B.I.O.S.—FINAL REPORT No. 466

ITEM No. 27

GERMAN PARACHUTE DESIGN AND MANUFACTURE

This report is issued with the warning that, if the subject matter should be protected by British Patents or Patent applications, this publication cannot be held to give any protection against action for infringement.

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE

LONDON—H.M. STATIONERY OFFICE

GERMAN PARACHUTE DESIGN

AND MANUFACTURE.

Reported by:

Mr. N. Shuttleworth	M.A.P.
S/Ldr.T.E.Pitkethly	A.F.E.E.
Mr. W.D.Brown	R.A.E.
Mr. G.Shackleton	M.A.P.
Mr. L.L. Irvin	Irving Air Chute Co.

BIOS Target Numbers
C27/392, C27/388, C27/425, C27/426,
C27/427, C27/428, C27/386, C27/390,
C27/397, C27/401, C27/429, C27/430,
C27/431, C27/432, C27/202, C27/316,
C27/433, C27/434, C27/435, C27/436,
C27/437.

Aircraft Equipment

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE
32 Bryanston Square, London, W.1.

Table of Contents.

/(a)

(a) Wind tunnel tests,
(b) Models from tower and in Gas holder,
(c) Gun for firing models,
(d) Electro magnetic shock measuring device,
(e) Normal aircraft release,
(f) High speed release from bombs.

1. Introduction.

This report is intended to give as concise an account as possible of the whole field of research, development and manufacture of parachutes in Germany. Much of the information gained from the many persons interviewed tends to dovetail or to overlap and for that reason no effort is made here to record separately the information gained at specific targets.

Information was gained from the following sources:-

C27/392 (a) Forschungsanstaldt Graf Zeppelin - at Stuttgart - Ruit (Short Title - F.G.Z.)

This unit included basic research on parachutes with the designing of types to meet specific operational needs. Its personnel included:-

(i)	Prof. Madelung	Head of Institute,
(ii)	Dr. Heinrich	Head of Aerodynamic Section,
(iii)	Dipl. Ing. Knacke	Developing Ribbon Chutes,
(iv)	Dip. Ing. Neuhauser	" Paper "

This Research Station was equipped with adequate facilities for carrying out the parachute work entrusted to it. They had a number of wind tunnels to which they had access at all times; a number of machines and operators who were capable of manufacturing their experimental parachutes and on the airfield adjoining they had aircraft for drop testing and ground staff for retrieval. It impressed us as being a very compact, almost self-contained unit specialising in parachute work.

C27/388 (b) Herr Kostalezky now living at SCHUTZENHANSLE, WIENGARTEN, NR. RAVENSBURG.

Designer of the WAKO type ribbon chute.

C27/425 (c) Herr Weinig - Professer of Aerodynamics - Stuttgart.

C27/426 (d) Herr Buss (interrogated in England)

Chief parachute test jumper at Rechlin.

/(e)

1. Introduction.

This report is intended to give as concise an account as possible of the whole field of research, development and manufacture of parachutes in Germany. Much of the information gained from the many persons interviewed tends to dovetail or to overlap and for that reason no effort is made here to record separately the information gained at specific targets.

Information was gained from the following sources:-

C27/392 (a) Forschungsanstaldt Graf Zeppelin - at Stuttgart - Ruit (Short Title - F.G.Z.)

This unit included basic research on parachutes with the designing of types to meet specific operational needs. Its personnel included:-

(i)	Prof. Madelung	Head of Institute,
(ii)	Dr. Heinrich	Head of Aerodynamic Section,
(iii)	Dipl. Ing. Knacke	Developing Ribbon Chutes,
(iv)	Dip. Ing. Neuhauser	" Paper "

This Research Station was equipped with adequate facilities for carrying out the parachute work entrusted to it. They had a number of wind tunnels to which they had access at all times; a number of machines and operators who were capable of manufacturing their experimental parachutes and on the airfield adjoining they had aircraft for drop testing and ground staff for retrieval. It impressed us as being a very compact, almost self-contained unit specialising in parachute work.

C27/388 (b) Herr Kostalezky now living at SCHUTZENHANSLE, WIENGARTEN, NR. RAVENSBURG.

Designer of the WAKO type ribbon chute.

C27/425 (c) Herr Weinig - Professer of Aerodynamics - Stuttgart.

C27/426 (d) Herr Buss (interrogated in England)

Chief parachute test jumper at Rechlin.

/(e)

C27/427 (e) Herr Christensen. (interrogated in England).

Head of Parachute Section at the German Air Ministry.

C27/428 (f) Herr Bahr. (interrogated in England).

Manager of one of the Autoflug factories repairing parachutes.

C27/386 (g) Benger Geratebou, 72, Boblingerstrasse, Stuttgart.

Parachute Manufacturers.

Personnel interviewed:-

(i)	Dr. Woernle	Technical Manager,
(ii)	Herr Benger	Proprietor,
(iii)	Herr Goebel	Factory Manager.

C27/390 (h) Schusterinsel, Opladen, Nr. Cologne.

Finishers of parachute fabrics.

Personnel interviewed:-

(i) Dr. Dunner Managing Director.

C27/397 (i) U/Stuf Schauenburg (in P.O.W. Camp 93 - U.S.7th Army)

Designer of triangular chute and technical Manager at Henking - Berlin.

C27/401 (j) Kohler Uhrenfabrik - Laufaaholz, Nr. Nurnburg.

Makers of barometric fuses.

Auxiliary equipment or materials were developed by the following firms who were not visited:-

C27/429	(k)	Henking - Berlin	Parachute Manufacturers
C27/430	(l)	Schroder - Berlin	
C27/431	(m)	Autoflug - Bechau, Nr. Berlin.	

C27/432	(n)	Scholz - Hamburg	Barometric
C27/202	(o)	Rheinmetall - Borsig; Mulhausen	Fuses

C27/316 (p) A.E.G. - Berlin

Makers of the gun for firing parachute models.

C27/433 (q) Delius u Sohn - Bielefeld.

Weavers of fabric.

C27/434 (r) Kammerer - Osnabruk.

Paper Manufacturers.

C27/435 (s) August Köhler - Oberkirch, Nr. Karlsrühe.

Chemical treatment of paper.

C27/436 (t) Spöhn - Neckersulm, Nr. Heilbron.

Spinners and weavers of paper.

C27/437 (u) Schirm & Co. - Kirchenlellinsfurt, Nr. Tubingen.

Spinners and weavers of paper.

2. General Discussion of Parachute Research & Development

The developments which had been made on parachute designs in Germany appear to originate from a desire to produce a stable parachute. Much less information is available and no great stress has been made on the certainty of opening of the canopy.

The standard Irving design was accepted in Europe as the best canopy available, in the same manner as in England and America. This canopy, however, although very compact, possessing good opening characteristics, is unstable and opens too

/quickly

quickly for release at very high speeds. This results in difficulty in its use for bombs or other purposes for which stability and great strength are required in order to achieve accurate aiming and opening at high speed.

The Forschungsanstaldt Graf Zeppelin at Ruit was commissioned in 1935 - 36 to design a stable parachute for fitting to aircraft and gliders to reduce landing speeds. They realised that stability varied with porosity (i.e. airflow through the parachute canopy) but found that when the fabric used had a porosity greater than 1,600 litres/sq.metre/sec. (5.248 cu.ft./sq.ft./sec.) opening became doubtful. The porosity measuring instrument used in Germany was designed and manufactured by the Schopper Co. and registered volume of air passing through at 16 m.m. (0.63") water pressure. This low pressure is known in U.K. to be a bad guide to the effective airflow at high pressures corresponding to the opening speeds of parachutes but no development work had been undertaken to produce a better instrument.

Enquiries at Schusterinsel - Opladen, one of the largest finishers of parachute cloth show that very little importance was attached by the German Air Ministry to the airflow clause in the specifications and that extra-ordinarily wide fluctuations were permitted to meet manufacturing difficulties. Typical ranges were:-

Silk	-	350 - 800 litres/sq.m./sec. (1.148 - 2.624 cu.ft./sq.ft./sec.)
Perlon	-	500 - 900 litres/sq.m./sec. (1.64 - 2.95 cu.ft./sq.ft./sec.)
Rayon	-	700 - 1,200 litres/sq.m./sec. (2.296 - 3.936 cu.ft./sq.ft./sec.)

Silk and Perlon were used for identical purposes.

These difficulties led Madelung at F.G.Z. to consider making a parachute from ribbons so that they could control the porosity by variation of the ribbon spacing and yet have great strength. At Fig.1. their ultimate design is shown.

/The

The technique of testing and developing a parachute design at F.G.Z. was to test first of all small models in a suitable wind tunnel at low speed. Heinrich was primarily responsible for this work and he tested fabric models which he realised would not give an absolute answer but would, he thought, show comparative merits of one design against another. Stability was their prime objective.

Further data was obtained by Heinrich by studying airflow round half models in the wind tunnel, as described at 7(a).

Subsequently, other designs were similarly tested and it was found that the results obtained were a qualitative guide to what may be expected from full scale models.

The next stage after tunnel testing for stability was to drop models from a tower and occasionally inside an empty gas holder of some 250 ft. high by 70 ft. diameter. This test was not considered very important.

In order to obtain further data on strength and shock loading conditions the institute then proceeded to test larger models by firing from a gun designed by A.E.G., Berlin, and connecting the launching apparatus and parachute to an oscillograph on the ground. This is described in greater detail at 7(c).

If a model appeared to be successful full size parachutes were dropped from aircraft in the conventional manner, the dropping being recorded by high speed cine cameras. Where, however, high release speeds were called for, the tests were made by dropping a bomb of suitable weight from sufficient height to build up a T.V. of the required magnitude before a specially designed tail was jettisoned, allowing the parachute to be released immediately. By this means release speeds of 1,000 - 1,100 KM/HR. (620 - 680 m.p.h.) were achieved.

After F.G.Z. or any other design unit had cleared their early tests, the parachutes were passed to Rechlin for full scale trials. In the case of paratroop equipment, tests would

/also

also be made at Wittstock, and for mines and bombs tests were carried out at Travemunde. It is, however, most noticeable that the Air Ministry would accept design on the basis of a small number of flight tests, generally not more than 20% of the number that we would consider necessary. Experience in this country has shown that designs which appear successful at an early stage, frequently produce troublesome symptoms on bulk dropping.

Some such disability did in effect show itself with the ribbon chutes, which, due to their great porosity assumed the "squid" state and did not fully open. Knacke noticed on examination of the films that in this squid condition the loose fabric at the periphery tended to flap around inside the mouth, resisting the tendency to inflate. This, it is claimed, is obviated by the fitting of a device known as a Taschengurt, described in detail at 4(b).

In the early ribbon chutes all the ribbons were concentric, but later a design known as the WAKO was produced by Kostalezky, in which the ribbon was continuous from one side of the canopy to the other, passing tangentially around the vent. This is described in detail at 4(c).

Another stable design originated by Heinrich has been designated the Mushroom parachute. The German designation is Leitflachen-fallschirm. It is shown in detail at 4(d).

There appears to have been some difficulty on the part of F.G.Z. in interesting the paratroop training school at Wittstock in any of their non-oscillating designs. Wittstock worked in conjunction with Schauenburg of Henking, Berlin, on a triangular chute which was subsequently accepted as standard for paratrooping (see 4(e)).

Unfortunately, no evidence was available of the parachute failures or accidents at Wittstock but we saw an extract from some Air Ministry statistics on emergency descents.

The following is a summary of the information gleaned from

/this

this report:

The analysis covered 2,500 emergency parachute descents made from 1939 to 1944. During this period the number of emergency descents increased 15 to 20 times.

The report shows that emergency descents were made for the following reasons:

Enemy action	- 35% (this rose markedly throughout the period)
Engine trouble	- 24%
Mid air collisions	- 14%
Other causes	- 27%

Analysis showed:

	Average	March, 1944
Successful	62%	86%
Injured on landing	18%	4%
Injured by aircraft	13%	17%
Injured through parachute	3.4%	0.8%
* Fatalities	2.5%	2.1%

* Of 2,475 descents, 9 fatalities were due to the canopies either not opening or opening too late, 37 fatalities were caused through too fast a rate of descent.

Shortage of Textile components was responsible for the development of paper chutes. These were originally tried in sheet-paper, creped in both length and width. It was found, however, that porosity is essential and a woven paper was subsequently successful (see 4(g)).

3. Manufacturing Technique.

We were unable to obtain reliable information on quantitive production in Germany and in the area visited only one factory was available for inspection in a reasonably undamaged condition. Very little comment can, therefore, be made on their methods of

/bulk

bulk production. It seems possible that they were not so highly mechanised as in U.K. They were prepared in the case of the Wako type to accept a degree of hand work which to us seems almost prohibitive, but in the fabrication of the normal ribbon type parachute some effort had been made to simplify the method of assembly.

This ribbon parachute was originally made by, firstly, assembling the main ribbons on a normal sewing machine, to which a moving belt had been fitted, which would feed the ribbon to the webbing forming the radial members at a correct spacing. Latterly, machines had been introduced which would assemble these ribbons by feeding some 60 ribbons simultaneously through slots, the spacing between the ribbons being accurately and simply controlled and the radial webbings were quickly sewn to this main frame work by a special sewing machine set on a track running the full length of this machine.

This machine was seen at the Benger factory in Stuttgart and although during the short time it had been in use they had not noticed any saving in production time, it seems to have been accepted that as the operatives became more conversant with its use there would inevitably have been a considerable time saving factor.

We were informed that wherever possible the manufacturer of a parachute had to use the same yarn for all textile components in any one canopy (i.e. a silk canopy would have silk lines and be sewn with silk thread).

4. Types of Parachute Developed.

(a) Schade Braking System.

In order to obtain higher performance with the standard type parachutes, i.e. either to increase the load carried or the release speed, a system was developed and tested by Herr Schade which merely involved the fitting of a circular metal disc. Around the rim of this disc a number of holes was pierced; this number corresponding with the number of rigging

/lines

lines for the particular parachute to which it was attached. The rigging lines were passed through the appropriate holes in the disc and the parachute was then packed with the disc at the lower end of the rigging lines. The auxiliary parachute was attached to this disc and during deployment the first operation was to pull the disc half way up the lines of the main canopy. As the canopy became filled with air the pressure tended to force this disc down away from the canopy, thereby delaying the opening period and considerably reducing the shock loading. It was claimed that the operation was comparatively simple although as we would expect not particularly reliable. We would anticipate that under abnormal conditions of opening a larger proportion of these would fail to inflate freely but nevertheless a large number were used.

(b) <u>Ribbon Type</u> (Cobweb type)

The first ribbon parachutes were developed at F.G.Z., Ruit, by Prof. Madelung and his assistant Herr Knacke. Presumably the idea was to obtain a parachute of sufficient porosity to render it completely stable. A sketch of a typical parachute is at Fig 1. This shows that the ribbons used are concentric, the spaces between the ribbons being controlled at will according to the calculated porosity required. These parachutes were comparatively straightforward in their manufacture although more complicated than the making of a standard fabric canopy.

Broadly, the ribbons are assembled into the form of a sheet or mesh by sewing the small ribbons across the main ribbons: this mesh is then cut into the appropriate gore shapes and these gores sewn together by the formation of a normal type main seam, employing a very strong ribbon.

It is claimed that there are numerous advantages for the ribbon parachute. Owing to the difficulty in obtaining strong, yet porous fabric, Madelung conceived the idea of a parachute made of ribbons, arguing that the use of ribbons meant a greater strength with controlled porosity. Prof. Weinig showed that the use of ribbons produced a greated drag or alternatively the same drag for a much greater porosity. It is further claimed that one of the advantages of this ribbon chute is that when the greatest load is imposed at the moment of opening the deflection of the ribbons tends to allow greater porosity at that instant.

As is to be expected some difficulty, however, has been experienced in the tendency of the canopy, due to the great porosity, delaying or failing to open. In order to overcome this disability a very interesting idea was incorporated which it is claimed tends to produced a positive opening. This is known as a Taschengurt and can readily be fitted to any type of parachute. It is merely a short length of webbing fitted to the periphery across the inter-section of the main seam and rigging line. This is shown in detail at Fig.1. and was introduced by Knacke because he noticed that the cine film of parachutes in which canopy opening was delayed show that the loose material at the periphery was flapping about inside the mouth and he thought tending to prevent the canopy from inflating. This taschengurt tends to prevent this by restricting the free movement of this surplus material inside the mouth.

These ribbon parachutes were quite robust but tended to occupy rather more bulk in the packed condition than would be the case with our own fabric parachutes designed for a similar purpose but this was not considered a great drawback by the Luftwaffe who apparently accepted it.

This type of parachute was used in many different sizes, the largest having a diameter of 27 metres (88.6 ft.), which was used for testing the dropping of a 4,000 kilogram (8,800 lb load with a falling speed of 60 metres per second (197 ft./sec) This load is thought to relate to the V.2 on which work is continuing for the Americans.

(c) <u>Wako Ribbon Chute.</u>

This ribbon parachute, designed by Walter Kostalezky was evolved because according to Kostalezky's submission the concentric type was not sufficiently strong for the heavy loads and high speed release conditions. The Wako type is shown in Fig.6. It will be seen that the ribbons are continuous from one side of the periphery to the other passing tangentially around the vent thus ensuring that the ribbons carry the whole of the load. Incidentally it also ensures that the greatest porosity is in the region of the periphery progressively decreasing to a very imporous region at the vent. It is thought that this will result is more positive opening for a given design.

The attachment of the canopy to the rigging lines with this parachute is interesting and possibly results in a very even distribution of load throughout the parachute and since

/they

they do not pass over the canopy a reduction in bulk is effected. Also it is claimed that considerably less sewing is required. It is a very difficult parachute to manufacture and it is most surprising to us that so many have been made in the very laborious manner employed at the two or three factories making this design. It seems, however, that of the two ribbon types this was preferred by Rechlin and the German Air Ministry, as in addition to its being used for bombs and mines, it had been tested and was being introduced as an emergency parachute for air crews.

This emergency design was evolved for use by pilots in jet aircraft in the event of their having to bale out at very high speeds. It was also to be used with the automatic ejection device fitted to the latest type of jet aircraft.

Kostalezky claims that this parachute would be safe for use by a pilot at 800 kilometres per hour (500 m.p.h.). The maximum speed at which it had been tested was 680 kilometres per hour (425 m.p.h.) and the highest speed at which a live test had been made was 420 k.m. per hour (260 m.p.h.) by Herr Buss at Rechlin. The parachute is very bulky compared with our own air crew types of parachutes and perhaps its most interesting feature is that it allows for the parachute to be withdrawn by an auxiliary in the standard manner by manual release and yet permits of the withdrawal of the rigging lines before the main canopy is inflated. It is well known that this method of deployment considerably reduces the shock on opening and it has been done by enclosing the canopy in a thin fabric sock at the bottom of which the rigging line stowages are provided. This stowage is shown in detail at Fig. 7.

(d) Mushroom Types.

This type of parachute is shown at Figs. 4 and 5. The first type at Fig.4 is used for the dropping of bombs etc., and it is claimed that it is very stable. It employs normal types of fabric for the canopy but has two inherent disadvantages. Firstly, it has a very small drag for the bulk of fabric which it uses and this results in a particularly large stowage space

/being

being required. The Germans call this design the Leitflachen-Fallschirm. It is alleged to be very stable under all conditions and the peculiar formation of the rigging lines is employed in order to prevent the roll of the bomb relative to the parachute. It is accepted that this righting moment which is imparted to the bomb can only be reasonably effective under conditions where the diameter of the parachute is similar to the diameter of the bomb. Apparently the number of crossings of the rigging lines affects the opening, since an instruction is known to have been issued, reducing the number of intersections from 6 to 5.

Tests have been made with the Mushroom parachute to be used for paratrooping but due to the excessive bulk of the parachute it had not been favourably accepted by the Parachute Training School at Wittstock.

This man carrying design is shown at Fig.5. and it will be noticed that the mouth diameter is much greater for the same size of parachute than for the bomb design but in making this reduction stability is not so good but it is nevertheless sufficiently good for dropping men. The convential form of rigging is employed as there is not the necessity to resort to the much more elaborate crossing of the lines.

The work carried out at the N.P.L. at Teddington on shapes of parachute canopy indicates that this Mushroom shape is likely to be somewhat doubtful in its opening characteristics under abnormal conditions.

The shock load of opening of the Mushroom type is thought to be only some 60% of that experienced with a standard type parachute. This figure had been experienced on tests in the tunnel, with the gun projection apparatus and from aircraft. Heinrich claims that in addition to this low shock opening figure the Mushroom parachute has the advantage that with a small canopy used as a drogue with a large bomb it will open under conditions where a ribbon chute will squid.

(e) <u>Triangular Design.</u>

The German triangular design was produced by Herr

/Schauenburg

Schauenburg who was Technical Manager at Henking of Berlin. It was produced in conjunction with the Parachute Training School at Wittstock, who had learned of the success which it is claimed the Russians had achieved with a square parachute for paratroops.

Schauenburg claims that his design was made without prior knowledge of the American Hoffman triangular design and it is very much simpler in its construction. A sketch of this parachute is shown at Fig.3. and it is claimed that it has the following advantages:

(i) Compared with the normal parachute it is very stable although it has an inherent side slip resulting in a drift but this rate of drift had not been measured.

(ii) Due to the smaller number of seams there is less wastage of fabric and for the same bulk of parachute smaller rate of descent was achieved.

This design was accepted as the standard for paratroops at a late stage in the war but although many thousands had been manufactured it had not arrived at the stage of being used on operations. It had been tested to a maximum speed of 350 k.m. (220 m.p.h.) per hour without damage, using dummies of approximately 100 k.g. (220 lb.)

An interesting point in the interrogation of Schauenburg was that he claimed that although this triangular design was in effect almost completely stable for the dropping of troops, tests in the wind tunnel had shown it to be violently unstable.

Insufficient tests (approximately 50 only at Rechlin) had been made to give any indication on the reliability of opening of this design but it is obviously a very simple parachute to manufacture if there are no inherent disabilities.

(f) <u>Faden-shirm.</u>

The Faden-shirm was an early development to make a porous

/parachute

parachute. It was not generally accepted owing to the ribbon chute showing much better performance. The Faden design achieved great porosity in a rather clumsy manner by using material woven in the normal manner except that at intervals the weft had been omitted. This gives the canopy the appearance of a grass skirt and is no doubt very prone to entanglement of the loose warp threads during deployment. See Fig.8. Drg, AER.15694.

(g) Paper parachutes.

Much interesting and apparently successful work has been undertaken in connection with paper parachute design. This was undertaken by Herr Neuhauser at the F.G.Z Ruit. This man is now conducting his own business as a paper merchant at 10 Eberhart Strasse, Stuttgart.

The parachute designs were convential in shape, ranging alongside the textile types previously described. Originally tests were made with an imporous paper sheet creped along both warp and weft, but this was not very successful, due to the lack of porosity and the resultant high shock loading. Paper was then woven in a similar manner to normal textiles, some with a twisted yarn and some with the paper merely folded so that the resultant yarn is like a braid. A very strong fabric was produced by the use of a "Sulphat" paper and a less strong variety using "Sulphit" paper. Rigging lines were of "Sulphat" paper.

Typical strengths were:

Sulphat - 8 Kg/15 m.(17.6 lb/.59") wide for a weight of 55gm/sq.m. (1.62 oz/sq.yd)
Sulphit - 3 Kg/15 m.(6.6 lb/.59") wide for a weight of 80 gm/sq.m. (2.36 oz/sq.yd.)

A list of associated firms is shown in Para. 1(r) to 1(u) inclusive.

These parachutes were used for dropping food supplies in containers, for bombs up to 500 KG (1,100 lb.) successfully

/released

released on test at 560 KM/HR. (348 m.p.h.) (This was a canopy of 3m. (9.84 ft.) diameter.) The canopies were naturally more bulky than textiles but this was accepted as inevitable in view of the shortage of materials.

5. Types of Textile used.

(a) Silk.

Supplies of silk of reasonable quality were available for man carrying parachutes until the end of the war. Its construction is very similar to that used in most other countries.

(b) Perlon.

This textile closely resembles Nylon and was used at a late stage in the war to augment silk supplies for man carrying canopies. Its strength was similar to our Nylon and samples tested here show a similar airflow quality.

(c) Rayon.

The bulk of the German parachutes for dropping supplies were Rayon with a strength approximately half that of the silk fabric. Its porosity was greater than the man carrying fabrics, ranging from 700 - 1200 litres/sec. (2.296 - 3.936 cu.ft./sq.ft./sec) compared with a desirable 600 - 800 litres/sec. (1.968 - 2.624 cu.ft./sq.ft/sec) for silk.

(d) Zellwolle.

Rayon supplies were augmented to some extent by the introduction of a lower grade spun rayon known as Zellwolle. This was weaker and more bulky than desirable but the textile supply position was apparently bad.

(e) Zellwolle Jute.

This, as is implied, is a mixture of Zellwolle and Jute but experiments did not give very satisfactory results.

/6.

6. Purposes for which parachutes were used.

(a) Emergency exits.

Standard Irvin canopies were used in conventional types of pack for all emergency chutes until quite recently, when a small number of WAKO chutes were made for high speed escape in such aircraft as jet fighters. The standard canopies were mostly made from Silk with a small number recently from Perlon.

Forced ejection was tried in German aircraft using both compressed air and explosives respectively for the propulsion of the seat from the cockpit.

Herr Buss was subjected to a number of tests, firstly on a test rig on the ground and subsequently from an aircraft. He states that 12 g is not an uncomfortable acceleration from the aircraft, and that when ejected from a machine flying at 350 KM/HR. (220 m.p.h.) he had no sensation of nausea or physical discomfort.

100 Dummy tests were made at speeds up to 620 KM/HR. (385 m.p.h.) with a drogue parachute fitted to the seat to maintain stability. Buss made three successful live descents, using a WAKO parachute in each case.

(b) Paratrooping.

Parachutes were used by paratroops in the conventional manner, firstly the Irvin canopy and latterly it was planned to use the triangular chute. It is known that saboteurs were sometimes dropped in containers, the men being suspended in the containers in a type of hammock.

(c) Containers.

250 KG. (550 lbs)., 500 KG. (1,100 lb.) and 1,000 KG. (2,200 lbs) were the standard type of container to which parachutes were attached. They were dropped both by the incorporation of delay fuses and by immediate opening from low altitude.

/(d)

(d) Dive Brakes.

Braking parachutes were fitted to many types of aircraft. The wing dive brakes previously fitted were very heavy, clumsy devices and they tended to create turbulence which caused considered difficulty for the aircraft designer to overcome. The parachute was about one third of the weight of the mechanical braking system and was claimed to be more effective in use.

The parachute was so arranged that it could be easily released to a partially opened condition, but the fitting of a reef line running around the periphery through a series of rings. By release of this line the chute could become fully open. Conversely the parachute could again be collapsed and arrangements were made for the parachute to be pulled in to the aircraft by means of a powered winch.

This parachute, normally of ribbon, had to be very stable, and in addition to its fitment for dive bombers was planned for use with the Me.262 in order to increase the period that this fighter could sight a bomber or other target.

(e) Landing Brakes.

One of the earliest uses for the Ribbon type parachute was in connection with landing brakes for gliders and bombers. The parachute was normally fitted in the tail of the aircraft and released by the pilot on approaching ground. A typical instance of the improved landing conditions was for a glider which from 2,000 metres would normally require five minutes to descend could safely be brought down in 55 seconds by the use of a parachute and in addition, the landing area required was very much reduced.

(f) Bombs and Mines.

At an early stage the Luftwaffe discovered that parachutes could be fitted to heavy bombs or mines which would control their trajectory and would at the same time occupy less space

/in

in the bomb bay than fins to achieve the same purpose. These parachutes had a diameter approximately the same as that of the bomb itself although the mine parachutes frequently had a somewhat larger diameter in order to reduce their velocity on impact. It wasfound that for this purpose a very stable parachute is required if aiming of the bomb was to be accurate. It was claimed that very great accuracy had been achieved in this connection.

(g) Flares.

The flare parachutes used were not unlike those employed in the R.A.F., the canopies normally being manufactured from artificial silk but it was freely admitted that a very large proportion of failure was to be expected. The lightweight paper parachute had been developed for flares and the designer claimed that with this canopy the percentage of failure was reduced considerably but like all paper parachutes this required a slightly larger stowage capacity.

(h) Torpedos.

Dr. Heinrich at F.G.Z. had made experiments on the fitting of parachutes to torpedos which appeared to be of particular interest. A parachute was required to reduce the striking velocity and also to stabilise the torpedo during its flight in air. On striking the water the whole of the rear section of the torpedo is jettisoned by the use of explosive bolts and the path of the torpedo in the water is claimed to be particularly accurate.

7. Equipment for Testing Parachutes.

(a) Wind Tunnels.

At the F.G.Z. Ruit, two of their five wind tunnels had been used for parachute work. Small models were tested at quite low speeds in order to get some qualitative indication of stability and shock loads at opening. Heinrich was responsible for these tests and he contends that in all cases the results obtained

/proved

proved to be a useful guide to the probable performance of the full size canopy.

In his work in the tunnels he experimented with a metal forma representing half a parachute canopy in order to determine the conditions of airflow around the canopy. This was done by fitting the forma to a horizontal plate on which a mixture of soot and petrol had been smeared. The passage of the air around the forma left streaks in the soot as the petrol evaporated and it is Heinrich's contention that these tests gave an answer to the query of instability in some canopies and comparative stability in others. The type of pattern produced by this method is given at Fig.9.

(b) Towers, etc.

The models used in the tunnels were later dropped from a tower to get confirmation of stability and drift, and to a lesser extent of opening characteristics. In this category was their use of a large gas-holder, some 250 ft. by 70 ft. diameter.

(c) Gun Projector.

Many of the model tests were made with a gun projector since this was a very convenient method giving a wide variety of speeds for the parachute.

The gun was a simple device consisting of a steel tube 12.5 cms bore with a breech end connected to a compressed air chamber and valve. The muzzle had a loose cap in which was fitted a 6-point plug and flexible leads to the batteries, oscillograph and other ground equipment.

The projectile weighing 5 Kg constituted the parachute load and contained a shock measuring device described below in addition to the parachute to be tested. In the nose of the projectile was fitted a socket which mated with the plug in the gun muzzle cap.

When the gun was fired, the projectile was ejected by the

/compressed

compressed air and picked up the muzzle cap on its way out of the barrel and was thus immediately coupled with the oscillograph which recorded the various loads experienced by the parachute.

The flight path of the parachute and its velocity at any instant were obtained by means of a timed camera stationed at a suitable distance from the gun.

With a projectile weight of 5 Kg. speeds up to 250 metres/sec. (500 m.p.h.) could be obtained.

Details of gun and projectile appear at Fig.10.

(d) <u>Electro Magnetic Shock Measuring Device.</u>

The F.G.Z had developed a special accelerometer for measuring the shock loads in model parachutes used with the gun projector described above. The body of the instrument was a thick walled cylindrical magnet with iron end plates and a centre core as shown in Fig.11.

Inside the instrument was a piston which was a close sliding fit on the core and also in the cylinder bore. This piston was perforated with .3m.m. diameter holes and carried a small coil of fine wire. The entire space within the body of the instrument was filled with a light oil. The piston and coil formed a free mass inside the instrument and thus any acceleration of the outer casing in an axial direction caused an increased pressure in the fluid on one side of the piston, resulting in a flow of oil through the holes. Since the oil flow was laminar the velocity of the piston was proportional to the pressure applied and hence the EMF generated in the coil bore a linear relation to the acceleration experienced by the instrument. Output through the coil was of the order of 1.5 m. volts and a valve amplifier was used in conjunction with a small moving mirror type oscillograph in order to obtain records from the instrument.

The instrument was considerably affected by temperature

/chiefly

chiefly on account of the variation of the viscocity of the oil. It was therefore necessary to have heating coils wound round the instrument by means of which the temperature could be maintained at any pre-determined value. A thermo-couple was also fitted to measure the temperature of the instrument.

(e) Normal aircraft release.

Various types of aircraft were used for releasing parachutes for test at Ruit and also at Rechlin. There appears to be nothing revolutionary about their technique in this respect, either in method of release or in photographic recording of the falling parachutes.

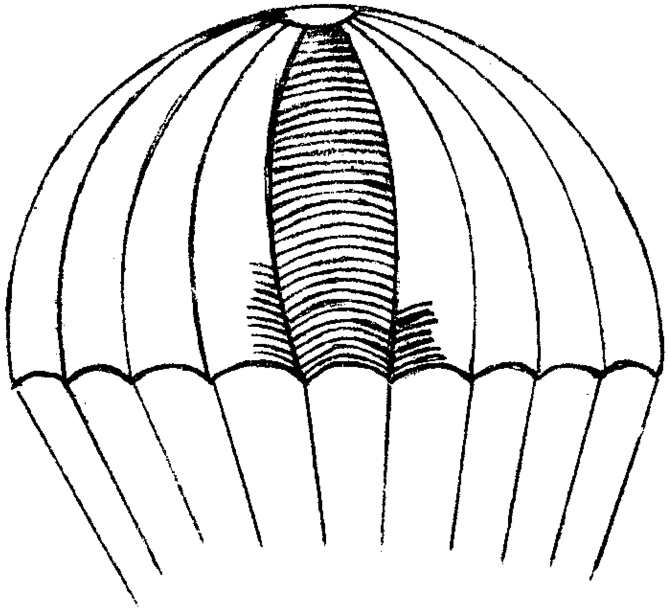
Containers and armament stores were dropped in the normal manner from aircraft, using either the method of direct opening by static line or delayed opening by time fuse.

(f) High Speed release for bombs, etc.

Where it was necessary to test parachutes at release speeds in excess of aircraft speeds, a system was developed in which the parachute was stowed in the tail of a bomb of the required gross weight and then released from an altitude which would permit the bomb to arrive at its terminal velocity. At this point, or if desired at an earlier stage, the bomb fins and parachute housing would be jettisoned and the parachute allowed to open immediately.

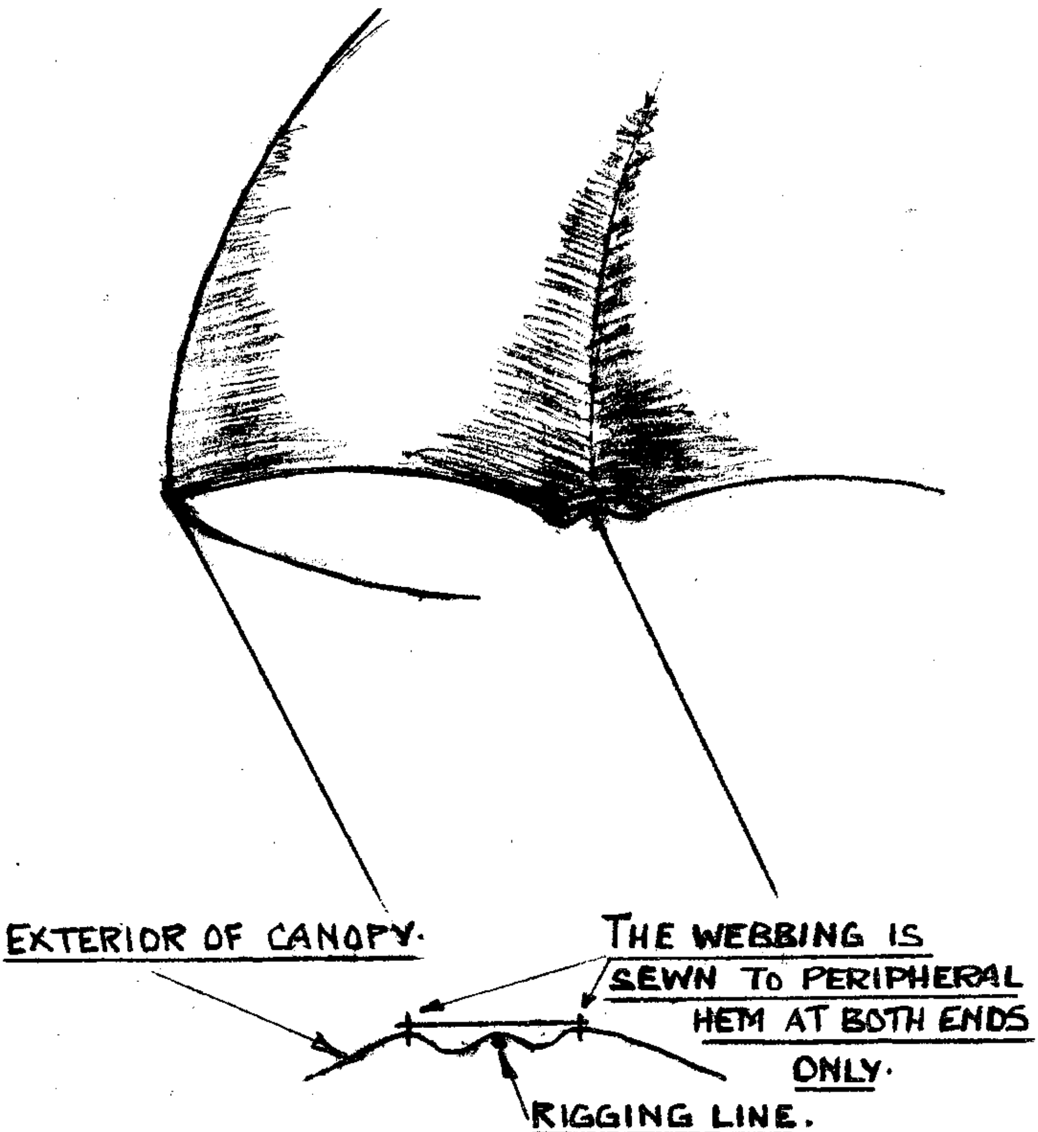
In this manner parachutes were tested at speeds at high as 1100 KM/HR. (683 m.p.h.).

FIG. 1



SITZBAND-FALLSCHIRM

FIG 2



SITZBAND-FALLSCHIRM

FIG. 3

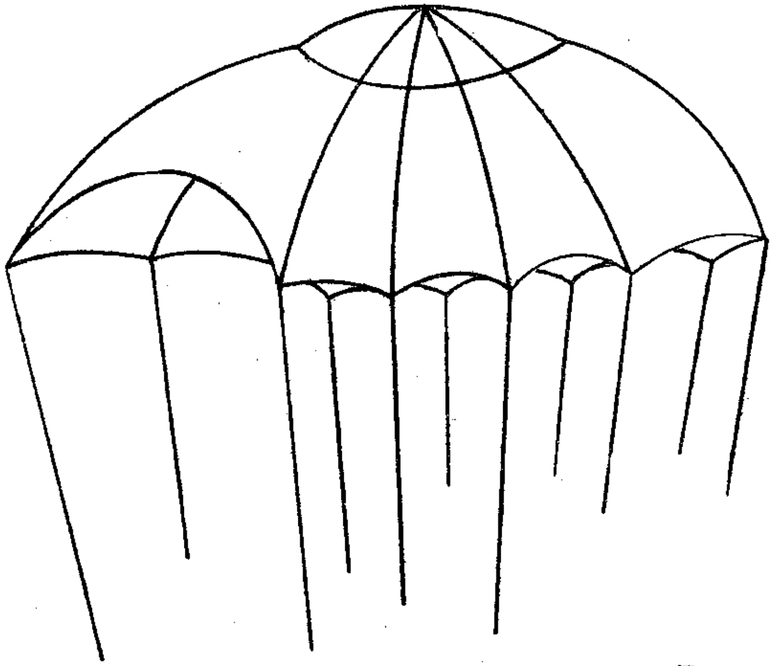


FIG 1

TRIANGULAR HEM RIGGED PARACHUTE

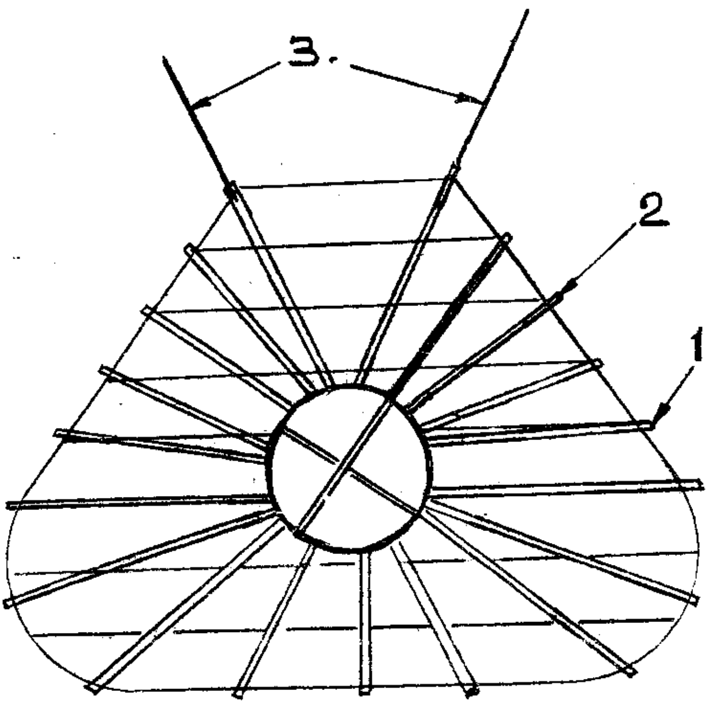
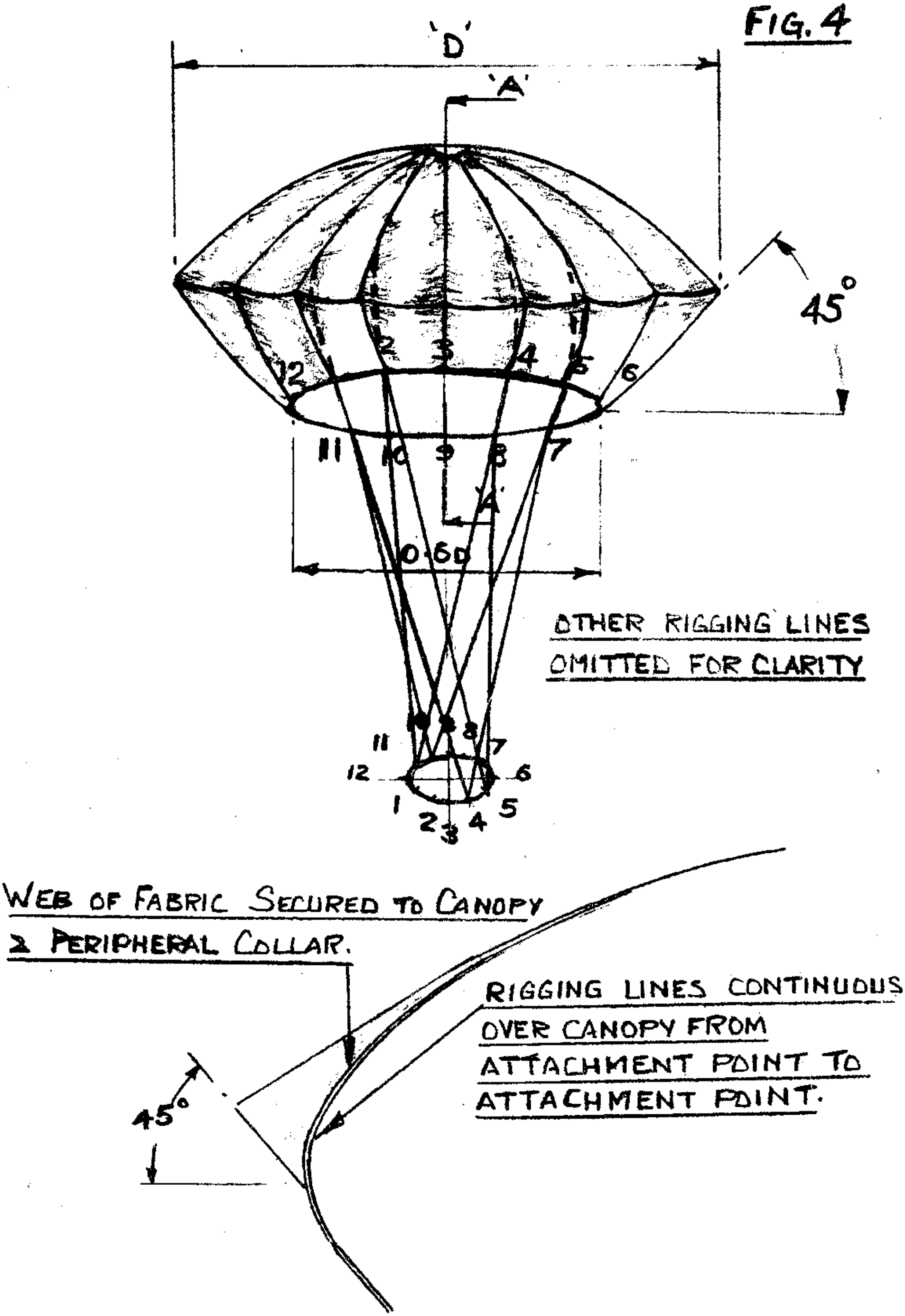


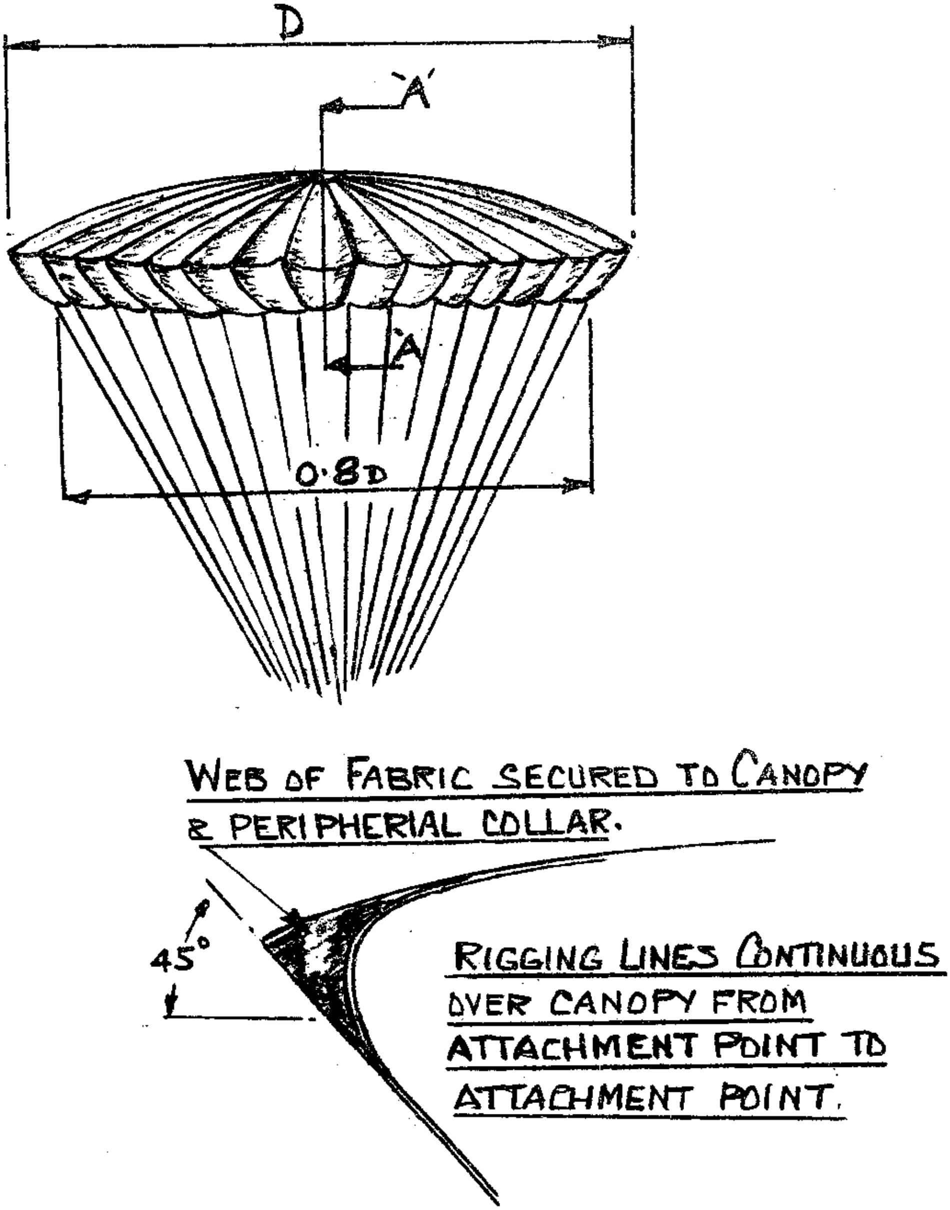
FIG. 2

1. METAL RING
2. STRIPS OF MATERIAL TO HOLD RING IN PLACE
3. 20 RIGGING LINES - HEM RIGGED.

FIG. 4

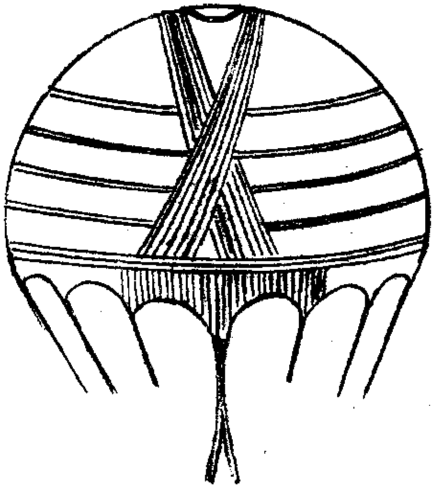


LEITFLACHEN-FALLSCHIRM

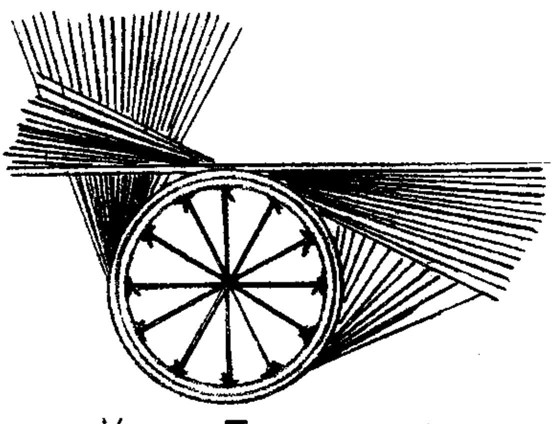


LEITFLACHEN - FALLSCHIRM
MUSHROOM TYPE

FIG. 6



THERE ARE 16 RIGGING LINES
ARRANGED IN 8 PAIRS

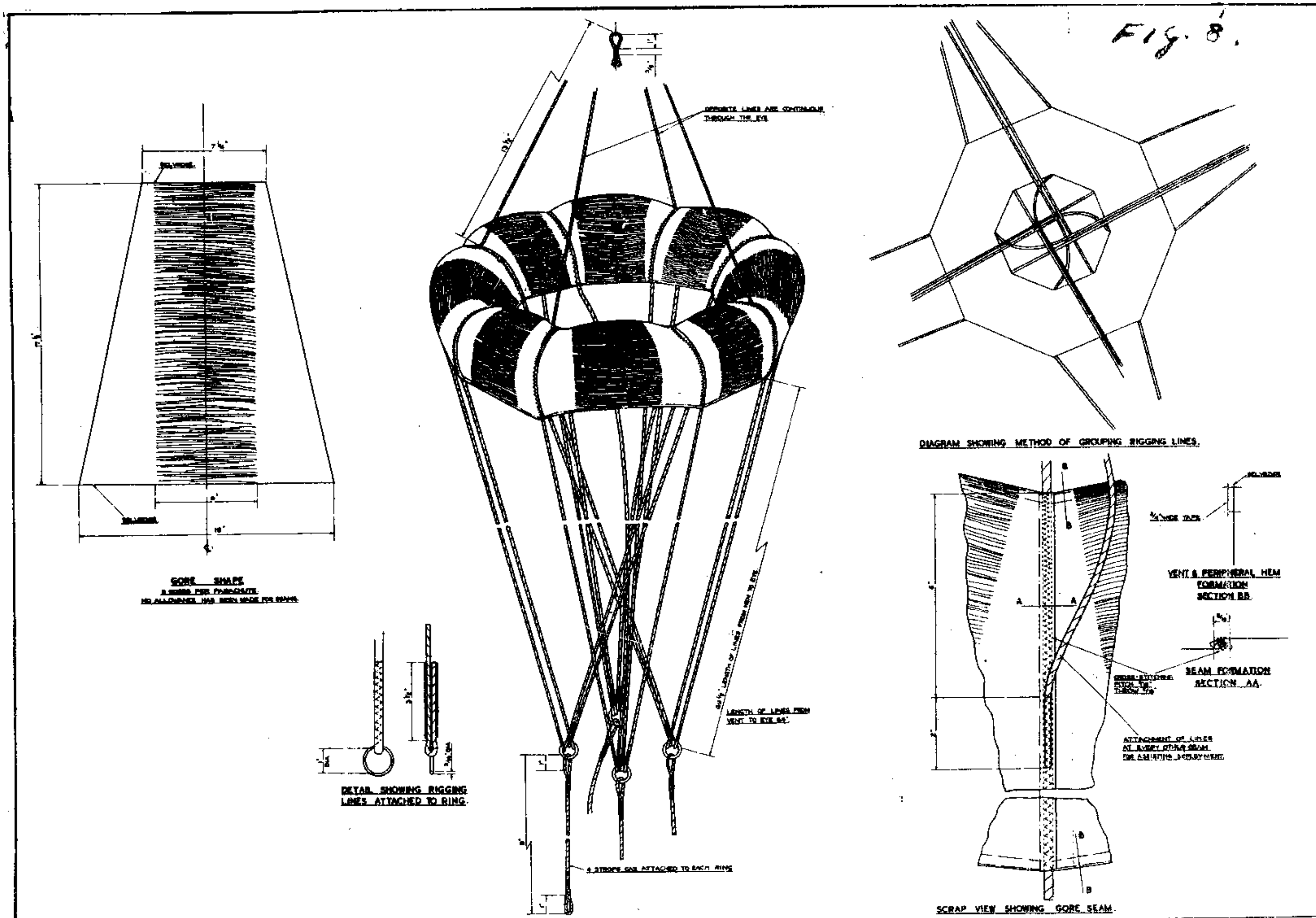


VENT FORMATION

SITZBAND FALLSCHIRM

WAKO

Fig. 8.



ISSUE Nº	A
ALTERATION Nº	

TITLE :- FADEN - SHIRM (GRASS - SKIRT)

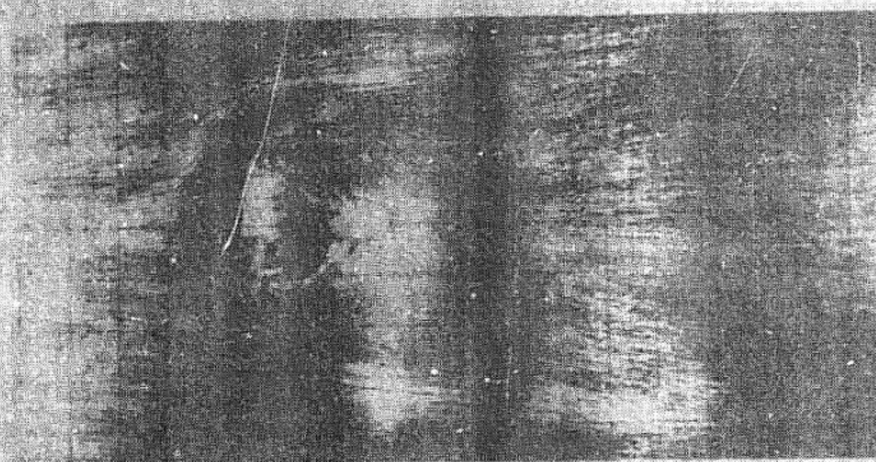
PARACHUTE SECTION.

ISSUED BY ROYAL AIRCRAFT ESTABLISHMENT · MINISTRY OF AIRCRAFT PRODUCTION

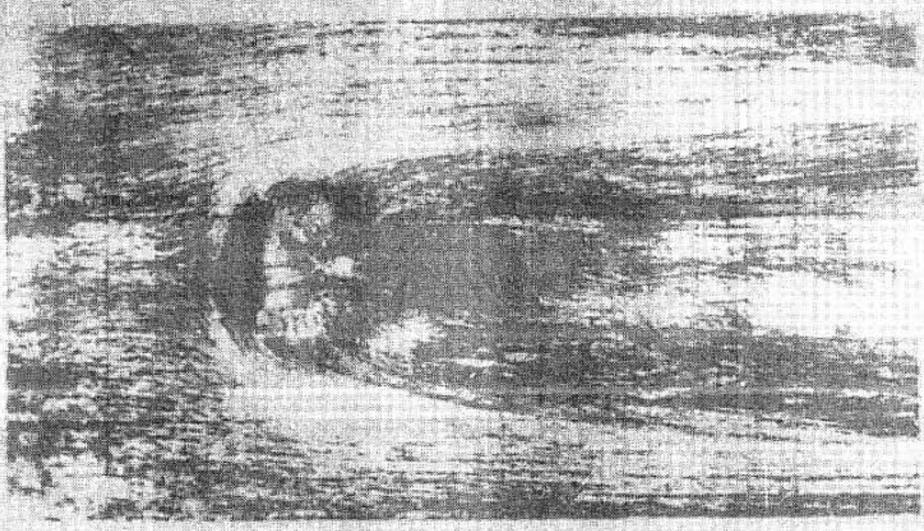
DRAWN	TRACED	CHECKED	DATE	APPROVED	DATE

DRC. Nº AER. 15694.

Halbkugel



Düsenschirm



Bänderschirm

Abb.12 Rußbilder der Strömung um Fallschirmmodelle bei 0° Anstellwinkel

FIG 10.

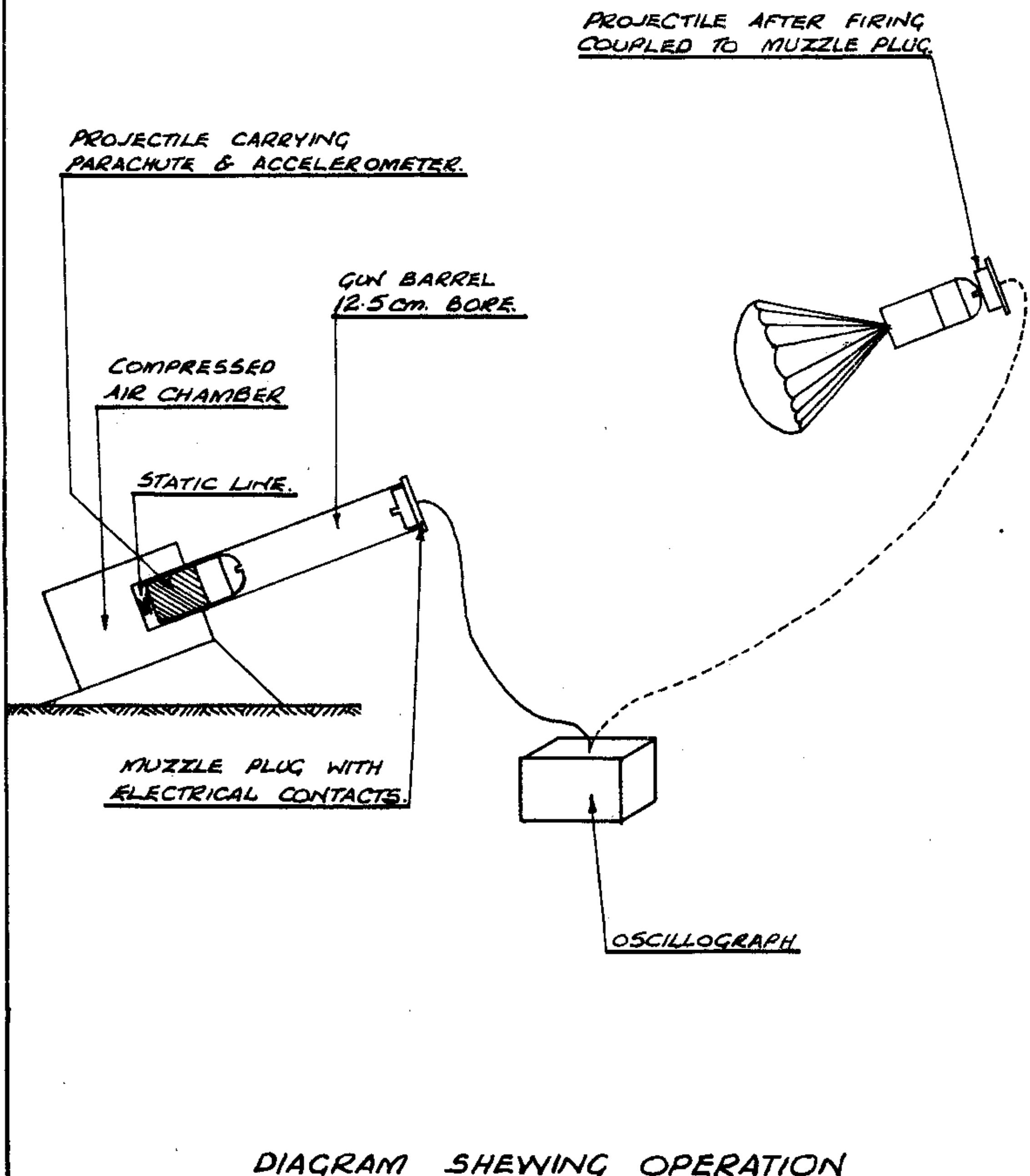
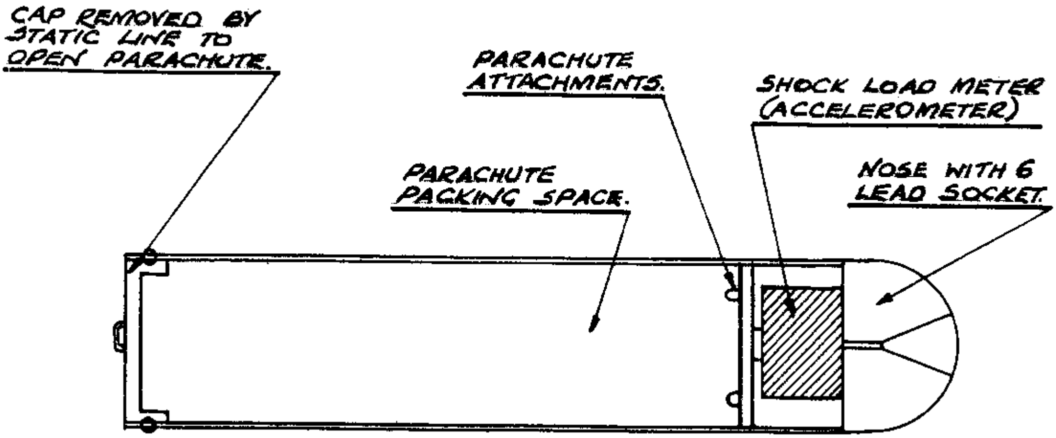
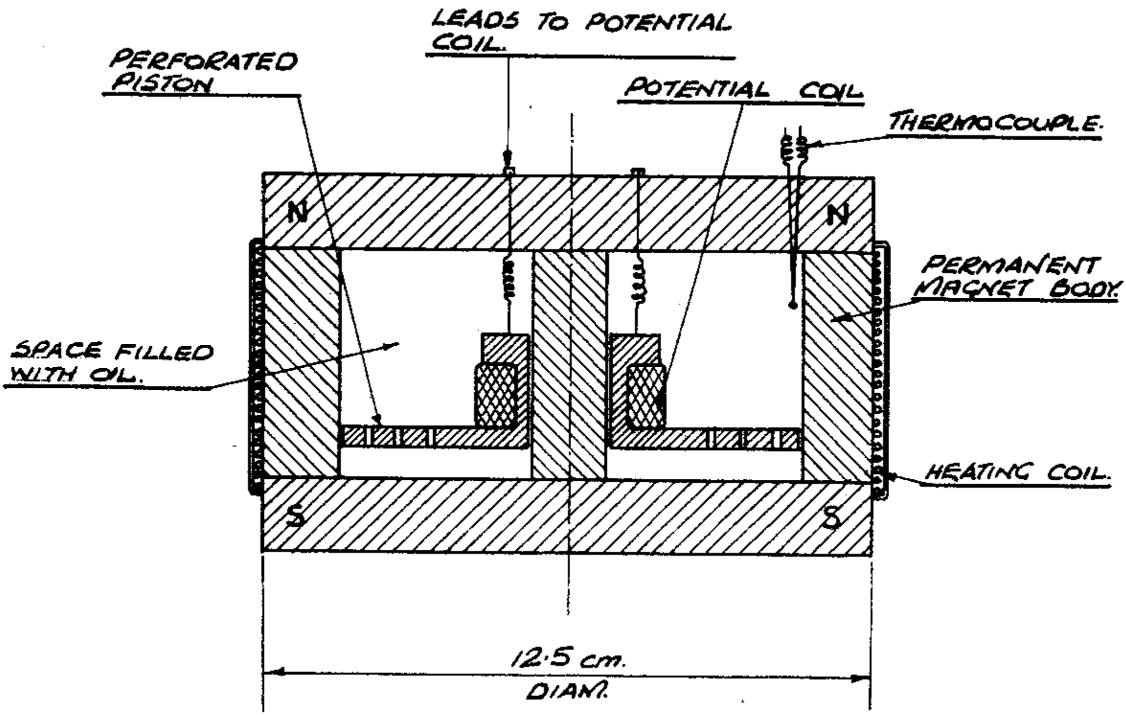


DIAGRAM SHEWING OPERATION OF GUN-PROJECTOR.

FIG. 11.



DETAIL OF PROJECTILE.



DETAIL OF SHOCK MEASURING DEVICE.

1250 S.P.& Co. LTD. 14.5.46 49098