for repetition tests on the sealing rings of shock absorbers and jacks. The stroke was 400 mms. but the machine was arranged so that smaller strokes than these could be used. The normal endurance test was taken as 10,000 strokes.

6.3 <u>Shock absorbers</u>

6.3.1 <u>Design of shock absorbers</u>. The general type of shock absorber design was similar to that made by V.D.M. (Fig.2), but they had also developed a neat design of a type not seen much in this country (Fig.4). Its main advantages were stated to be ease of production and small hydraulic fluid content.

The use of grease was not favoured by this company as no advantages could be seen and filling would be difficult with the types of unit manufactured by this firm.

Orifice sizes were determined from the shape of the load deflection curves required (Method not stated but probably similar to that in use in Britain).

Dr. Michael had previously done some work on prediction methods which had been published in "Luftfahrtforschung" 1937, but it seemed that little work of this type had been carried out by the designers of undercarriages during the war period. It was stated that the theoretical investigations had been continued by D.V.L. (Kochanowski) but there had been little contact with industry.

Dr. Michael was of the opinion that the law governing the compression of air in shock absorbers was neither simply adiabatic or iso-thermal, but that the value of n in the equation pv^n = constant started at 1.3 at the beginning of the stroke and decreased to 1.0 at full compression. No experimental confirmation of this was given.

6.3.2 <u>Shock absorber construction.</u> Apart from the use of welding mentioned in paragraph 6.2.2 their methods of construction are orthodox by British standards. Towards the end of the war they received considerable pressure from the German Air Ministry to simplify the job in order to cut down production times. An alternative method of making FW.190 undercarriages had been introduced in which the outer cylinder was flash welded in two places and was built up from a circular section by bosses attached by welding in place of the original forged version. The FW.190 shock absorber contains an interesting form of self aligning bottom bearing made up of rocking segments. Honing operations were omitted altogether and ground bores were used. The hard chromium plating 1/100 - 2/100 mm. thick was retained, however, on the sliding tubes. As an example of low production times the Me.262 shock absorber and jack were being made in a total time of 100 man hours by one of their subcontractors -

Opel, Frankfurt. Generally their landing gear units appeared to be heavy by British standards.

7. Landing gear design

7.1 Miscellaneous outstanding problems

7.1.1 It appears that the effect of large drag forces at touch down due to spinning up of the wheels has recently become a serious problem. The Germans consider that this was mainly due to the high landing speeds of their aircraft compared with those of the British - they quoted figures of 200 - 220 k.p.h. for their jet aircraft.

The drag forces thus persist for a considerable time, during which the shock absorbers are jammed by friction effects resulting from the drag component, so that the whole impact of landing was taken on the tyre. This resulted in bottoming of the tyre and subsequent failure.

This state of affairs was almost catastrophic on Me.262 at first, on which only a few (5 or 6) landings could normally be made before tyre failure occurred. Ar.234, FW.190 and other aircraft were mentioned as having high failure rates from this cause.

Some mention was made of the fact that inexperienced pilots tend to land tricycles faster than necessary which accentuates the problem.

Two approaches were made to the solution of this problem. Firstly steps were taken to improve the functional qualities of shock absorbers under drag conditions, and to increase the tyre strength, and secondly, they were trying out the possibilities of spinning up the wheels before landing.

The first mode of improvement met with some success. In the case of the FW.190, increased shock absorber bearing centres, a special lower bearing, and repositioning of the torsion links in front of the leg produced a substantial improvement. In the case of the Me.262, tests showed that by lowering the tyre pressure* and increasing the

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* It is not understood why this reduction of tyre pressure (from 75 to 60 p.s.i) should have resulted in much improvement. It is suspected that it may have been made simultaneously with a reduction of shock absorber pressure. (See interrogation report of Herr Helmschrott) and some mention was also made of centrifugal effects on tyre stiffness which they thought was increased at speed.

number of plies in the tyre a more satisfactory state of affairs could be obtained.

The second mode of improvement (i.e. pre-rotation of the wheels) had not been fully explored. The general opinion was that electric or hydraulic motors, although they do the job effectively, are too heavy and complicated for general use, and they thought that a flapping type of vane as projected for Me.262 production was a better solution. This had been flight tested at Rechlin and gave peripheral speeds of 140 k.p.h. for an approach speed of 250 k.p.h.

General opinion had not crystallised on the best line of attack. Improvement in under-carriage layout was regarded as the best solution but failing this prerotation of wheels was considered desirable, but not at the expense of excessive complication. (N.B. From a cursory inspection of some drawings it appears that their bearing centres are short compared with British practice and it is our opinion that this is responsible for much of their difficulty). When asked about reduction of abrasive wear due to spinning up they said that such wear would be reduced, but it was clear that their main problem was to prevent failure of the tyre by bursting for the reasons described.

The general adoption of drop testing machines which could operate on to rotating drums was a clear indication of the importance of this problem to the Germans.

7.1.2 Nosewheel strength and energy absorption criteria appeared to be in an unsatisfactory state. None of the undercarriage personnel interviewed had much information on the way in which these were determined, but the failure rate of nosewheels was apparently not serious.

7.1.3 Shimmy. Nosewheel shimmy had caused a certain amount of trouble which was cured by hydraulic shimmy dampers. V.D.M. said they always incorporated hydraulic shimmy dampers in their designs, and the fluid was removed from these during prototype tests to determine whether it was necessary to embody dampers in production units.

Theoretical studies of shimmy had been made by Professor Fromm of the Technical High School, Aachen and a professor of the Technical High School, Darmstadt, according to information received. Professor Kamm of Stuttgart Technical High School had been involved in much practical work on the problem.

7.1.4 Me.163 Skid undercarriage. This proved unsatisfactory for two reasons:-

(i) The aircraft was immobile after landing which resulted in congestion of the landing strip.

(ii) The skid was harsh in operation and had caused injury to the pilots on landing. This was partly due to the absence of the cushioning effect obtained from the tyre, and partly due to the complicated shock absorber-retraction jack combination which limited the initial flow of fluid in a manner difficult to overcome. Experience had indicated that accelerations of the order 6g were experienced fairly often at touch down, and a special sprung seat was introduced to reduce injury to the pilot.

7.2 Landing gear layout

The Germans' unfortunate experience with the large drag forces at touch down mentioned in paragraph 7.1.1 has coloured their outlook on undercarriage layout. Both firms visited expressed a preference for articulated arrangements in which the shock absorbers would function when large drag forces are present. For the same reason, presumably, the opinion was held that the best setting for a cantilever unit was to incline it at about 20° (but not more than 25°); the importance of obtaining adequate "overlap" was recognised.

For nose wheel units the best inclination for cantilever units was regarded as 12° - 15°.

7.3 Landing gear requirements.

These were stated generally in "Bauvorschriften für Luftfahrzeuge", last issued in 1938, and which had been amended from time to time. We were unable to obtain a copy of this or of the relevant amendments. These requirements were issued by Prufstelle für Luftfahrzenge. Berlin-Adlershof and the chief man concerned was Oberstabsinginieur V.Pilgrim. The man concerned with the undercarriage side was Fl. Haupting Kaspereit.

Such information as was obtained on the undercarriage requirements is given below

7.3.1 Vertical velocity and energy absorption. The original requirements defined the vertical velocity as corresponding to the sinking speed of the aircraft at stalling speed, engine off. When this became too large to be practicable, a certain percentage, generally 60% to 90% was laid down by D.V.L. for each aircraft according to its duties. (As the aircraft weight increased and it was no longer possible to meet the requirements, arguments ensued over the percentage of stalling sinking speed to be used).

This velocity determined the limit landing condition.

The energy absorption was then based on this velocity and the static load on the undercarriage; airborne conditions were assumed. In addition it was only required that 50% additional energy should be absorbed between limit and ultimate conditions.

It appears that the energy absorption conditions only needed to be proved under conditions of zero drag and side load.

7.3.2 Strength under landing conditions. For the main undercarriage there were three main stressing cases as shewn in Fig 5. The maximum vertical reaction, P, was determined through the required energy absorption and available stroke, which was given by the aircraft firm. In general P was between 3 and 4 times the static load on the undercarriage.

An ultimate factor of 1.5 was required on limit loads for ultimate strength on the undercarriage and a factor 1.8 to 2.0 on the rest of the airframe. A factor of 1.35 was required on the structure for limit conditions. There was also a drift landing case of which no details were obtained.

7.3.3 Strength under taxying conditions. Two cases were mentioned but no details given. These were -

(a) Straight taxying at take-off weight.
(b) Curved taxying for which the side load had been doubled during the war years.

7.3.4 Tailwheel units. The tailwheel unit energy absorption was based on the static load above the tailwheel and the same velocity as the main undercarriage. No details were obtained on drag and side loads.

7.3.5 Nosewheel units. It appeared that requirements for nosewheels was still in a state of flux. The undercarriage firms stated that generally they were provided with a vertical velocity and energy absorption by the parent firm, and they thought some formulae were evolved for this purpose. At V.D.M. it was stated that nosewheel static loads were generally 8 to 10% of the aircraft weight and that the unfactored dynamic nosewheel loads were usually about ten times the static. No further details were obtained.

8. Aircraft wheels

8.1 General. The largest aircraft wheel and tyre combination made was 1600 x 600 mms., two of which were used on Ju.290 weighing 40 - 50 tons. This equipment was made and tried but not in large quantities. The German opinion was that as the size of aircraft increased designers would be more likely to use a greater number of small wheels than ask for larger wheel and tyre equipment. In a projected development of the Ju.290 it was intended to use four wheels, 1450 x 550 mms. for a static load of 14 tons per wheel.

8.2 Wheel strength. Two strength tests on wheels had been used, an endurance test and a static test. The endurance test was made with a tyre in place and the combination was driven by a drum standardised at 3 metres diameter for a distance of 2,000 k.m. at a speed of 30 k.m. per hour. It was understood that wheels rarely failed on this test but tyres did and stopping times were allowed for the tyres to cool.

The static test was made with the tyre deflated, the nominal factor required on static load being at least 5.0 and the strength achieved was usually much higher than 6.

Apart from wheel troubles due to overheating of brakes or to bottoming of tyres, German aeroplane wheels were stated ti have generally been satisfactory in service.

8.3 Wheel brakes. The design and testing of wheel brakes has been dealt with by the wheel brake team and will be covered by a separate report.

At Elektron G.m.b.H the opinion was held that their multiple disc type brake in which alternate discs were chromium plated and faced with "powdered iron" was far superior to the shoe brakes usually used.

9. Aircraft tyres

9.1 Design firms. It was ascertained that aircraft tyre design development in Germany was in the hands of three firms, viz.,

Continental, Hanover.
Deutsche Dunlop, Hanau.
Phoenix, Harburg.

Several other firms made aircraft tyres but they acted under the guidance and instructions of one of the three firms already mentioned. The aircraft tyre team is visiting these targets and a separate report will be issued.

9.2 Tyre troubles. In paragraph 7.1.1 particulars are given of German troubles due to the large drag forces arising from high landing speed. These troubles were shewn up at once by high tyre failure rates. Generally, Messerschmitt types gave most troubles with tyres because that firm consistently overloaded tyres in an endeavour to keep wheel size small for ease of stowage. The maximum tyre pressures in general use were about 4-5 atmospheres. No indication was obtained of any tendency to use higher pressures presumably because their aerodrome surfaces are not so good as in this country where much higher pressures are proposed.

FIG.1

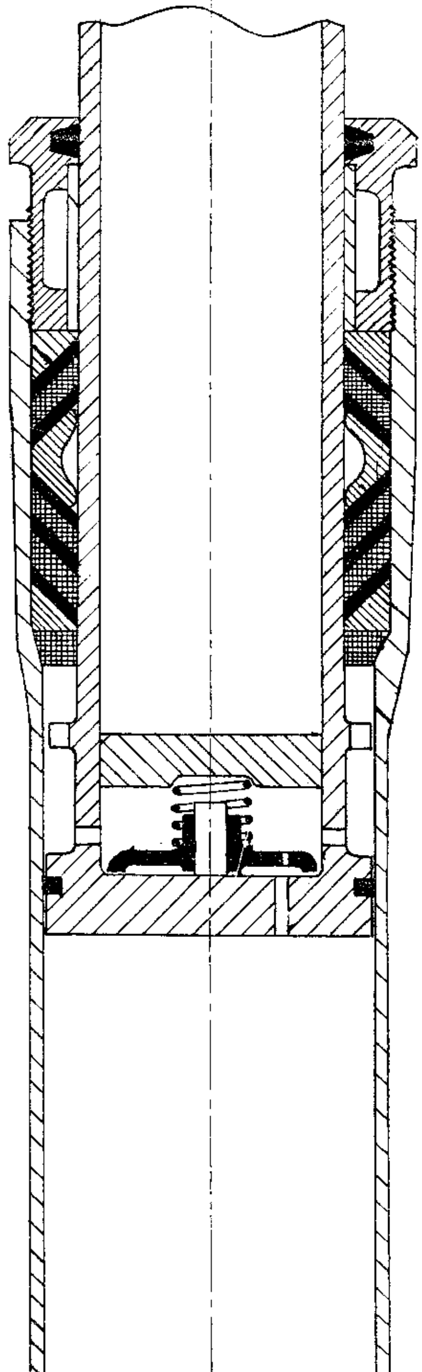
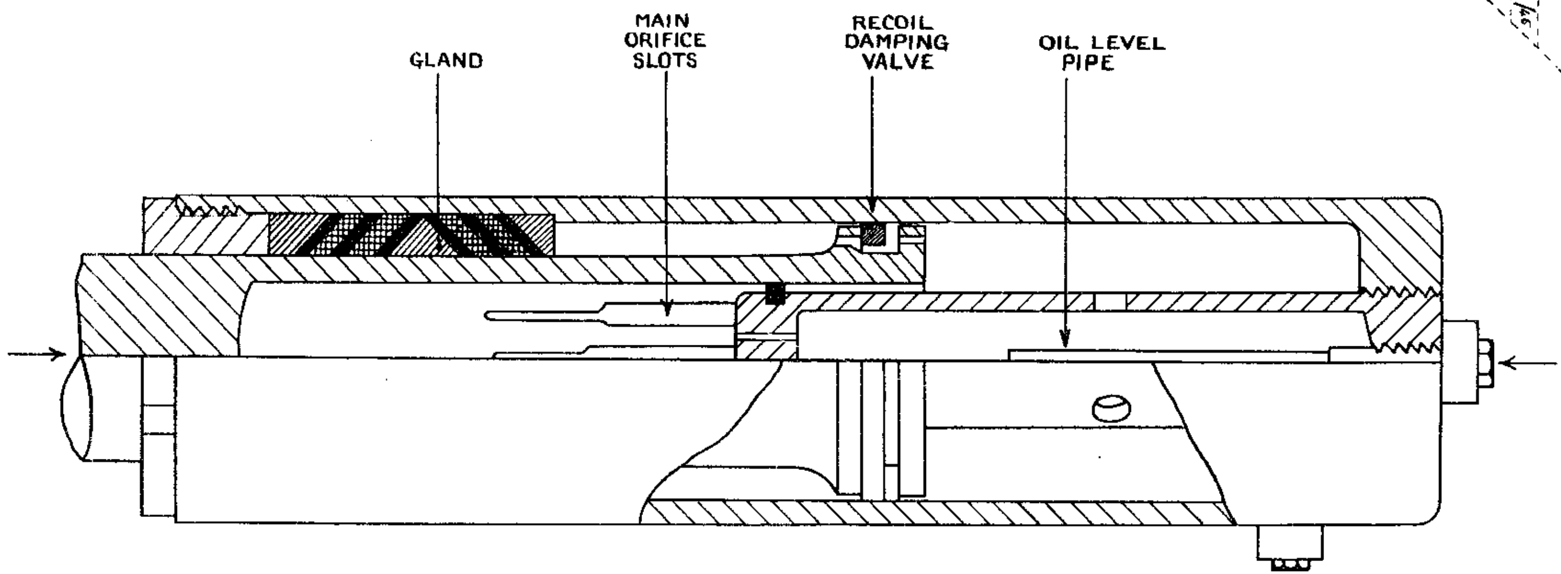


FIG 1 - 'FAUDI' (V.D.M) TYPE OF AIR COMPRESSION SHOCK ABSORBER.

Nº SME.14909/R.
DR.
TR. 14/12/46
CH.
APP.



DIAGRAMMATIC ARRANGEMENT OF ME. 110 SHOCK ABSORBER (V.D.M TYPE)

FIG 2.

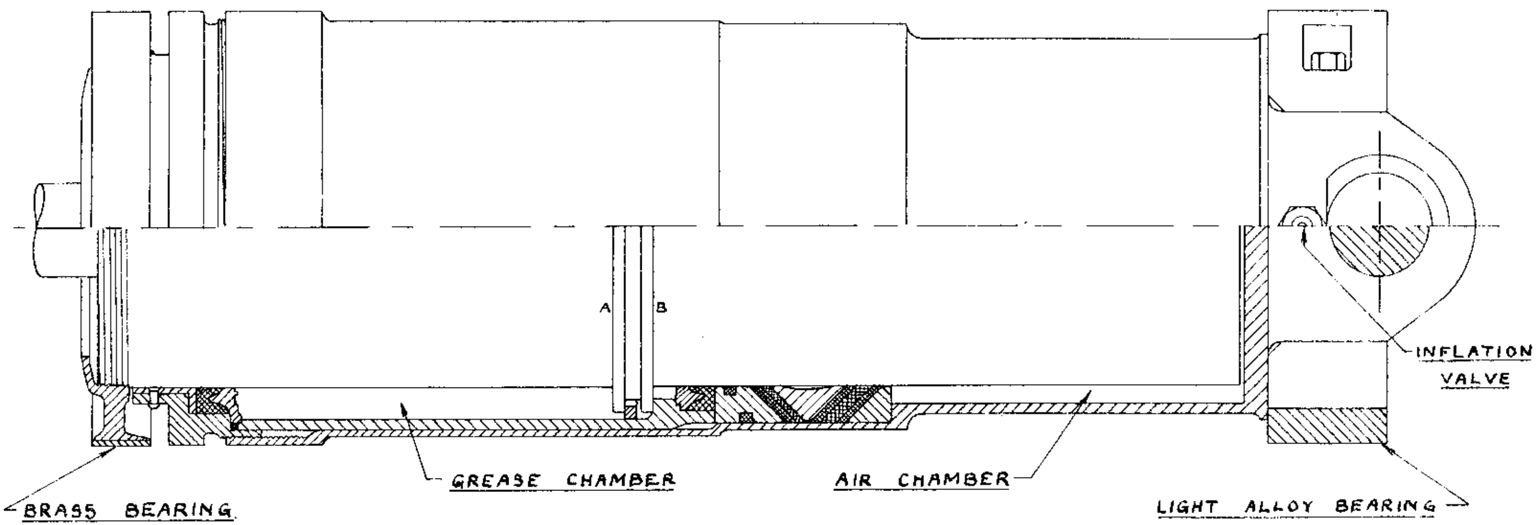
R

SME 7/5245/B.R.D.

SME 11073/R

SHOCK ABSORBER ELEMENT FROM H.E. 177 UNDERCARRIAGE

UNIT DRAWN IN FULLY COMPRESSED POSITION



Air Displacement Area = 19·1 ins.^{2}
Grease Displacement Area = 8·36 ins.^{2}
Orifices: Flange A - No. 53 Holes - 2 off.
Flange B - { No. 53 Holes - 2 off. / No. 34 Holes - 4 off.

APPROX. HALF SIZE.

FIG. 3.

Nº S.M.E. 14901/R.
DR.
TR.M.H. 13/12/45
CH.
APP.

FIG. 4.

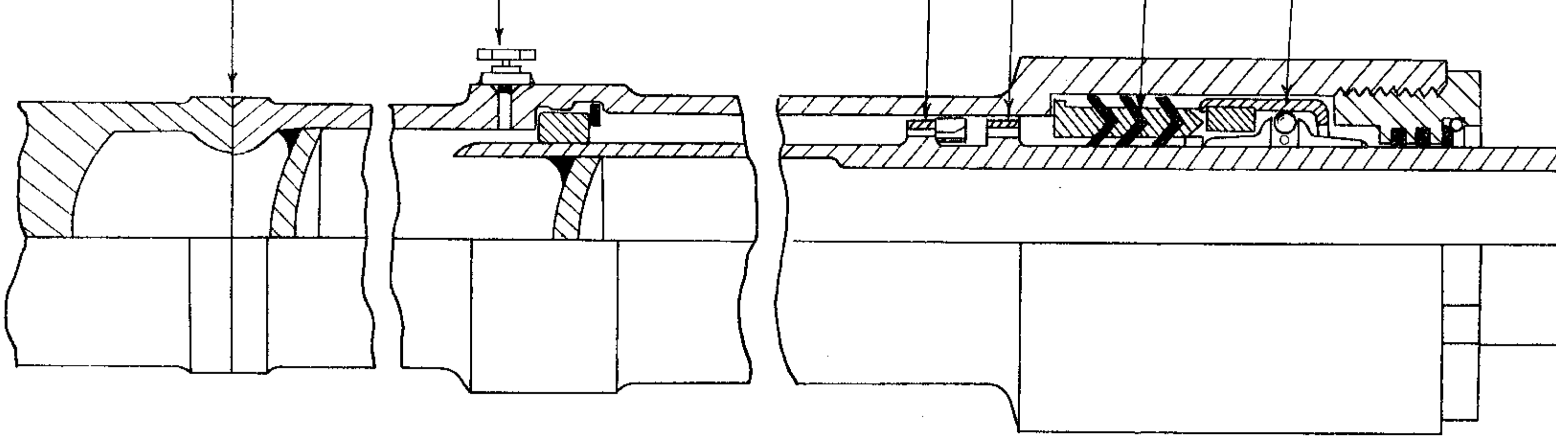
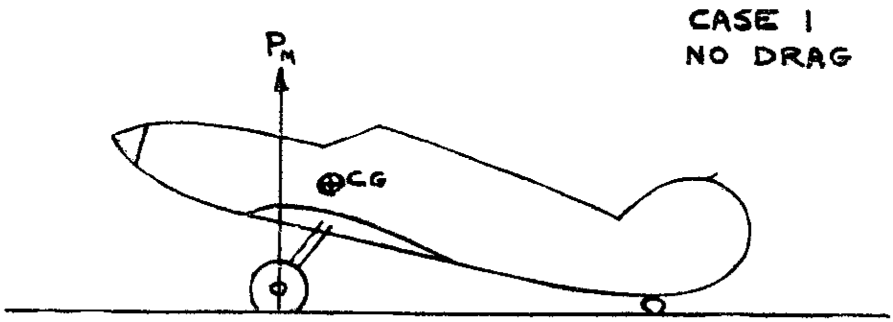


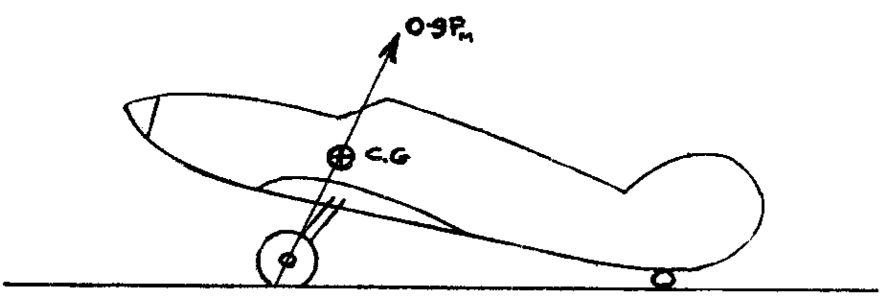
FIG 4 - ELMA TYPE OF SHOCK ABSORBER - AS FITTED TO FW 190.

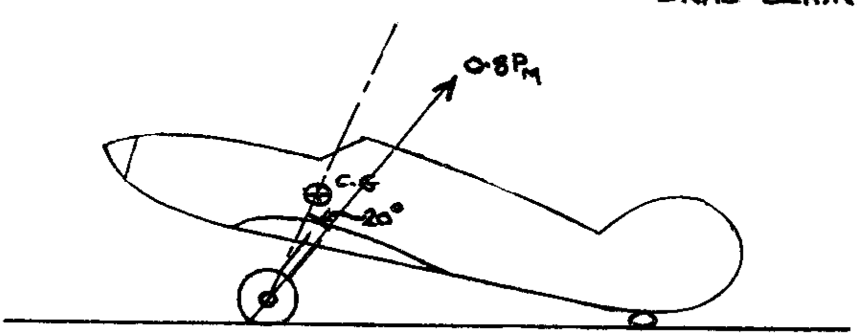
R

TABLE 1 FIG 5



P_M = MAX REACTION OBTAINED FROM DROP TEST





ATTITUDE FOR ALL CASES: 3 PT TOUCH DOWN