LIST OF ILLUSTRATIONS

SECTION III

Chapter 9

RADIO EQUIPMENT

General Description

Radio equipment in the Messerschmitt Me110 comprises two complete communication channels, radio compass receiver, blind approach and traffic communication equipment, and interphone. The location of this equipment in the navigator's cockpit of the airplane and its relation to other items of equipment can be seen in Figs. 1 and 2. On the bulkhead located directly in front of the radio operator are, from left to right in the top row, a short wave receiver, a long wave receiver, and a radio compass azimuth indicator; with the short wave transmitter, long wave transmitter, and radio control box located in the lower row. At the left side of the cockpit are located an interphone switch box, emission-selector switch box, compass receiver control, ultra-high frequency channel-selector switch, and the main beacon receiver antenna-matching unit. The radio operator's key is located on the upper, right-hand longeron. This is the only item of equipment mounted on the right.

The distribution of all radio equipment on the left side of the cockpit and exclusive routing of radio wiring on this side, lends itself to pre-fabrication of the entire radio installation as a bench assembly. This procedure is facilitated through the use of the wiring clips used throughout the airplane to cable radio and electrical wiring in the proper groups as mechanical assemblies of the desired lay, prior to installation in the airplane. These wiring clips are a mechanically fastened type wherein the wires are banded through an adjustable fastening to a metal back plate, and are designed to

Editor's Note: The technical data for this portion of the Messerschmitt analysis was furnished by Mr. H. A. Gibb, Staff Engineer, and Mr. J. Morecroft, Electrical Engineer, for the Engineering and Development of Vultee Aircraft, Inc.

slide into suitable brackets riveted to the airplane structure.

Mass production permits exact determination of every cable and wire in the airplane, and these are undoubtly cut to length, fitted with suitable terminals as a sub-assembly operation, and then stocked until required for an installation. The design is such that it is possible to lift the entire installation (as shown in Fig. 2) into the airplane as a complete unit, with nothing more than mechanical attachment of each component in its proper location being required to complete the installation.

Trim panels are installed over the wiring after the installation is complete. These are secured by spring-type snap fasteners which can be operated by the fingers, making tools unnecessary for inspection of the wiring.

Due to access and space limitations imposed by the airplane structure there are some isolated locations where it is necessary to make electrical connections at installation of the radio, but these are a mechanical type using a set-screw clamp, and all wires are previously cut to length and supplied with end fittings.

Connecting to the cables leading from the units in the cockpit are the pilot's station box, send-receive switch, two antenna -tuners, interphone amplifier, three dynamotors, radio compass receiver, antenna reel, and blind-landing equipment. The location of these items is shown in Fig. 2.

The dynamotors are located on the battery mounting bracket. However, this is apparently not for electrical reasons but rather for balance and accessibility, as a large door is placed in the fuselage adjacent to this mounting. The electrical connections for these dynamotors, however, connect to the main circuit-breaker and electrical switching panel in the gunner's cockpit. These dynamotors, with the exception of the one used for operation of the direction finder and blind landing equipment, are started directly by operation of the relevant cicuit-breaker in the gunner's cockpit, and apparently are turned on prior to making a flight and run continuously throughout the flight.

The antenna-tuners, reel, fairleads, and lead-in insulator are located in positions determined by the best electrical characteristics for each antenna, with the high-impedance antenna leads in each case limited to absolute minimum length; in no case being longer than eighteen inches. The antenna-tuners and reel are remotely controlled from the radio operator's position by means of the radio control box. The lead-in insulator from the fixed antenna mast on top of the cock-pit enclosure is designed to provide the least possible wind resistance while maintaining a favorable electrical leakage path. This is accomplished through the use of recessed leakage path allowing the antenna connection to be substantially flush with the portion of the insulator mounting to the skin. Standardization of these ceramic parts is achieved by providing a flat mounting surface recessed from the outer face of the insulator, and using contoured wooden rings to bring this surface flush with the skin contour of a particular airplane. In the case of connections to the lead-in insulator and to the antenna tuning units, a special type of gland connection is used as shown in Fig. 6.

The trailing antenna fairlead shown in Fig. 6 is quite massive, indicating the probable use of an extremely long antenna and heavy weight, as would be required for long-wave communication. This fairlead does not pass through the skin, but merely goes close to the inside of the skin with a large opening below it sufficient to allow the antenna weight to be fully retracted within the airplane.

Blind landing equipment of the Lorenz type is provided, with the apparent addition of those changes required to enable this equipment to serve the additional purpose of ultra-high frequency ground reception. This equipment is located immediately aft of the gunner, and mounted on a frame suspended by a standard-type German shock mount.

This standard German shock-mount consists of a rubber column acting in bending with the load applied to one end, the other end having a base secured to the structure of the airplane. Fittings on both ends of the column are steel plates valcanized to the rubber. These rubber columns are about 1-1/2 in. long by 1 in. dia., and are used throughout the radio installation for mounting all items containing vacuum tubes, with the exception of the radio compass receiver.

The radio compass receiver is located opposite the blind landing equipment, mounted on an unusual shock mount having a section approximating the letter "W", where the load is applied to a mounting plate fastened across the two lower points of the "W" and the mount is fastened to the structure by a plate fastened to the upper points and middle apex.

The radio compass receiver is controlled from the radio operator's (navigator's) position by two flexible shafts, a pair of steel wire controls (similar to an American Ahrens control) and two electrical cables. The loop antenna is located on the bottom of the fuselage, and mechanically controlled from the operator's position by an additional flexible shaft. Quadrantal-error correction is provided within the indicator itself.

The airplane, in addition to the direction finder loop antenna, carries a "V" antenna, extending from a mast mounted on the cockpit enclosure above the radio operator's position to the twin tail-assemblies, a trailing antenna, previously discussed, and dipole antenna mounted on the bottom of the fuselage, aft of the direction-finder loop.

The radio equipment provides the following facilities: reception and transmission of C.W., I.C.W., (continuous wave, and interrupted continuous wave) and phone on bands of 300 to 600 kilocycles and a band of three to six megacycles, with a power output of from 50 to 75 watts. Amplified interphone communication is available between radio operator and pilot but no provision is made at the gunner's position. Radio bearings may be taken over the range of 167 to 1000 kilocycles, homing also being provided in this range.

Blind approach, using the Lorenz system, is provided for the guidance of the pilot, and in addition, an ultra-high frequency traffic control channel is built into this equipment.

Operation of Radio Equipment

Operation of this equipment is under the direct control of the radio operator with the exception of the primary power-supply switches located in the gunner's compartment. When the power is turned on to the main radio-control panel at the radio operator's station by closing one of these switches, the filaments in the interphone amplifier, both transmitters, and both communications receivers are turned on, making any of these instantly available without waiting for cathodes to heat. Selection of the function of the equipment is made by an eight-position rotary switch, shown in Fig. 5. This switch selects the antenna to be used for transmission and reception by the communication channel, and connects the relevant antenna tuner control circuits and power supply circuits.

Reception is controlled through the interphone switch box which connects any or all of the receivers to the phones of both pilot and radio operator. Individual volume controls are provided in each interphone box. The pilot may select either interphone, or interphone and radio, and may also call the operator through the use of a call button mounted in the volume control knob of the pilot's interphone box. The pilot's control of the radio equipment is limited to a push-to-talk switch conveniently mounted on the left-hand edge of the cockpit enclosure.

Either the normal blind landing frequency or the communication frequency may be selected by the radio operator through the use of a two-position switch mounted in his cockpit controlling the necessary relays in the main beacon receiver and its antenna loading unit. Whether this receiver will be used for communication or blind landing indication is controlled by suitable switches in the interphone switch box to direct its output to either headphones or blind approach indicator on the pilot's instrument panel.

The control of the indicator for homing, also mounted on the pilot's instrument panel, is likewise provided in the interphone switch box. Since a common power supply is used for both blind landing and radio compass, mechanical interlocks are provided to make it impossible to listen to one receiver and have the other receiver, not connected to any source of power, connected to the indicating instruments for pilot's guidance, since this situation would give inconsistent indication between aural and visual signals.

The key for telegraphy on either C.W. or I.C.W. is connected to keying relays in the radio control box, one of which is of the slow release type, making it unnecessary to do more than press the key to change from transmission to reception. A time delay of approximately one-half second is allowed following transmission before the equipment will return to reception.

Since the transmitters are of the self-excited type it is necessary to provide a monitoring position of the radio control switch in which reception can be maintained from the ground, or other net control station, while the transmitter is tuned to zero-beat. Selection of unmodulated transmission is through an additional switch external to the radio control unit.

Transmitters

The transmitters used on this airplane are mechanically identical, the only differences being the coil and condenser sizes required to provide a range of 300 to 600 kilocycles for the long wave transmitter, and 3 to 6 megacycles for the short wave transmitter. The views of Fig. 3 show both the long and short wave transmitters, and the description of the transmitters given herein will apply equally well to both, unless otherwise noted.

The transmitter circuit is a M.O.P.A. (master oscillator, power-amplifier) type, using a type RL-12-P35 tube as oscillator and two in parallel as amplifiers.

This tube is an R.F. pentode of 50 to 75 watts plate dissipation whose design makes it particularly adaptable to high frequency operation. The emitter is this tube is an indirectly heated cathode running directly on the 24 volt supply. It is reasonable to believe that the M.O.P.A. type of circuit was selected because of a lack of suitable quartz for control crystals,and the fact that a transmitter using this circuit can be set at any desired frequency without using a special control unit.

Both stages of the transmitter are tuned with variometers and fixed open-stacked mica condensers. In the case of the low frequency transmitter the variometers have moulded plastic forms, powdered iron cores, and Litz wire windings. Those in the high frequency transmitter have ceramic forms, powdered iron cores, and flat-wound copper-ribbon windings. Because of the concentric line coupling from the transmitter to antenna tuner it is possible to gang the tuning of both oscillator and amplifier and to directly calibrate the tuning control in terms of frequency. This tuning control is provided with a mechanical indexing system whereby any four frequencies may be predetermined and a magnifying lens is provided to facilitate reading the index markings. The indexing system operates mechanical stops as the dial is rotated. Each of these stops will open an associated target indicating which channel has been selected. Directly under these targets is a plate with writing surface for noting the frequency set up on each channel. To compensate for possible inaccuracies of this system a vernier control is provided to adjust by small increments the exact tuning point as established by this mechanical means. These stops may be readily set from the front of the transmitter with either a large screw driver or ordinary coin.

The plate voltage applied to these transmitters is between 750 and 800 and comes through fuses in extractor-type fuse holders forming an integral part of the junction box for the transmitter mounting. This junction box is located on the bulkhead supporting the transmitter rack, adjacent to the connecting plug. The rack on which these two transmitters are mounted is fastened to the radio operator's bulkhead with four of the column shock-mounts previously discussed in connection with the ultra-high frequency equipment. Connection from the rack to a junction box on the supporting bulkhead is through a single flat cable terminating in a multiple connector plug.

Servicing is a paramount factor in the design of this equipment, and it is mounted by two hooks in the upper corners of the transmitter, with two quick-release fasteners with screw driver heads in the lower corners. Connections between transmitter and rack are made through an integral plug (Refer to Fig. 1).

When the transmitter has been removed from the rack, protective covers over front and rear may be removed to expose the mechanism and tubes, and that portion of the transmitter carrying the tubes and part of the fixed components of the set may also be disassembled. Use is made of integral plugs to facilitate disassembly without unwiring.

In the transmitter, extensive use is made of die-cast supports for the various units. Internal wiring of the units is made with wire between No. 28 and 30 size, insulated with varnished cambric tubing. With the exception of those wires carrying radio frequency, all wires are cabled tightly together and run in channels of the die cast chassis.

Testing and servicing of the entire unit is facilitated through the use of a test-set receptacle in the front panel. This receptacle provides testing of all circuits without disturbing the set box in any manner. Servicing of the individual component chassis would be a very slow and laborious task by anyone except a man thoroughly familiar with the particular piece of equipment as the wires have neither color codes nor numbers, and yet are cabled together. Some help to service personnel is given by decalcomania labels applied on or adjacent to each item in the set giving the designation of that part as used in schematic and wiring diagrams. Further help are the complete value markings on each part, including the electrical size, operating and test voltages, and current limits; together with tolerances and any other information pertinent to the particular part.

The appearance of these units gives the impression that primary importance has been placed upon removal of the unit from the ship for service, and secondary importance upon removal and replacement of faulty components in minimum time.

Receivers

The receivers are identical, with the exception of the components determining the frequency range, and these frequency ranges are identical to those of the companion transmitters. The receivers are eight tube super-hetrodynes, using in all positions a type RV 12P 2000 tube, this tube being a miniature R. F. pentode of remote cut off characteristics. The tuning control of this receiver is mechanically similar to that of the transmitter, but operating in this case a three-gang variable condenser, connected to iron core fixed inductances. As in the transmitter, a magnifying lens is provided for viewing the scale on the tuning control. The receivers are provided with individual volume controls, as well as beat-frequency oscillator controls, and have concentric-line antenna connections which lead through the radio-control box to the proper antenna loading unit. The receivers, like the transmitters, have a test receptacle on the front panel and plate voltages are supplied through a similar fusing arrangement in their junction boxes. Each receiver will disassemble into two units as shown in Fig. 4, in a manner analogous to that of the transmitter, with one unit containing the R. F. and I. F. circuits, and the other housing the audio circuits.

Radio Control Box

All functions of the radio system are controlled through switches and other components contained in the radio control box. This unit is mounted in a manner similar to the transmitters and receivers except that, since it does not contain tubes, it is neither provided with shock mounts or quick release fasteners.

Connections are made to this unit through a seventy-five terminal connector which is an integral part of the mounting unit, as shown in Fig. 11. Concentric lines are brought through this connector with apparent complete disregard for their concentric characteristics; they are likewise handled within the unit as any other wire carrying radio frequency power, i.e., spaced away from the cables of other wires.

Control of transmitter and receiver operation is provided through a centrally-mounted eight-point, cam-type rotary selector switch. The mechanism of this switch is identical with that of a toggle switch, with operation by cam lobes on the shaft carrying the rotating handle on the front of the control box. The operation of the antenna reel is controlled by a normally off-momentary on-on switch with indication of its operation provided by two targets adjacent to the switch. The antenna tuning units are operated by A C Selsyn motors mounted directly behind the tuning dials. Power for these Selsyn motors is provided by a 12 volt 400-cycle winding on the transmitter dynamotor. Incorrect operation of either antenna tunner is prevented by an electric clutch between the dial and Selsyn motor. This clutch disconnects the tuning handle from the dial and Selsyn motor unless the setting of the selector switch requires that the associated antenna tuner be adjusted for transmission. Antenna-current indications are given by an emission meter mounted on this control unit, calibrated in arbitrary units and arranged to operate from thermocouples in the antenna loading units. Two keying relays are also in this control unit. The first of these relays is quick-make, slow-release, and operates the instant the key is closed. It serves to disable the receivers and connect the antenna to the transmitter. The other is quick-make, quick-release type and performs the actual keying operation. These relays are both of telephone type and are contained within a separately covered compartment shown in Fig. 5.

Antenna Loading Units

One antenna loading unit is provided for each antenna, top and trailing. The units are identical with the exception of the electrical parameters of the circuits associated with the low frequency channel, being larger in the case of the top antenna. Iron core variometers are used for tuning; one for both long-wave channels and another for the two short wave channels. Very effective use is made in these units of moulded plastics, including gears, cams, variometer parts, switch plates, and various structural members. Channel selection is by a rotary switch ganged with both variometers and the cam type change-over switch, with the whole being driven by the Selsyn motor. These variable circuits are used to tune the antenna as required for transmission, and serve to match it to the concentric line from the transmitters.

A vacuum relay is incorporated in the antenna tuning unit. This relay automatically connects the antenna to the transmitter through an adjustable network while the transmitting key is being operated, and automatically switches the antenna back to the receiver through a broadly tuned network when the key is not operated for a short period of time. The contact assembly for this antenna change-over relay is encased in an evacuated glass tube with connections making it possible to plug in this portion of the relay without disturbing the operating coils which are external to the glass tube and permanently mounted in the tuner.

Antenna Reel

The antenna reel shown in Fig. 6 is motor-driven and remotely controlled. Braking is provided by the lateral displacement of the spring-loaded armature when power is disconnected. This proves to be highly effective since the gear reduction between the antenna reel and motor for the reel will operate in either direction as selected by the radio control box. When operation is desired on a channel using the trailing antenna, the antenna reel switch may be operated to cause the reel to unwind and pay-out the antenna wire. This operation will continue either until the switch is returned to the "off" position, or until the end of the wire and the limit of the antenna reel is reached, at which time an integral limit-switch will stop the motor. Auxiliary contacts on the spring-polarized motor-operating relay supply power to the solenoid operated targets on the radio control box, thereby indicating the actual operation of the antenna reel as against the setting of the reel operating-switch at the moment. This reeling out operation can be performed only when the channel selector switch is in a position requiring the use of a trailing antenna.

The antenna may be reeled in at any time, provided only that momentary contact be made at the reel operating switch, regardless of the position of the channel selector switch. When the antenna starts to reel in it can not be stopped until it is fully retracted. When the antenna is fully reeled in, the antenna weight will bottom against the antenna fairlead stopping the reel and putting an overload on the motor, which will tend to draw the wire tighter against this stoppage. A thermal cut-out is provided so that when this overload has existed for a moment the motor will turn off, thereby braking itself, holding the antenna tight against the fairlead and causing the reel position indicating target to drop. If, however, the antenna weight becomes lost, the antenna reel will wind the wire through the fairlead and continue to wind until an integral stop is reached, at which time the motor will cut off. When stopped by this limit switch it will be impossible to again reel out the antenna, thus precluding the possibility of fouling an unweighted antenna wire within the ship. To again restore the reel to operation it is necessary to remove the reel assembly from the motor drive, replace the antenna wire and recock the limit switch.

Radio Compass

This radio compass is a piece of equipment apparently older in design than the other items of equipment installed in the airplane, being originally designed for battery operation but now provided with plate power from the same dynamotor used for the blind landing equipment. The receiver is a tuned radio-frequency type equipped with a static surpressor, and a beat-oscillator for reception of C.W. signals. It can be operated on two bands to provide aural-nut direction finding, cardioid direction finding, interlocked A-N aural homing, or visual homing. Type of operation and band are selected by a rotary switch driven from the receiver control unit in the radio operator's cockpit, the various indications being given by a motor driven rotary switch within the receiver. The receiver when used as aural-nul direction finder is not sensed, however, the 180° ambiguity can be removed in the normal manner for a receiver of this type. When operated as direction finder the indication of the loop position is given on a large azimuth scale whose lubber line is also variable, being operated by the remote indicating, aperiodic navigational compass mounted in the after portion of the airplane fuselage. Through this method it is possible to get direct magnetic headings from the station upon which bearings are being taken without mathematical correlation of loop position and compass reading. Within this indicator is also contained the automatic quadrantal-error cam. Connection between the azimuth indicator and the loop rotating head is by flexible shaft contained in rigid tubing. This contributes to lightness and reduces backlash of the entire installation. Direction change is accomplished through the use of right-angle mitre gears. A section of this type of flexible shafting is shown in Fig. 7, as are the aximuth indicator, receiver control and loop head. The loop for this receiver consists of two 6-1/2 in. dia. turns of steel tubing, without protection or streamlined housing. However, the specifications for this loop call for the drag not to exceed ten pounds at 250 mph with the loop set perpendicular to the axis of the ship.

In order to eliminate broad nul indications common to radio direction finders mounted in aircraft, a zero cleaning circuit is provided which is also controlled from the radio operator's position. The signal required for this circuit is obtained from the short vertical antenna on the top of the canopy, this antenna being used also for the main beacon receiver. Coupling to the compass receiver is through the antenna-loading unit and a concentric line.

Blind Landing Apparatus

A Lorenz blind-landing system is provided, consisting of two units, main beacon-receiver and marker-beacon receiver, as shown in Fig. 8. The tubes used in this equipment are similar to those used in the direction finder receiver, making up the total, together with those in the transmitter and communication receivers, of three types used in this airplane. The main beacon-receiver is of the tuned radio frequency type and operates from a vertical antenna 80 cm. high on top of the cockpit enclosure directly over the radio operator, through an antenna loading unit at its base and a concentric transmission line. Both this loading unit and the receiver are provided with frequency change relays making it possible to operate this equipment for both visual indication of approach and traffic control. The construction of this equipment places great stress on mechanical rigidity to the extent that its mechanical design approximates that of conventional high-frequency transmitters. The audio output of this main beacon receiver is fed to the audio system of the marker-beacon receiver, since the single audio-system can serve for both of the disassociated signals. The marker-beacon receiver has no radio frequency amplification. Its detector operates directly into the audio amplifier and filter. The antenna for this marker beacon receiver is a dipole coupled to the receiver through a matching transformer and concentric transmission line. Operation of the main beacon is on 9 meters and the marker beacon receiver on 7.9 meters. Output of both receivers is fed to the interphone switch box where it may be either monitored orally or fed to the visual indicating device on the pilot's instrument panel.

Interphone Equipment

Interphone communication is provided only between the radio operator and pilot. The interphone amplifier shown in Fig. 9 uses the same tubes as the receivers, and the small extractor knob for removing these tubes is stowed inside inside its case. The amplifier chassis also contains the tubes used as suppressor grid modulators for the transmitters. It is shock mounted in a similar manner to the receivers and transmitters and is likewise independently fused.

The interphone control box has switches for connecting any one or all, of the receivers to the headphone bus, as well as the output of the interphone amplifier. Switching is also provided for operating visual indicators mounted on the pilot's instrument panel. This switching is provided with suitable interlocks to control the plate supply dynamotor for the two units.

Dynamotors

Three dynamotors are provided on this airplane, with the largest being a 750-volt, 300-milliampere machine. In addition, this machine supplies A.C. for the operation of the Selsyn tuning motors and modulator filiaments, as well as bias voltages. Cooling is achieved through the use of a large centrifugal blower. Integral fusing is provided for each of the windings of the machine and the entire unit is again mounted with integral plug and quick-release fasteners similar to the receiver mountings, with exception that shock-mounts are not provided.

A 250-volt, 150-milliampere machine is provided for communication receiver plate voltage and interphone amplifier supply. This machine is cooled by a small fan. Fusing is again integral and the mounting is identical to the transmitting dynamotor.

The remaining dynamotor is used to supply plate voltage to either the main and marker beacon receivers or the radio compass receiver. Its operation is controlled by the switches on the interphone amplifier switch box, which in turn, operate the starting-relay built into the dynamotor unit. A ballast tube is provided for the control of filament voltages of these units and a gaseous-discharge type regulator for control of plate voltage.

Internal fusing of this machine would be impractical since it supplies power to two separate items of equipment and failure of either of these would blow the fuse making it impossible to operate the other. Therefore, special fusing adaptors are provided in the power plugs for each of these items.

Each of the dynamotors is provided with adequate low and high frequency filters in the circuits of each winding, these being indicated in Fig. 10

Conclusions

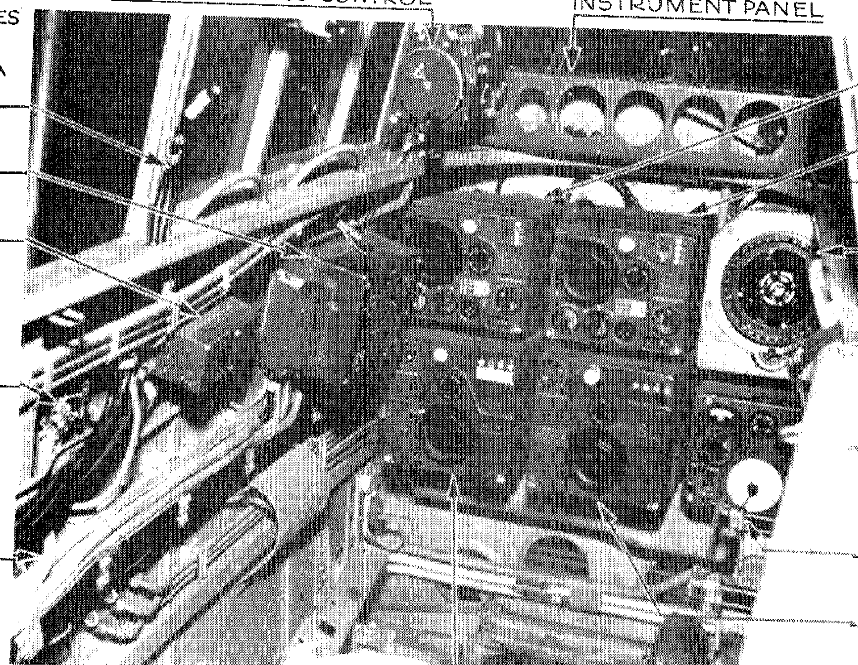
The radio equipment of the Messerschmitt Me110 represents the best practices of modern American design and equipment for airplanes of equivalent size. The facilities listed herein have been provided at a total weight of only 300 lbs., despite the fact that the equipment appears heavier than American equipment. This illusion is probably created by the fact that the units are each smaller than equivalent American units and therefore in the aggregate, due to their number, would seem to represent a considerable increase in weight.

Standardization appears to have been the watchword. This is particularly true of cabling in the installation, and with individual components within the pieces of equipment themselves. This standardization is indicated in such ways as the use of only three types of interconnecting cables in the installation. In cases where a number of wires different than that of the standard cable was required, standard cable was used and the unused wires were doubled back and allowed to remain. Standardization is again indicated in the inclusion of several cables and plugs which were not used in this installation but were nevertheless installed, indicating that other equipment could readily be used in this same airplane without cable changes.

Standardization of tube types has been achieved through the selection of the most complicated tube structure necessary and providing this tube with sufficient external connections so that it may be connected as required by each particular usage.

It is difficult to fix the exact date of this radio equipment since some of it appears to be more modern than other parts. However, the best indication can be derived from the date on which the radio compass loop azimuth indicator was calibrated for quadrantal error, this date being August 8, 1939.

RADIO EQUIPMENT



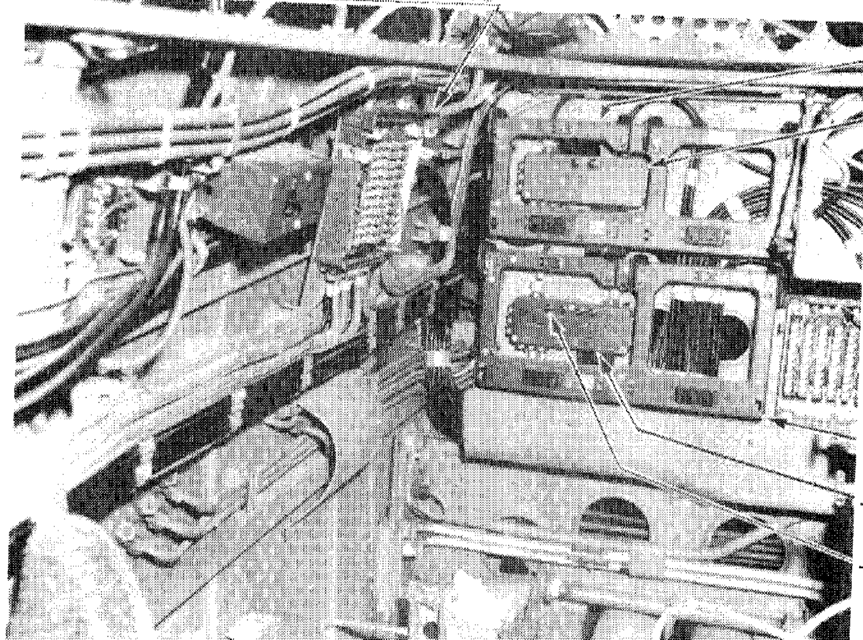


FIG. 1 RADIO EQUIPMENT IN COCKPIT FIG. 1

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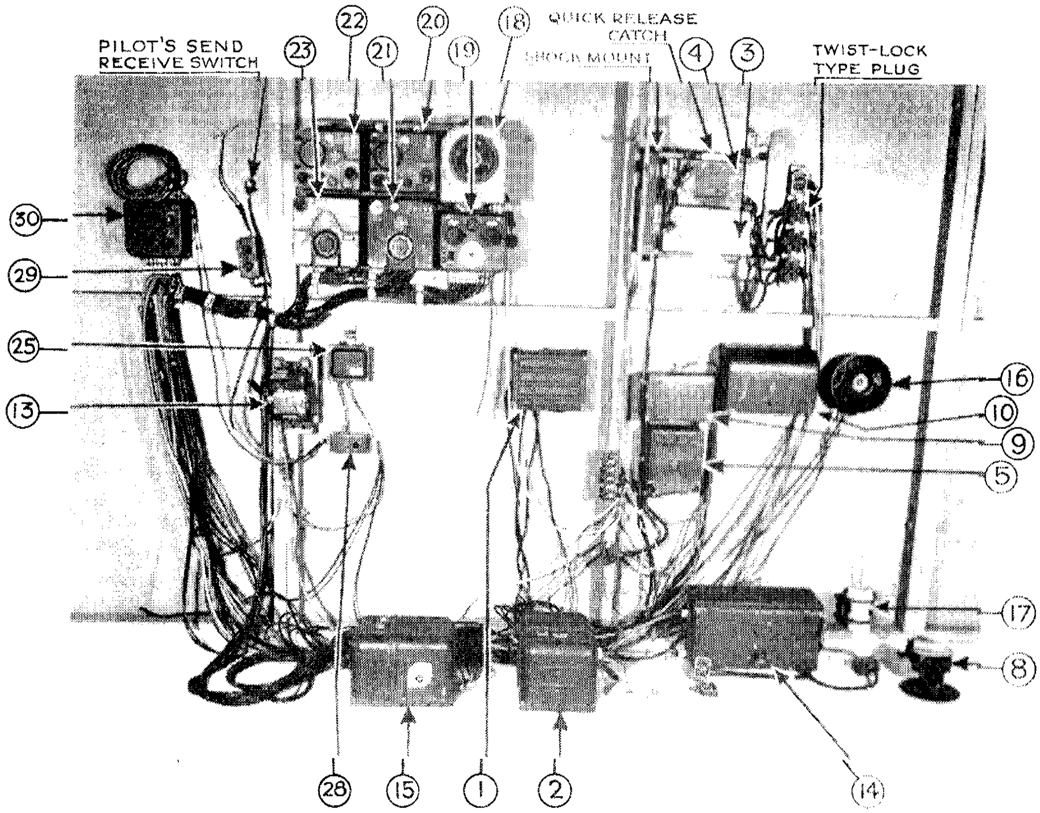

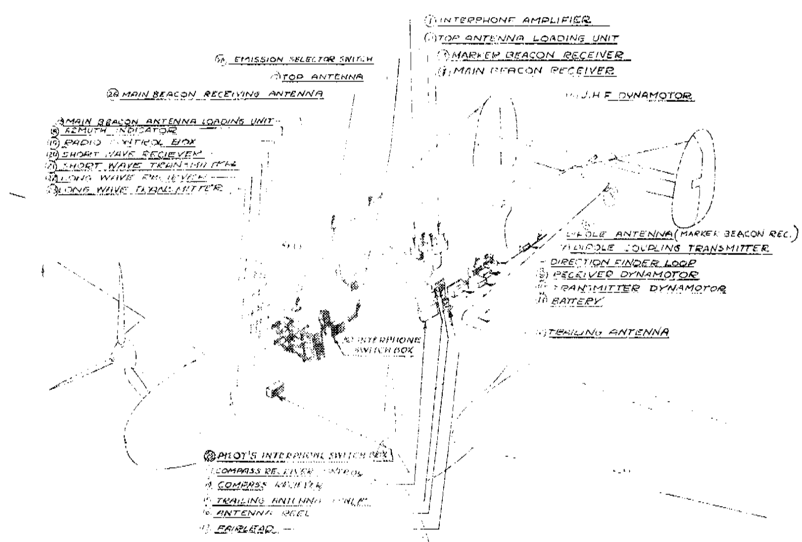

FIG. 2   RADIO EQUIPMENT & LOCATION DIAGRAM   FIG. 2

RADIO EQUIPMENT

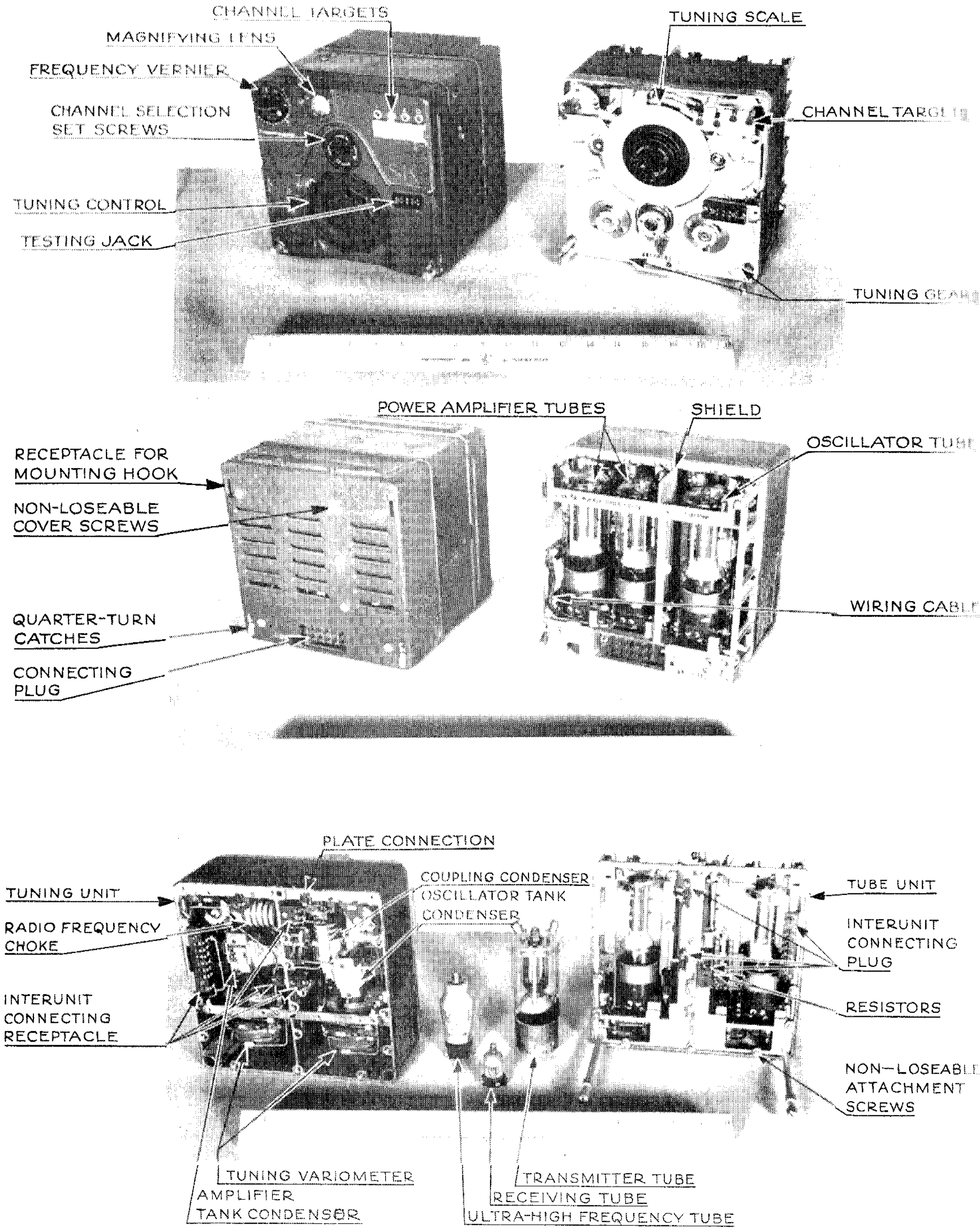

FIG.3 LONG & SHORT WAVE TRANSMITTERS FIG.3

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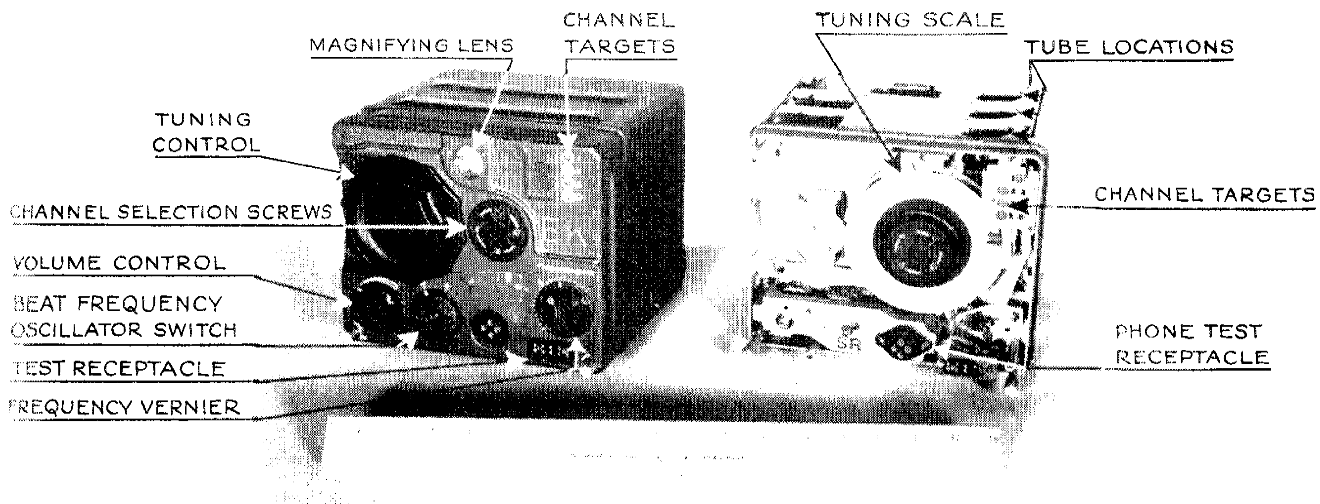
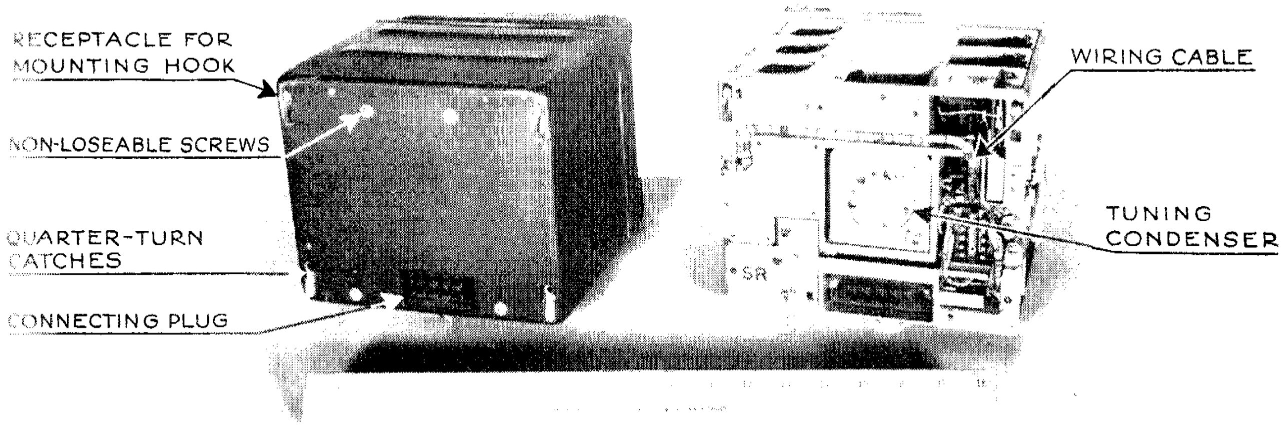
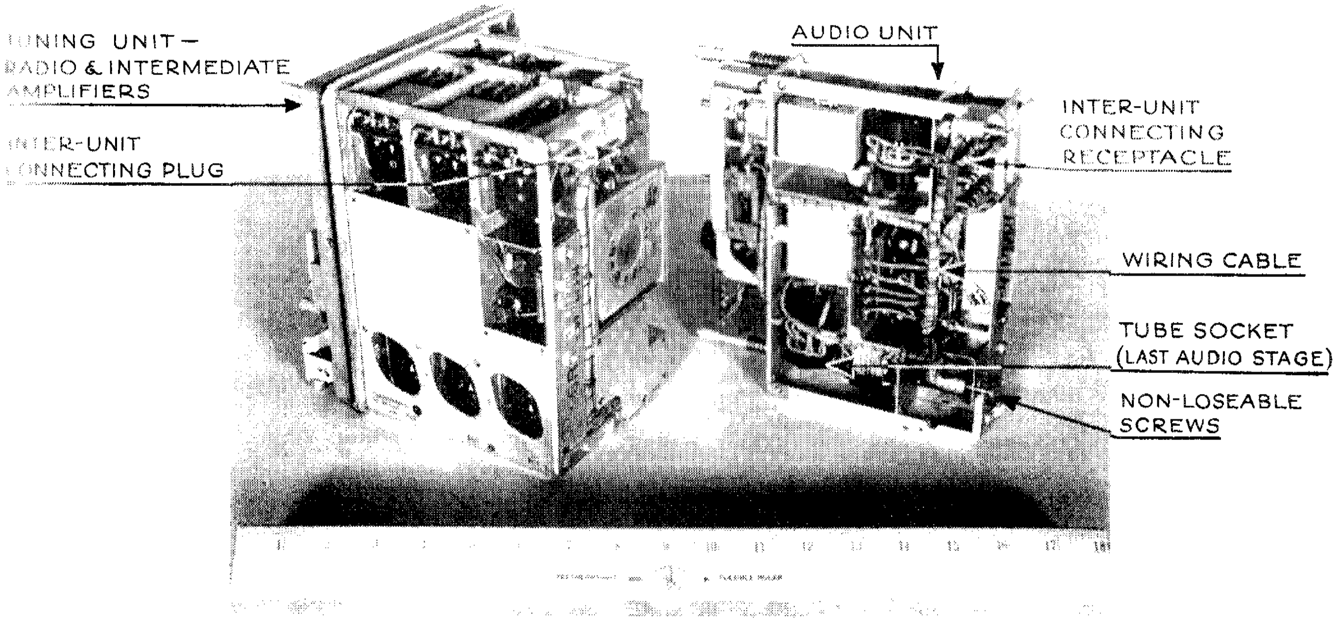


A. FRONT VIEW



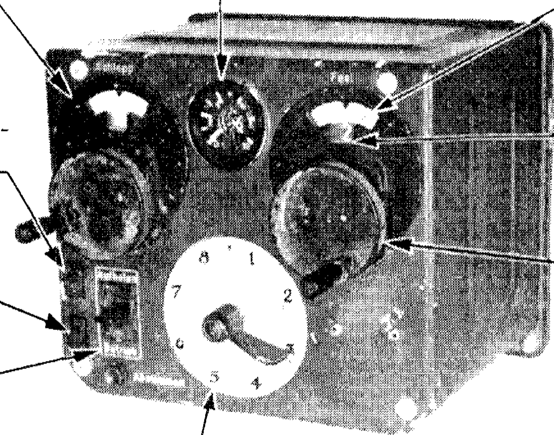
B. REAR VIEW



C. DISASSEMBLED

FIG. 4 LONG & SHORT WAVE RADIO RECEIVER UNITS FIG. 4

RADIO EQUIPMENT



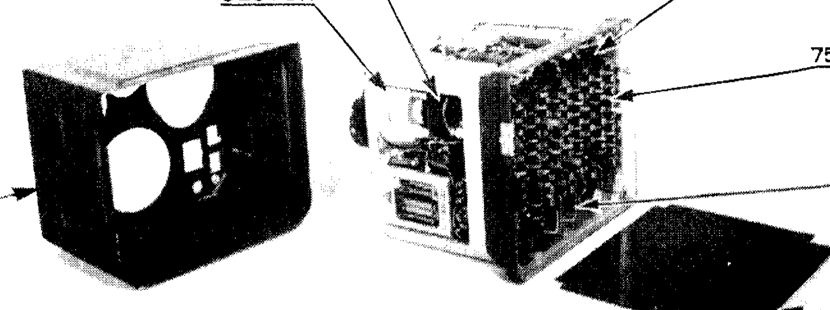


FIG. 5 RADIO CONTROL BOX FIG. 5

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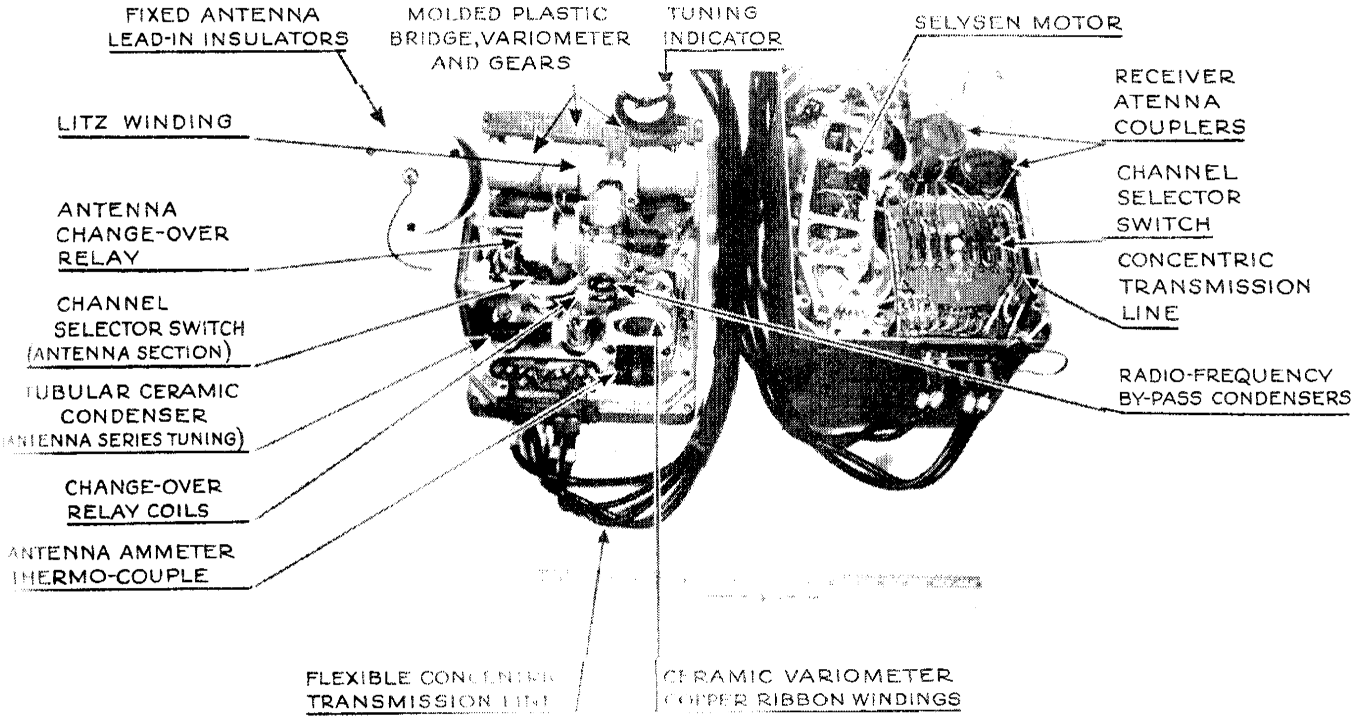

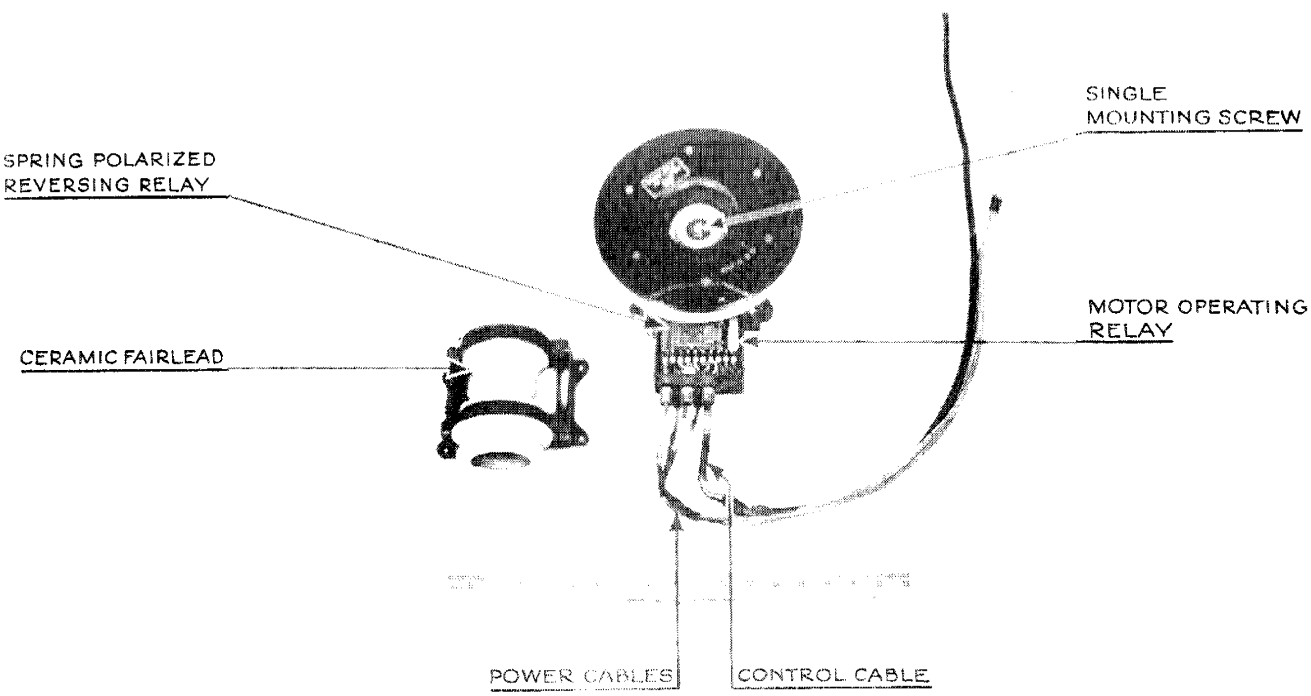

FIG. 6 ANTENNA LOADING UNIT & REEL FIG. 6

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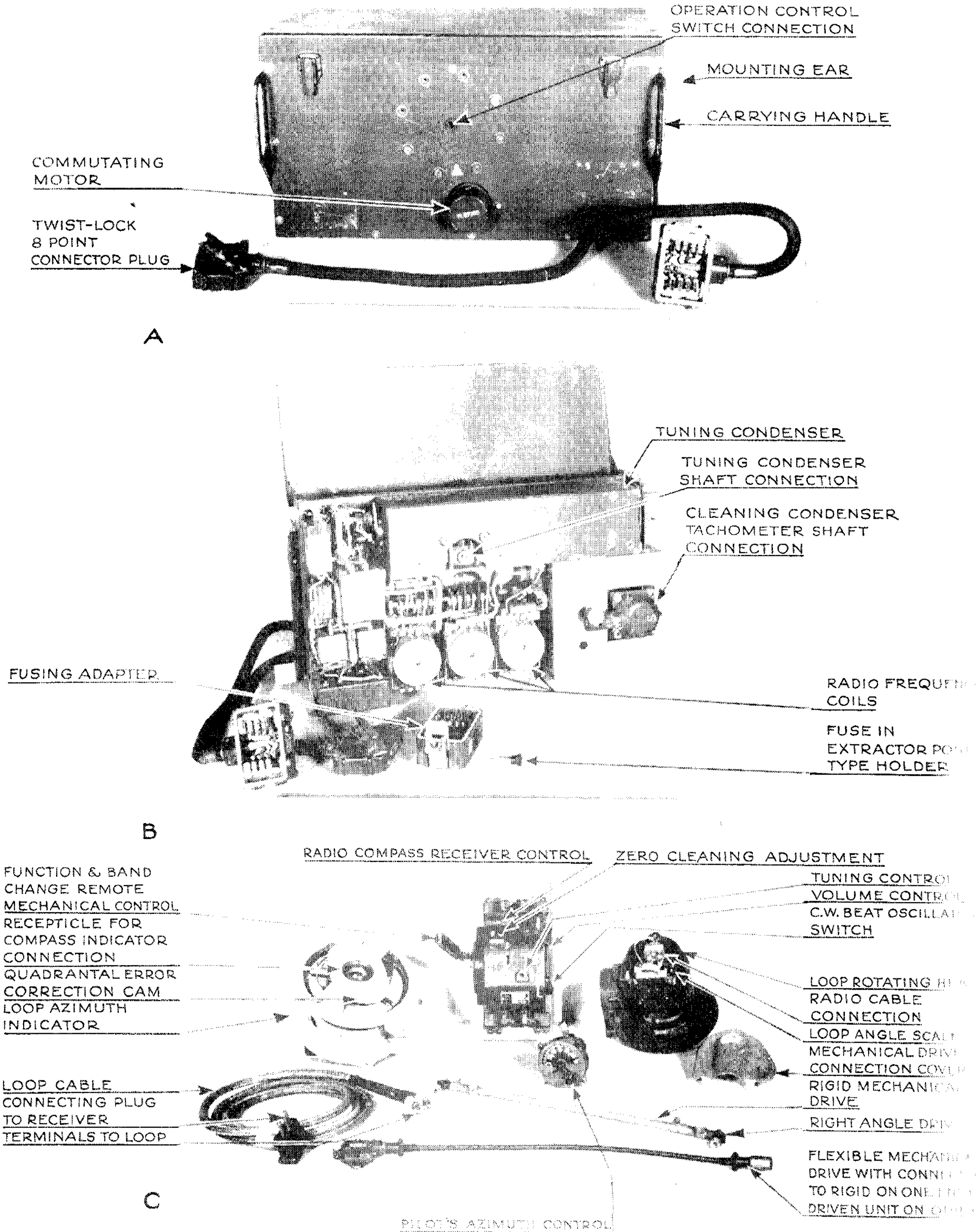

FIG. 7 RADIO COMPASS RECEIVER UNITS FIG. 7

RADIO EQUIPMENT

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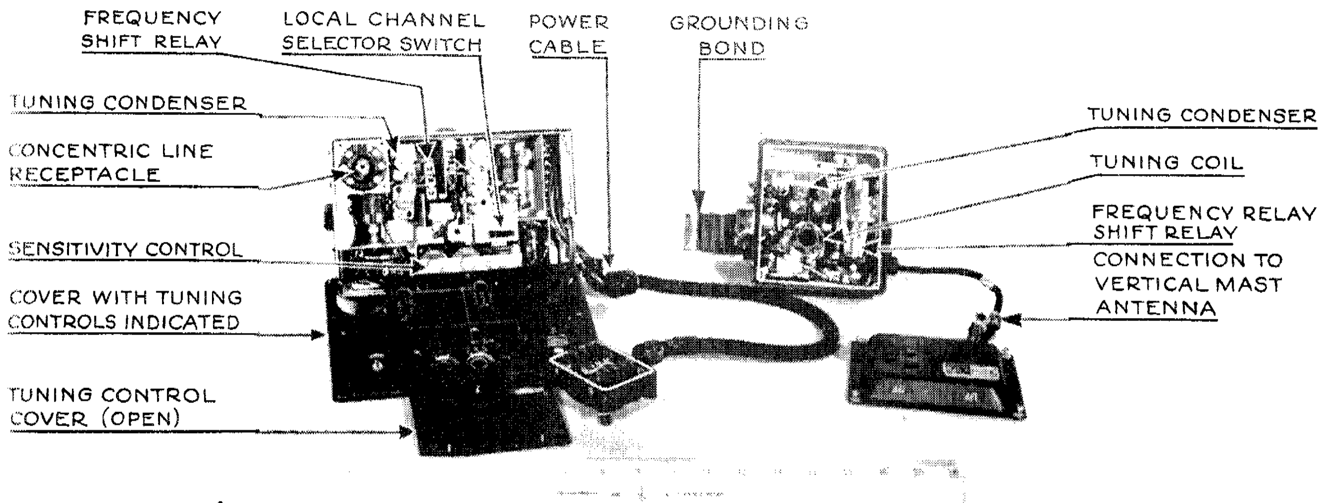

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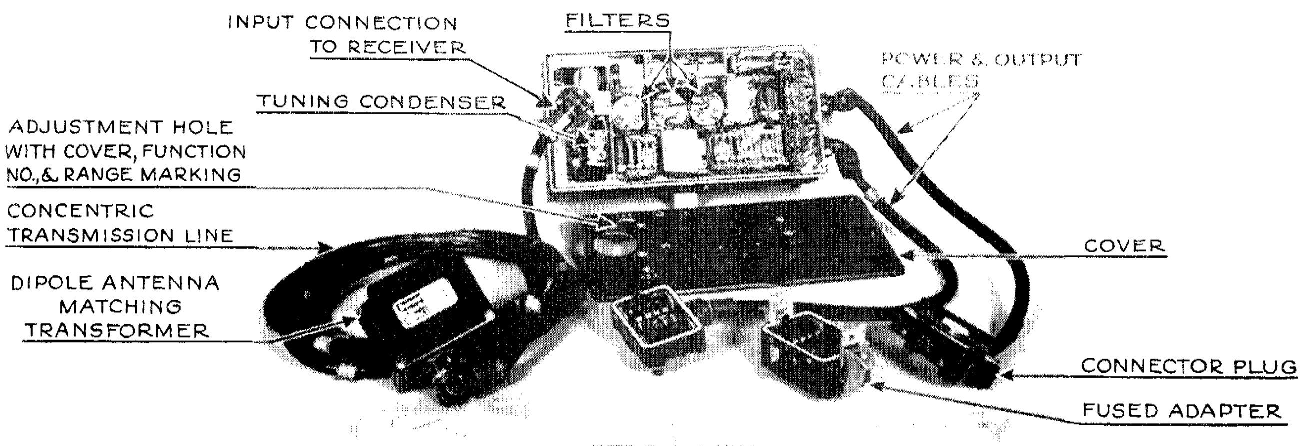

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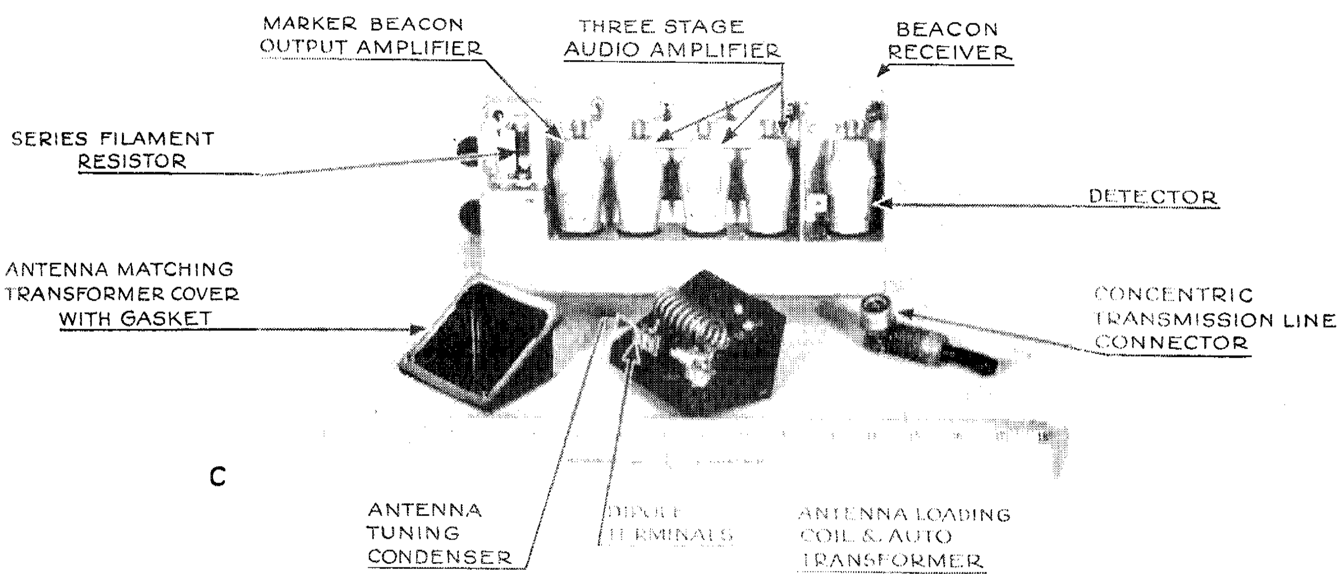

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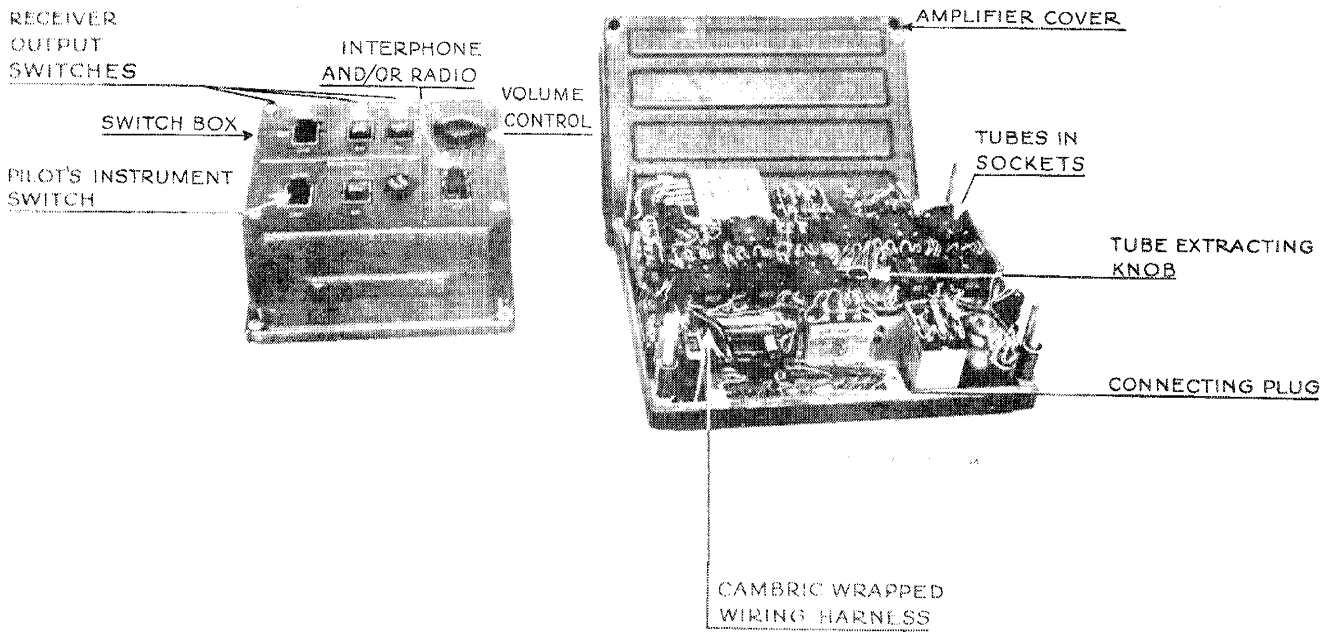
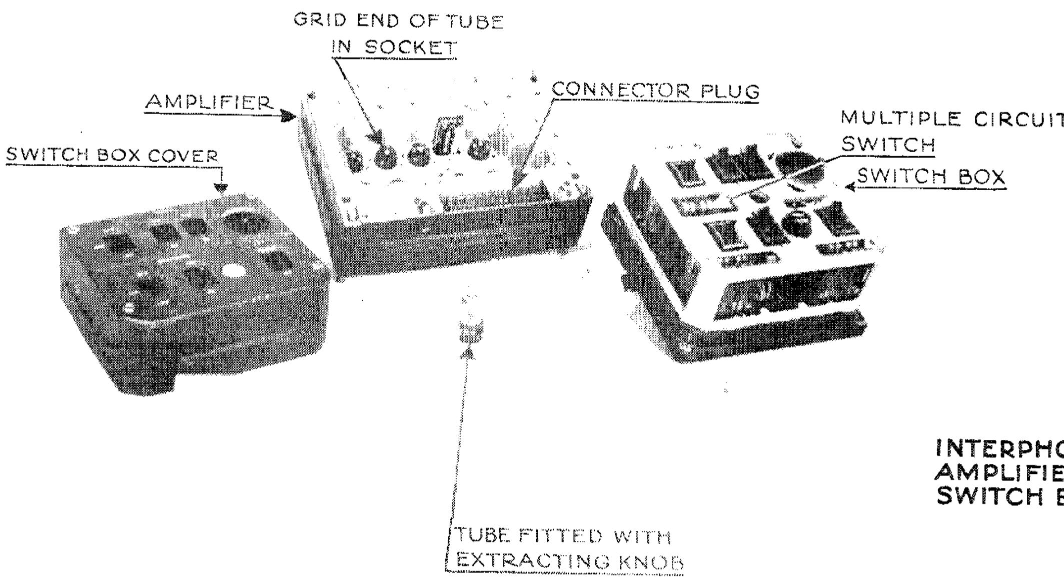
FIG. 8 BLIND LANDING EQUIPMENT FIG. 8

RADIO EQUIPMENT



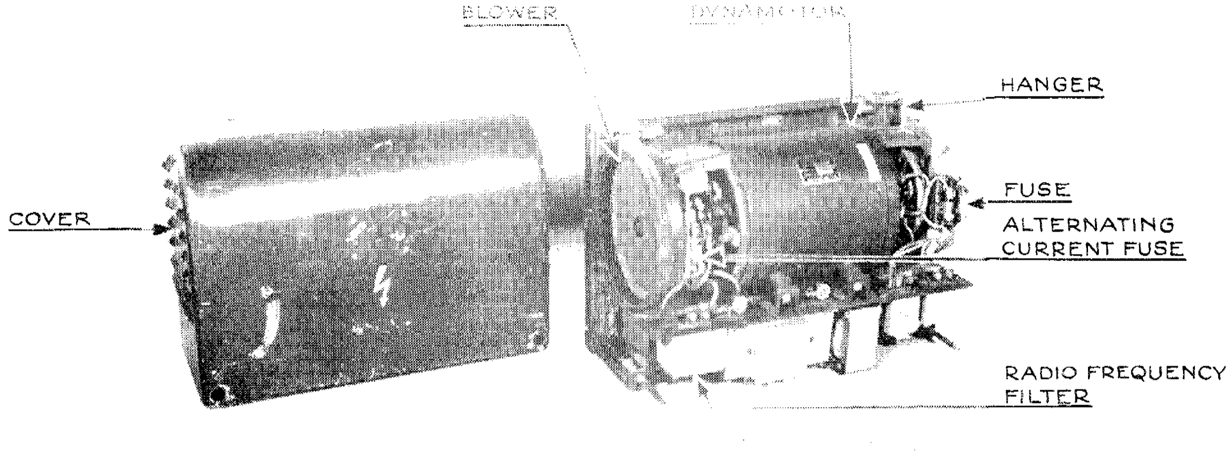


INTERPHONE AMPLIFIER & SWITCH BOX

FIG. 9 INTERPHONE UNITS FIG. 9

RADIO EQUIPMENT

SECTION III CHAPTER 9



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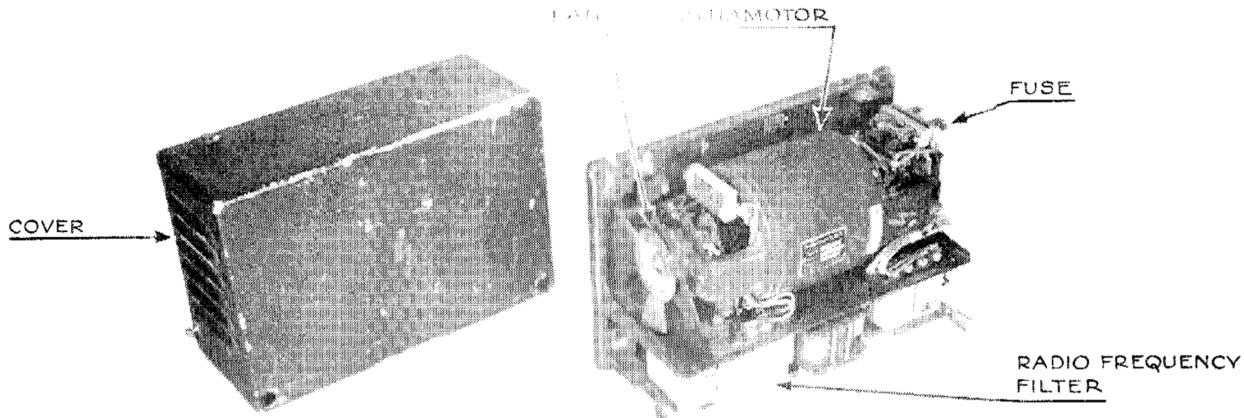

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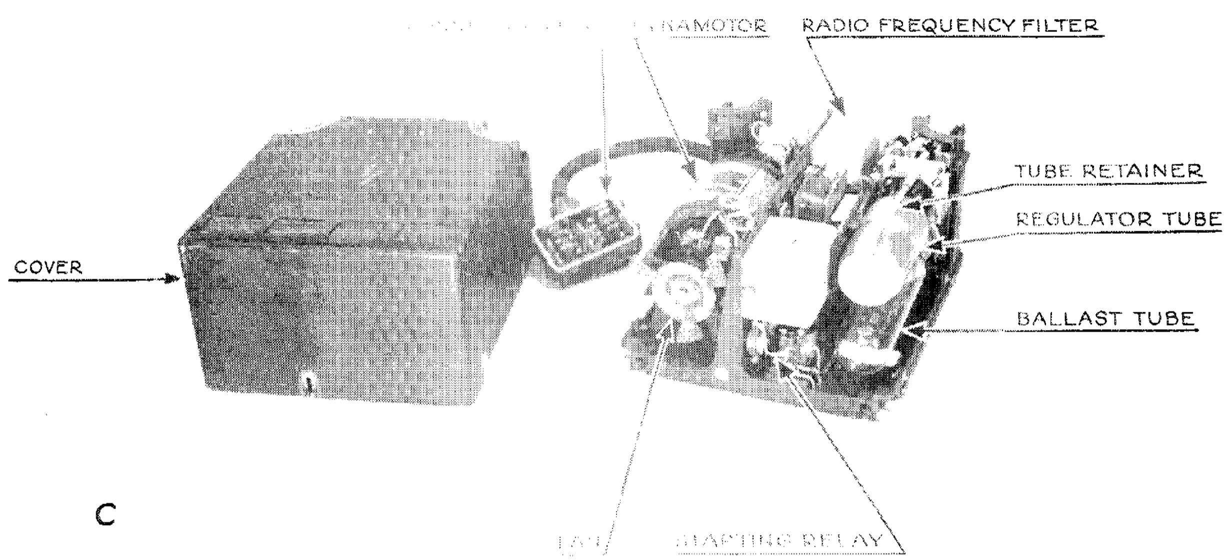

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FIG. 10 DYNAMOTORS FIG. 10

Chapter 10

GUNNERY EQUIPMENT

Chapter 10

GUNNERY EQUIPMENT

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LIST OF ILLUSTRATIONS

SECTION III

CHAPTER 10

GUNNERY EQUIPMENT

General

Five machine guns and two cannons give the Me110 terrific striking power as a fighter or as an attack airplane for strafing troop concentrations and transportation units. These same airplanes, [illegible] of fact, were used during the Polish campaign to disorganize rail transportation, by flying along railroad tracks and disabling locomotives with explosive cannon shells. Four fixed machine guns of about .32 caliber, [illegible] arranged on a deck in the fuselage nose section, with ammunition boxes [illegible] about 1,000 rounds for each gun located beneath the guns. The [illegible] are installed in the extreme lower portion of the fuselage [illegible] cockpit, and fire through steel blast tubes extending through [illegible] portion of the fuselage nose section. Selective command of [illegible] through firing switches on the pilots control stick. [illegible] (cocking) and electric solenoid firing control is provided [illegible] cannon. The gunner is furnished with a single flexible [illegible] .32 caliber, supported in a universal mount for [illegible] through a wide range. The gunner fires from a [illegible] bucket seat. 500 rounds of ammunition are supplied [illegible]. No armor plate is used in the airplane.

[illegible] GUNS

Gun Compartment

The four 8 mm. Rheinmet[illegible] fixed machine guns are mounted in a

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Editor's Note: The technical data for this portion of the Messerschmitt analysis was contributed by Mr. [illegible] O'Hare, Staff Engineer in Charge of Armament Design, Mr. [illegible] and Mr. Sonntag, Armament Engineers for the Engineering and Development Dept. of Vultee Aircraft, Inc.

streamlined compartment forming the nose of the fuselage. This compartment is divided into two main sections by a horizontal deck located approximately on the fuselage centerline, and into a third compartment by a transverse bulkhead near the front of the lower section. The lower section is a rigid structure connected to the fuselage forward bulkhead with four 7/16 in. steel bolts, while the upper or hood section is hinged to open by moving forward and upward in a manner similar to some automobile hoods.

The guns are located in the upper compartment and securely mounted to the deck structure, with ammunition being fed through chutes extending from the deck and connecting with ammunition compartments located in the lower compartment. Provisions for retaining ejected cases and links are made in the lower compartment. The small compartment in the nose of the lower compartment contains four compressed air cylinders for charging the guns, and mounting provisions for a camera gun arranged to sight through a small opening directly on the fuselage centerline.

Gun Mounts

The two inner guns of the group are mounted on an aluminum-alloy casting base with rear supports and front trunnions. This mounting base also forms a passage for the case-ejection chutes. The outer guns of the group are mounted in a manner similar to the inner guns, excepting that these mounting bases are welded steel tube structures with welded steel sheet case ejection chutes.

All four rear supports are identical and interchangeable, and each consists of an aluminum-alloy casting, attached with four 3/16 in. bolts to its mounting and shaped as a hoop to encircle the gun receiver. The receiver is round, and held by two semi-circular pads located within the hoop-section of the rear support. The lower pad is fixed to the support, and the upper pad carried by a clamping bolt having sufficient adjustment to raise the pad enough to permit removal of the gun.

The front trunnions are also identical and interchangeable, and are steel castings in the form of pivoted yokes, each attached to its gun mounting base by its pivot stud passing through a boss. Lock nuts on the pivot stud provide for vertical adjustment. Transverse slots in the arms of the yoke locate the trunnion block, and provide lateral adjustment.

Ammunition Chutes and Boxes

The feed and ejection chutes are formed from .030 in. steel sheet and fasten with two spring loaded toggle [illegible] to mating openings in the gun compartment deck.

The ammunition boxes were not received with the airplane, but the available space indicates each box is approximately 21 in. by 15 in. and should hold from 900 to 1000 rounds of ammunition. Narrow doors, two at each side of the lower compartment, provide for sliding ammunition boxes onto suitable shelves within the lower compartment. A toggle latch secures the box in place.

There are no link and case retainer boxes provided. Instead, provision is made for cases and links to be ejected into the spaces between the ammunition boxes, from which they can be removed when the boxes are withdrawn for reloading.

Blast Tubes

The blast tubes are [illegible] in. steel sheet formed to a circular shape. The forward end of each tube is shaped to conform with the contour of the nose section. Each tube is fixed to the hood section, and automatically disengages from its respective gun barrel upon the hood being moved forward preparatory to raising into open positions.

Charging and Firing System

The charging system is pneumatic-electric, with an integral charging cylinder located aft of each rear gun support. A flexible hose leads from the solenoid of the charging valve beneath the charging cylinder to connect with a 1/4 in. O.D. aluminum alloy tube leading to the compressed air cylinders. The four air bottles are interconnected by a line leading to a charging connection, recessed flush into the nose skin, and arranged to permit refilling the bottles from a service tank during reloading of the guns. Each bottle is equipped with a regulator and valve which controls the airflow to charging cylinders or charging connection. The cylinders weigh empty, 1.49 kg. each, and are approximately 3 in. O.D. and 10 in. overall length. The electrically controlled charging valves are actuated from push-button switches in the pilot's cockpit. The firing solenoids are attached to the guns, and operated by a conventional control-stick trigger-switch.

CANNON

Cannon Installation

The two 20-millimeter Rheinmetall-Borsig cannons are located beneath the pilot's floor, with their receivers extending beneath the navigator's cockpit to positions below openings in the cockpit floor for loading. Stowage provisions exist for two spare ammunition drums of about 75 rounds each. The cannons strongly resemble the original Swiss Oerlikon cannon from which they were developed. Only the mounting fittings on barrel and receiver appear to have been modified.

Both cannons --- together with their accessories of compressed air cylinders, firing and air-valve solenoids, electric disconnect plugs, and air recharging coupling --- are installed in a cannon mount frame to form a complete, independent assembly. The complete cannon unit is installed in the airplane by passing through an opening in the bottom of the fuselage, and supported by two 1-1/8 in. diameter steel cross-tubes fixed to the fuselage structure in positions immediately fore and aft of the cannon mount. The aft cross-tube is stationary, while the forward tube may be rotated about 90° to engage notches near the tube ends with two hooks at the forward corners of the mount, and thus lock the cannon installation securely to the fuselage structure.

Cannon Mount

The frame forming the cannon mount consists of three longitudinal extruded aluminum-alloy angles(1-1/8 x 1-1/2 x 5/32), with the right side member being reinforced by addition of a bent up aluminum alloy angle (3/4 x 1-3/4 x 1/16) to form a channel section. An extruded aluminum alloy angle (1-1/2 x 1-1/8 x 5/32) forms the aft cross member, while the forward cross member consists of a formed aluminum-alloy "C" section (1-1/8 x 3-1/4 x 5/32) which serves as a support for the left side cannon's front mounting post. The frame is covered by 1/16 in. thick aluminum-alloy sheet, with necessary cut-outs for accommodation of ammunition drums and the like. Another "C" section cross-member supports the right-side cannon's front mounting post. Both "C" sections are mounted on top of the frame by three 1/4 in. diameter bolts passing through filler blocks and the longitudinal members. Two fittings of .051 in. thick aluminum-alloy sheet are riveted to the top of the frame as supports for the rear mounting posts.

Simple channels of .032 in. thick aluminum alloy-sheet attach the compressed air cylinder clamps to the top of the frame at left-front and right - rear corners. Similar channels carry the electric disconnect plugs, and simple bent-up "Z" sections of .030 in. thick aluminum-alloy support the solenoid-valves of the charging control system. A stamping of .032 in. thick aluminum-alloy sheet locates the air cylinder charging connection in a position registering with a cut-out in the lower skin. This charging connection is one half of a quick-detachable coupling similar to that used for railroad air-brake lines, and permits recharging from a service tank as compressor.

The cast steel mounting hooks at the forward end of the frame are fastened to the outer longitudinal members by riveting through the vertical legs of the angles, and using the three bolts attaching "C" section cross-members to fasten the hooks to the horizontal leg of the angles. The similar mounting hooks at the aft end of the frame incorporate provisions for fore-and-aft adjustment, and are each secured to the aft ends of the longitudinal members by four 5/16 in. dia. bolts.

Mounting Posts

The front mounting posts for the cannons are attached to lugs on the cannon barrel sleeves. The rear mounting posts incorporate provisions for lateral and vertical adjustment in one fitting. Lateral adjustment requires a wrench, while vertical adjustment is effected by means of a small hand wheel. A check nut locks the threaded shaft of the handwheel.

Blast Tubes

The blast tubes are .093 in. thick steel sheet formed into a 4 in. dia. circular shape. A strip 1-3/4 in. wide is welded the length of the tube to close the seam. The forward ends are profiled to the fuselage contour. The aft ends are formed into a rectangular box, open at the bottom, to relieve excessive muzzle-blast pressures. A flange bent inside each tube provision receives four locking pins to secure the blast tube to the fuselage structure. The forward part of each tube rests on a channel-section cross-member in the bottom of the fuselage, and is attached to that member by a threaded metal band.

Charging and Firing System

The charging system is pneumatic-electric, while the firing system is entirely electric. A charging cylinder is attached to the receiver of each cannon by fittings utilizing mounting lugs on front and rear posts, and on top of the cannon. A 1/4 in. dia. aluminum-alloy tube connects the charging cylinder with the solenoid-valve which in turn is connected with an air bottle. Both air bottles are interconnected by a line leading to the recharging coupling. Each air bottle weights 1.6 kg. empty, and measures 9-3/4 in. overall length and 2 7/8 in. diameter.

The solenoid valves are wired to disconnect plugs accessible from inside the airplane for connection to the electrical system after installing the cannon mount in the fuselage. Push-button switches in the pilot's cockpit operate the charging controls, and firing is controlled by a conventional control-stick trigger-switch.

Each cannon has its firing solenoid and rounds counter attached to the upper rear portion of the receiver by means of the rear mounting lugs.

The entire cannon assembly, including all accessories, weighs 125 pounds.

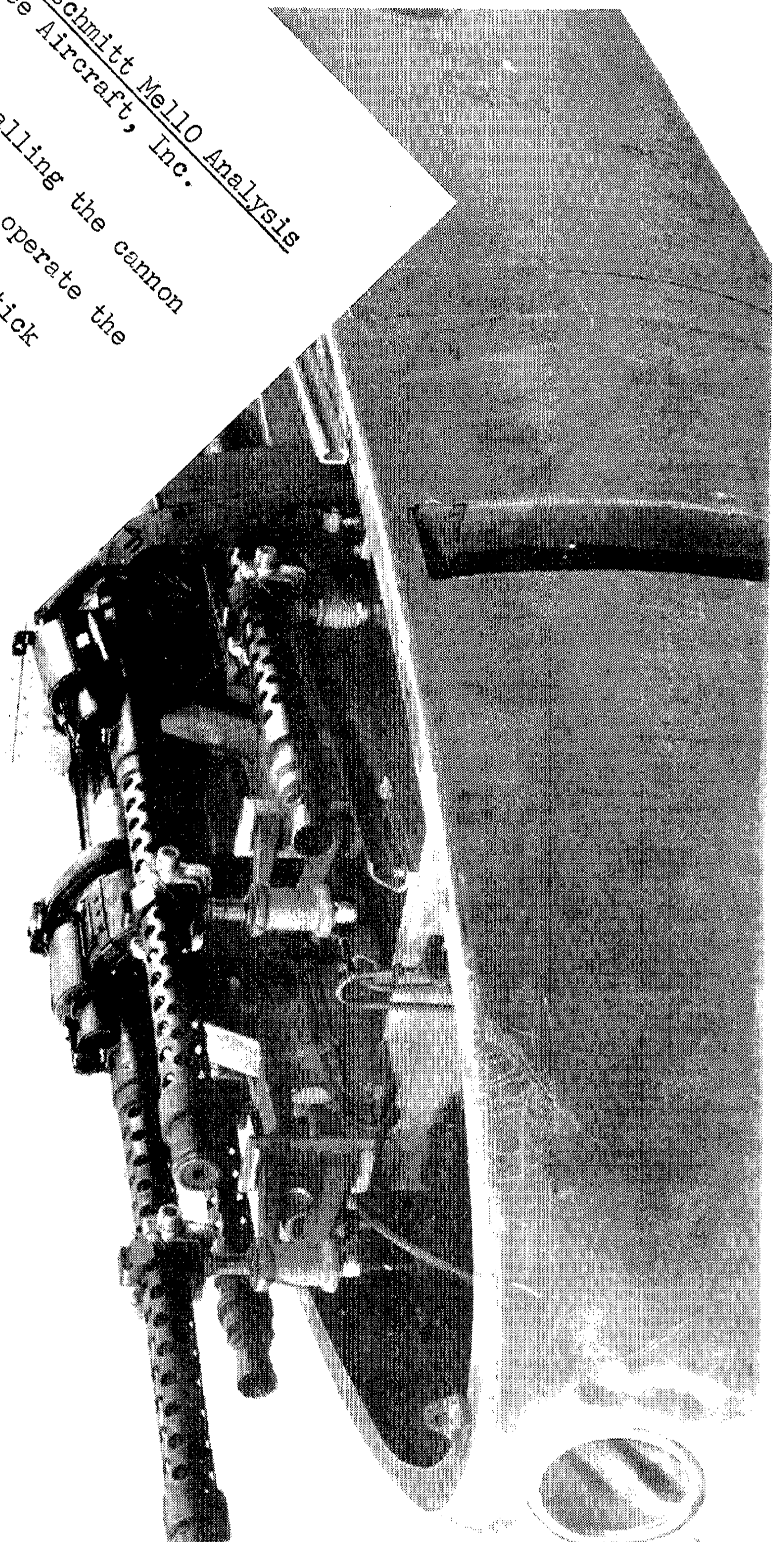


FIG. 1 NOSE GUN INSTALLATION FIG. 1

GUNNERY EQUIPMENT

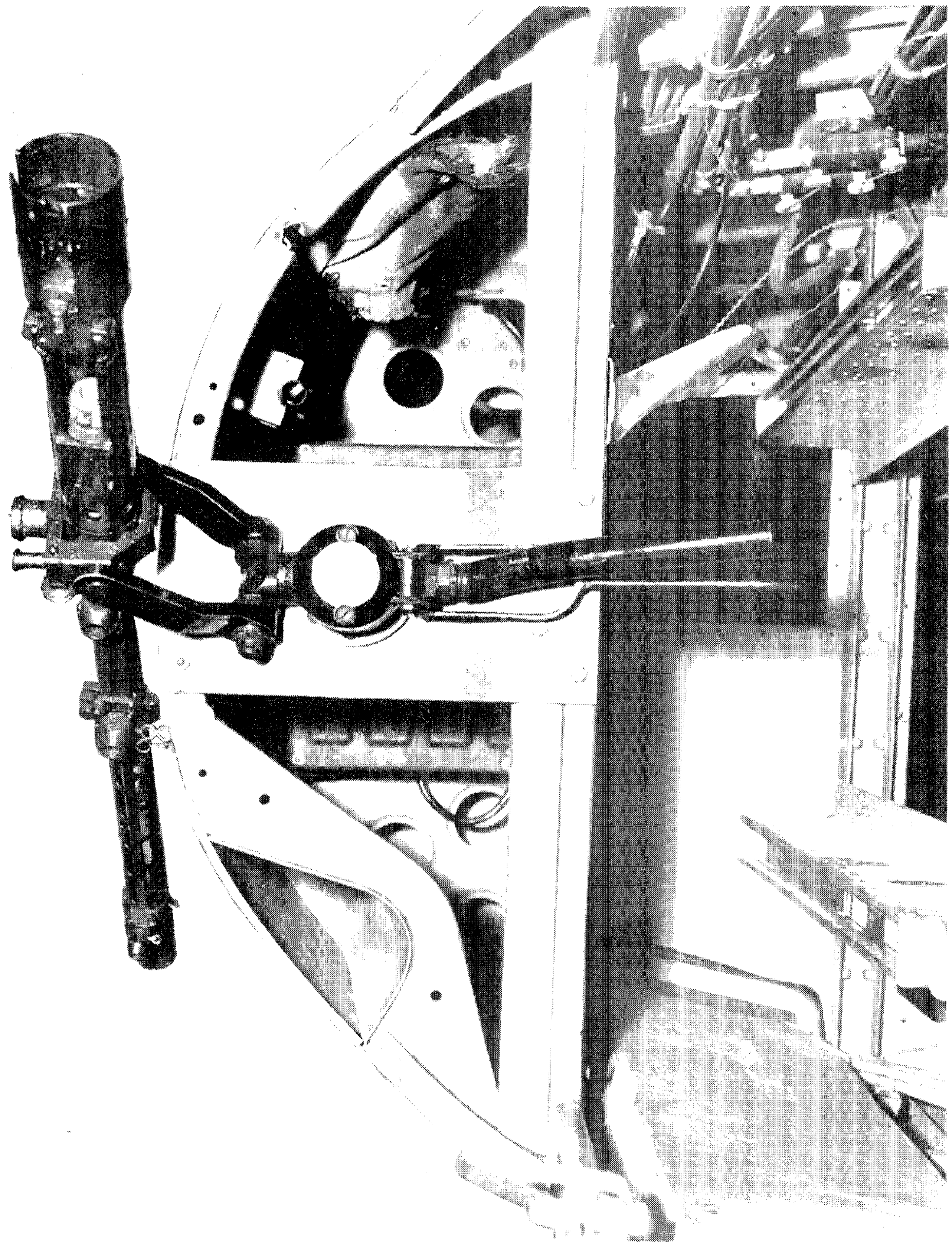
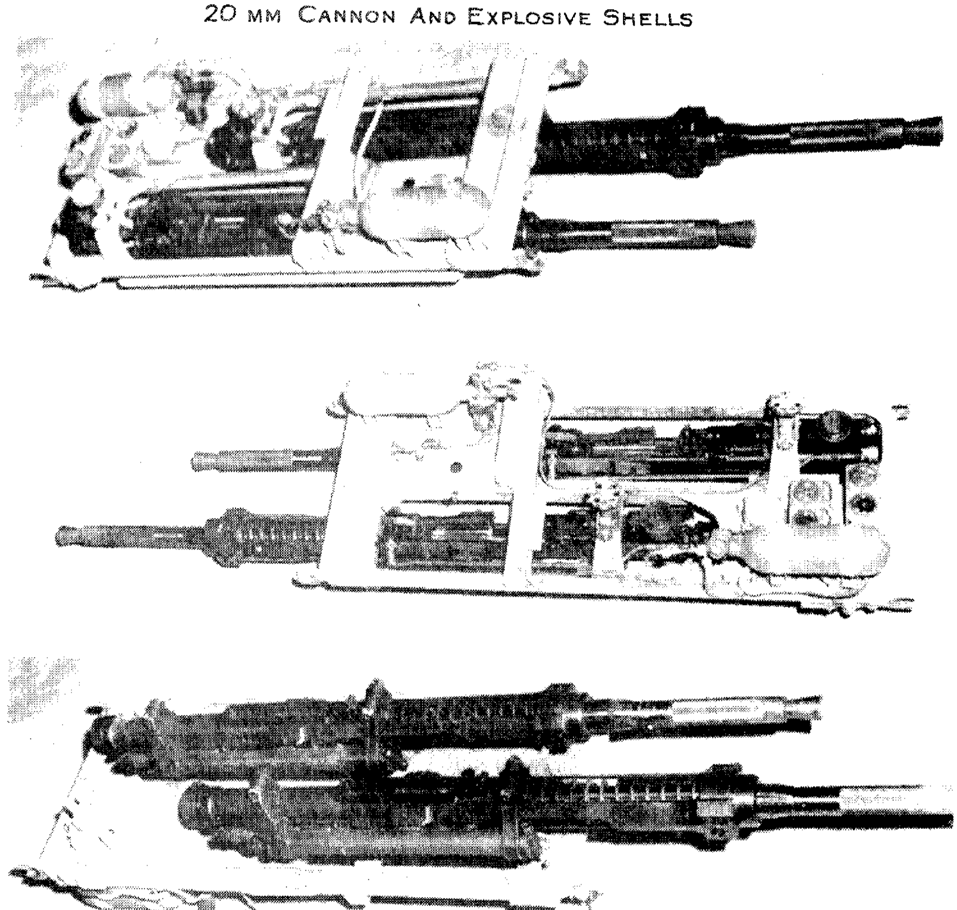


FIG. 2 FLEXIBLE GUN INSTALLATION FIG. 2

GUNNERY EQUIPMENT

20 MM CANNON AND EXPLOSIVE SHELLS



TWIN CANNON ASSEMBLY WITH CHARGING AND FIRING EQUIPMENT

FIG. 3 CANNON INSTALLATION FIG. 3

Chapter II

BOMBING EQUIPMENT

SECTION III

Chapter II

BOMBING EQUIPMENT

General Description

A detachable bomb-rack assembly capable of carrying two bombs of the 250 kg. class is provided for the Messerschmitt Me110. This unit attaches to the bottom of the fuselage in a location directly below the cannon receivers in the navigator's cockpit, with cut-outs provided in the bomb-rack fairing to clear shell cases ejected by the cannon.

It is apparent that this bomb-rack assembly is intended for use only when Me110's are pressed into emergency service as light bombers, and is not carried when the airplane is used as a fighter or bomber convoy.

The bomb-rack assembly for the Me110 comprises essentially a pair of bomb-racks supported by two transverse cross-members, which also attach the entire unit to the airplane structure. A fairing, riveted to these cross members, smoothly fairs the racks to the underside of the fuselage. A manual arm-and-safe central is provided, while bomb release and fusing are electrically controlled.

Bomb Rack Installation

A bomb rack fairing is made from five pieces of drop-hammered aluminum-alloy sheet joined by welding. This fairing assembly is stiffened by a longitudinal member comprising two base-angles of 0.064 aluminum alloy placed back-to-back, and reinforced along the free edge by another angle that varies in depth to conform to the fairing contour. The outside edges of the fairing are reinforced by drawn hat-section stiffeners of 0.040 aluminum alloy.

Editor's Note: The technical data for this portion of the Messerschmitt analysis was contributed by Mr. George O'Hare, Staff Engineer in Charge of Armament Design, and M. H. Sonntag, Armament Engineer, for the Engineering and Development Dept. of Vultee Aircraft, Inc.

Box-section cross members formed from 0.051 steel sheet support the fore and aft ends of the bomb racks, and rivet to the fairing assembly. Clevis ends on the cross members provide attachment to lugs on the fuselage, and a group of four lugs near each end of the cross-members form saddles to bolt to the bomb racks. Two outrigger fittings on the forward cross member support bell-cranks for connection of an arm-and-safe control cable leading to the navigator's cockpit. Disconnect receptacles for the electrical conduit are mounted on the aft end of the longitudinal fairing stiffener, and are readily accessible from the navigator's cockpit.

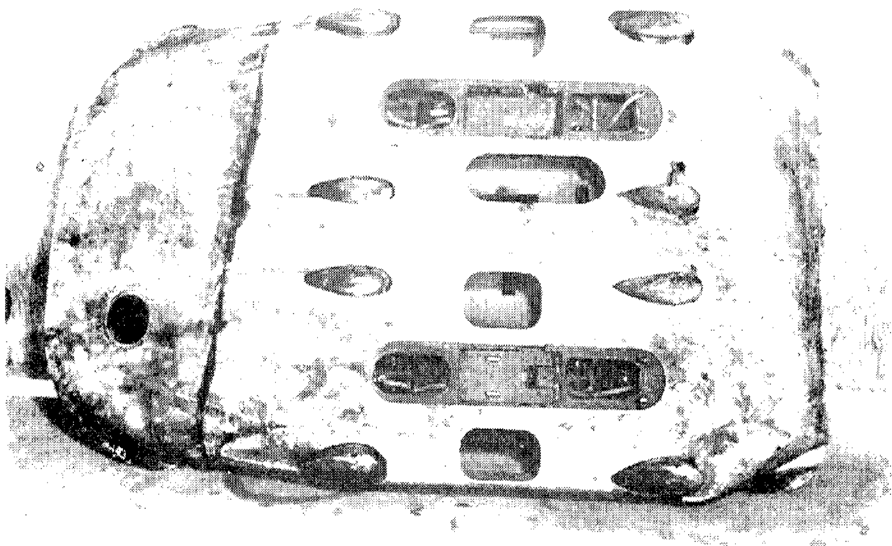
Streamlined bomb sway braces are mounted directly on both sides of each bomb rack.

The entire unit is attached to the fuselage by four 3/8 in. bolts passing through clevis fittings welded to the ends of each cross member and lugs bolted to the sides of the fuselage. The clevis fittings are weld assemblies formed from two bent-up angles of 3/16 in. steel sheet. The entire bomb rack unit is separated from the cannon assembly by a hinged cover plate of .041 dural sheet, provided with cutouts for passage of ejected shells.

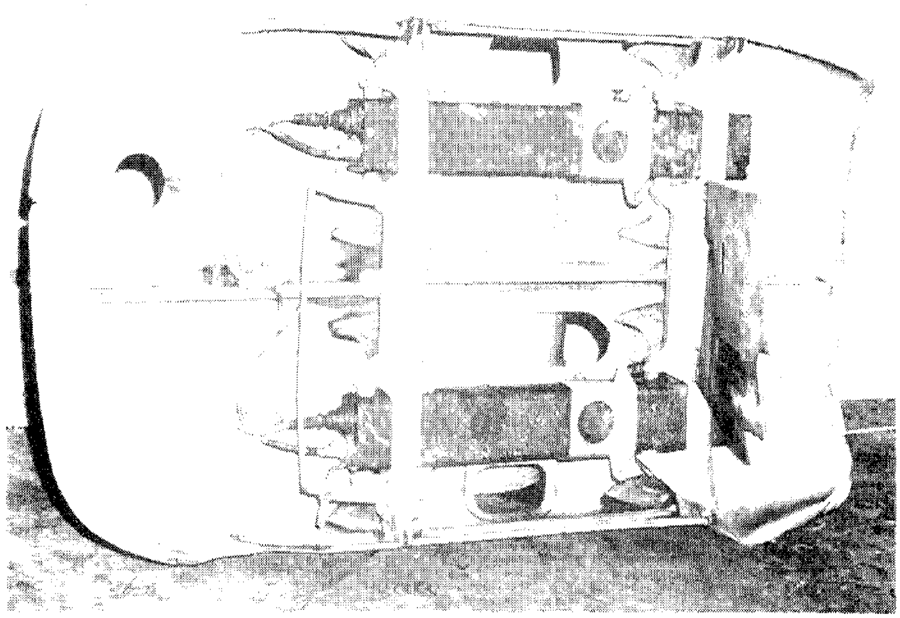
Bomb Rack Construction

Each bomb rack is a rectangular box, 35 in. long, 5-1/4 in. wide, and 4 in. hight, made from 1/4 in. thick aluminum alloy sheet, and containing all the mechanism necessary for loading, arming and release. The bomb release control arm is a conventional ratchet, which is moved into position for loading by a geared quadrant. This quadrant is rotated by a lever located on the side of the bomb rack, and accessible through a hand hole in the fairing. Electrical connections inside the bomb rack are mounted on a spring loaded swivel arrangement for easy accessibility. All bomb carrying parts on the inside of the bomb rack housing, including the control mechanism, are made of steel.

BOMBING EQUIPMENT



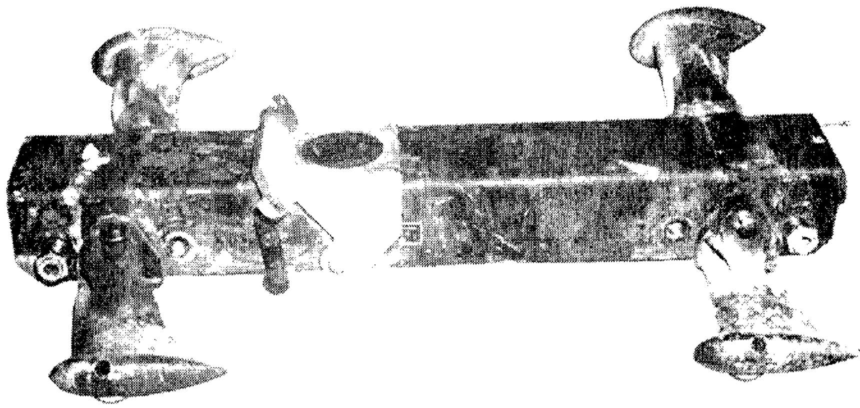
BOTTOM VIEW



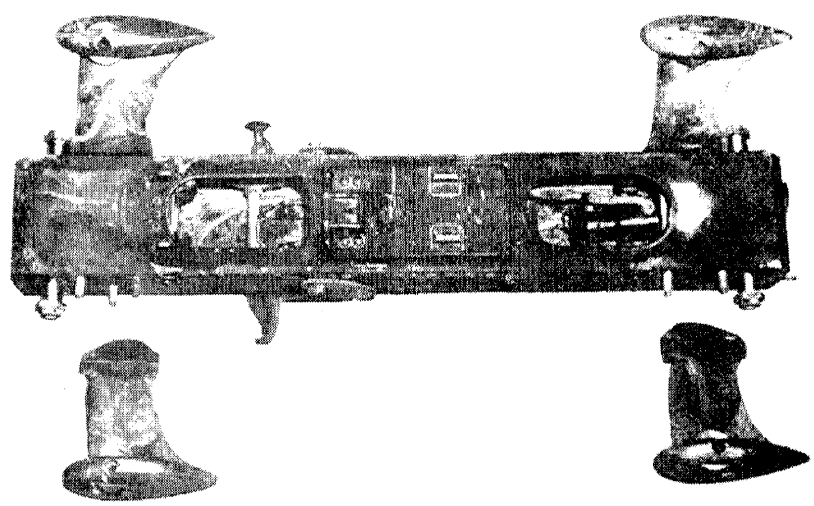
TOP VIEW

 BOMB RACK INSTALLATION

BOMBING EQUIPMENT



TOP VIEW



BOTTOM VIEW

FIG. 2 BOMB RACK FIG. 2

Chapter 12

PYROTECHNICS EQUIPMENT

SECTION III

Chapter 12

PYROTECHNICS EQUIPMENT

Emergency Landing Flares

So far as can be ascertained the flare controls of the Me110 are similar to American practice, comprising T-handles with bayonet-type locks, and control cables. The flare handles, located on the control-panel shelf at the right side of the pilot's seat, have about a two-inch stroke, and are connected to 1/16 in. dia. flexible steel cables. These cables extend aft to deflecting pulleys on the fuselage bulkhead just behind the pilot's seat, and there cross over to pulleys on the left side of the fuselage. The cables then extend aft and slightly out board to pass through the left side of the fuselage at a fairlead immediately forward of the main spar and slightly below the wing upper skin, to terminate in turnbuckle eyes for connection to the flare rack cable ends. The flare racks were not received with the airplane, nor were there installation provisions evident, and it is surmised that the racks were located between the wing-root and fuselage; and were either installed very infrequently or had been removed by a design change taking effect near this airplane's date of manufacture, with the result that the flare control installation was not removed until a later point in the production schedule.

The pulleys used are about 1-1/8 in. dia., and made of aluminum alloy. Cable fastenings are simple clamps, rather than swaged or spliced joints.

Very's Pistol

The Very pistol ammunition is stowed in the floor of the gunner's cockpit, near the right rear corner, in the form of a 6-round clip refillable only

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Editor's Note: The technical data for this portion of the Messerschmitt analysis was contributed by Mr. R. E. Krueger, Group Leader in Charge of Fuselage and Furnishings Design for the Engineering and Development Dept. of Vultee Aircraft, Inc.

from outside the fuselage. The ammunition clips are fixed to a cover plate assembly secured by two pins to an opening in the fuselage skin. A spring-loaded door in the gunner's cockpit floor provides access to the ammunition clips.

The gunner may either fire the Very's pistol aft over the tail surfaces or use a blast-tube in the right side of the fuselage, midway between gunner's and navigator's cockpits. This blast tube is pointed aft, down, and outboard to clear the tail surfaces, and is about 1 1/4 in. dia. with a split end for clamping to the pistol muzzle. The pistol could either be stowed by clamping to the blast tube, or be carried in a holster.

PYROTECHNICS EQUIPMENT

SECTION III CHAPTER 12

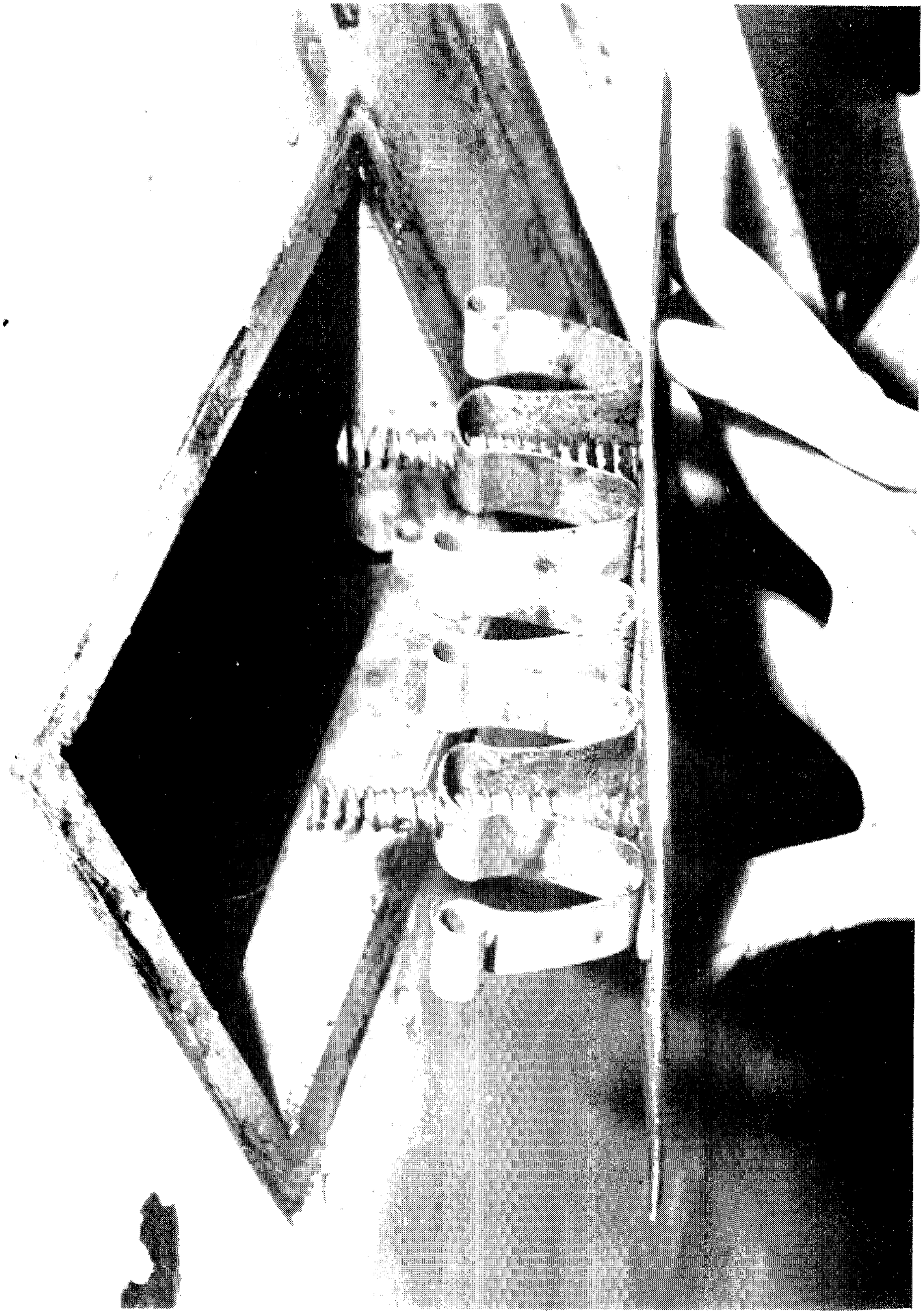


FIG. 1 FLARE CARTRIDGE CLIP FIG. 1

EDITOR'S NOTE

Subsequent to the preparation of Vultee's analysis of the Me110, there were received several technical reports covering the more interesting accessory components of this airplane. These were prepared by certain firms which had requested the loan of various accessories for the purpose of engineering investigation, and their reports are reproduced in the appendices following.

APPENDIX 1

GERMAN BOSCH MAGNETO

Prepared by

THE B. G. CORPORATION

136 W. 52ND ST., N. Y. C.

Project No. M-62
Report No. 1

PROJECT TITLE: MAGNETO, DESIGNS OTHER THAN BG

SUB-TITLE: GERMAN BOSCH MAGNETO ON MERCEDES-BENZ ENGINE

Description:

This magneto is a flange-mounted dual ignition, twelve cylinder machine. Its overall dimensions are 11" in length by 11" x 6". It consists of five main castings and a roter assembly. The castings are: 1) the pole shoe housing; 2) the housing cover equipped with automatic advance; 3) the breaker compartment; 40 sealing cover; 5) a breaker cover.

Operation:

The magneto is of unique design in that it has no gears for spark distribution, but obtains twelve double sparks every revolution of the rotor. It therefore runs half-engine speed. Twelve magnetic breaks are obtained each revolution by having four pole shoe inserts in the housing and six magnetic inductors on the rotor. The pole shoes are symmetrically spaced 90° apart around the rotor tunnel. The inductors on the rotor are spaced 60° apart. The diagram shows how magnetic reversals occur every 30° as a result of this construction.

The rotor travels clockwise, looking down at the diagram as indicated. At a particular instant, opposite rotor inductors #1 and #4 engage with pole shoes A and C. Magnet #1 then sends flux through pole shoe D to coil core #1 in the direction shown. The return to the south pole is made through pole shoe A and the rotor. Similarly magnet #2 sends flux through the rotor inductors pole shoe C and thence to the #2 coil core in the direction shown, the return being made through pole shoe B.

When the rotor has turned 30°, inductors #1 and #4 have passed by pole shoes A and C, and now inductors #2 and 5 completely engage with pole shoes B and D. Magnet #1 now sends its flux through these rotor inductors to pole shoe B and thence to coil core #2, but now in the opposite direction to that in which magnet #2 sent its flux through the same core just previously. In other words, a reversal of flux occurs. Similarly magnet #2 now sends its flux pole shoe A to coil core #1, (again in the opposite direction) the return being made through pole shoe D and the rotor inductors.

Note that in this design the width of pole shoes and rotor inductors cannot be made the same as the spacings between pole shoes and inductors, as in more conventional designs. If, for example, leaving the pole shoes as they are, the rotor inductors had been made 30° wide instead of 18° (their actual width), the magneto could not function, since reversal of flux would have started in a given coil core long before the E gap had been reached. In fact there would be no E gap. As it is, when inductors #1 and #4 move off pole shoes A and C to give the E gap, inductors 2 and 5 just start to engage pole shoes B and D for the reversal and "scavenging" of flux.

The fact that each spark must be obtained in 30° of rotation is somewhat of a disadvantage. The Bosch magneto has certain mechanical advantages in the elimination of distributor gears and the consequent case of assembly, but it obtains these advantages by a sacrifice in electrical generation. The primary current is built up in 20° of the 30° allowable, and then the spark in the secondary must dissipate itself in the remaining 10°. This is quite a short interval. Fortunately for Bosch, the maximum speed of rotation is low, since engine speed is around 2500 and therefore magneto speed need only be 1250 RPM. If the magneto had to run at high speeds, it would give very poor performance, if it operated at all. In fact, in order to eliminate the adverse effects that would result from having the breaker contacts close while there is still current in the secondary circuit, Bosch must use a condenser in series with the secondary winding. This is incorporated right in the coil.

Magnets:

The magnets are stationary. This cuts down the weight of the rotor considerably, since otherwise the rotor would have to be much larger in diameter to accomodate the magnets. Because of the short time for build-up of primary current, the magnets are quite heavy. Each one is made up of five bar magnets totalling 1-31/32" in width, each 1-5/32" high and 1-1/8" thick. The area of cross-section is therefore 2.214 sq. inches for each magnet. Bosch has made full use of the advantages of Alnico (or something similar) by having a very short magnet with large cross-sectional area. This enables a magnet of high coercive force to support a maximum flux.

Rotor Tunnel:

This is 2" in diameter. The width of laminations on the ends of the pole shoes, is 21/64" which corresponds to 18.8^{o}. The laminations completely cover the magnet width, being 1-31/32" along the shaft. The end laminations are 5/64" thick, the rest .018" thick. By cutting laminations properly the pole shoes taper down from 1-31/32", to 15/16" at the coil seat. The width at this seat is 7/16". The pole shoes are completely surrounded by the casting metal on three sides up to the coil seat. The rivets are not visible anywhere.

Rotor:

From the end of the shaft to the end of the cam the rotor assembly measures 8-1/4". This does not include the separable advance mechanism which lengthens the rotating part to 11". In order on the shaft, starting from the breaker end, we have the cam, the breaker-end ball bearing, the high tension collector ring and distributor for No. 2 coil, the high tension collector ring and distributor for No. 1 coil, the rotor inductor laminations, drive-end ball bearing and the helical spline for the advance mechanism.

Cam:

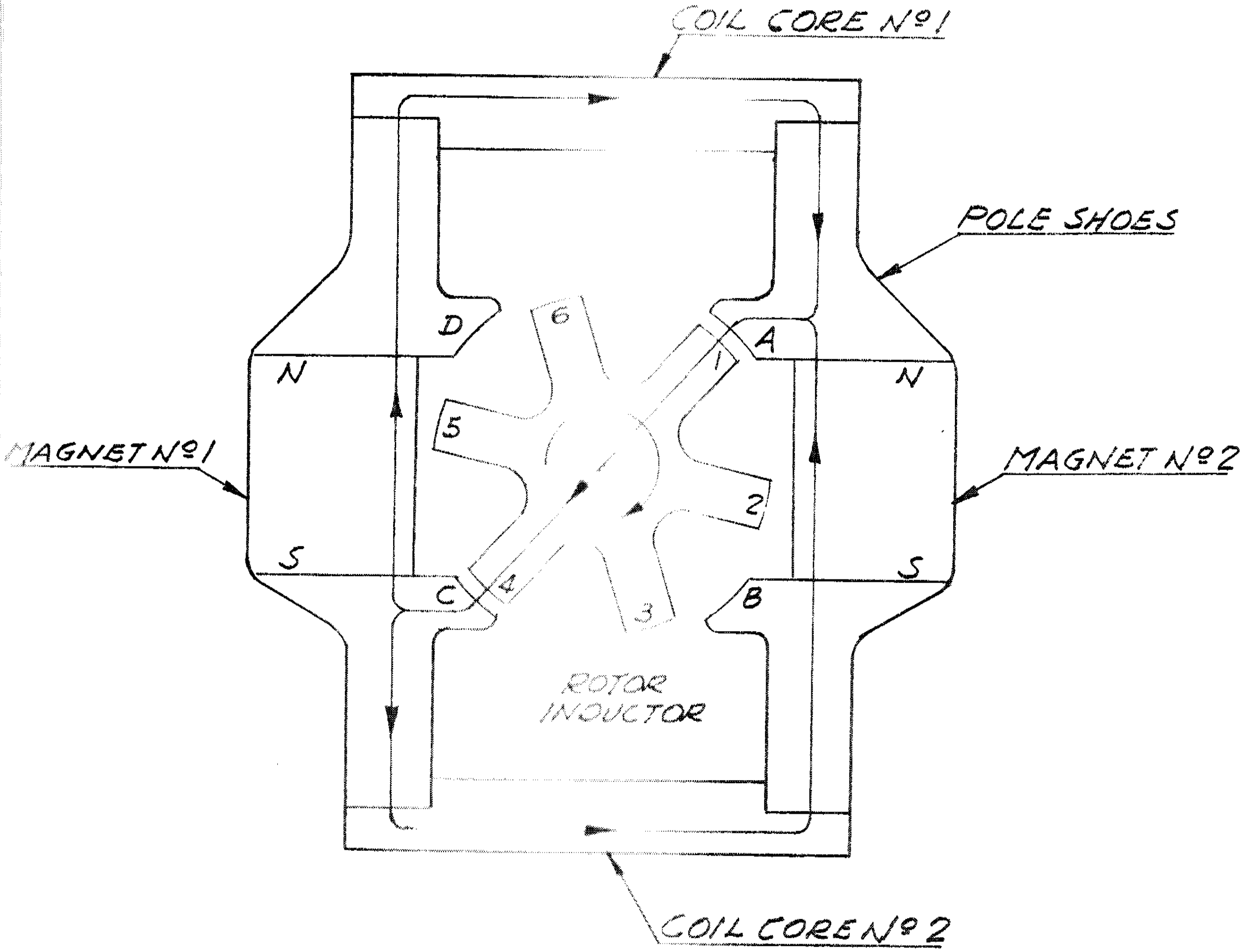
This is a six lobe cam of laminated horn fibre, 1-1/32" in diameter and 3/4" wide. It presses against a shoulder on the shaft and is held on with a special lock-nut. The lobes of the cam are wide (similar to the B G) since the lobe has had to keep one breaker open while the second one for the same coil (there are two breakers per coil in this magneto) is closed. The depression between lobes keeps a set of contacts closed for 20°. The lobe proper keeps these contacts open for 40°. During 10° of this 40° the secondary spark is occurring due to this breaker. During the next 30° the second breaker is in operation.

Bearings:

The bearings are of the separable type, the inner race and the ball retainer coming off with the shaft, the outer race remaining in the housing. The ball retainers are brass. At the drive end the bearing has an O.D. of 1-23/32" and an I.D. of 15/16". For this size bearing the width of bearing is unusually narrow, being 9/32". The retainer has 17 balls. No particular pains are taken for sealing against oil or grease leakage, an ordinary leather seal and spring steel thrust washer being used. The breaker-end bearing is smaller, being 1-13/64" O.D. The retainer has 11 balls. Here too, the width of bearing along the shaft is small. Due to the low speed of operation, the bearings were made small in this dimension. This saved length overall (1/2" total) and the corresponding weight of housing, shaft, etc.

High Tension Collectors and Distributors:

These are made of bakelite. The end of the brass electrode is on a radius of 1-37/64". We do not have the distributor blocks, but this would indicate that


COIL CORE Nº1
POLE SHOES
MAGNET Nº1
MAGNET Nº2
N
S
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A
C
B
1
2
3
4
5
6
ROTOR
INDUCTOR
COIL CORE Nº2

the electrodes in the blocks would be on a 3-3/16" diameter with a spacing between electrode centers of .835".

The Distributor for No. 2 coil has a brass pin driven through the bakelite and into the electrode near its end. This provides a safety gap of 5/8" from the pin to the flat surface of the rear of the breaker housing.

The brush slip rings of brass are 9/32" wide. Protection against flash-over to ground is provided in the form of spool rims or aprons either side of the brass rings. The brass ring is 1-23/32" in diameter. The spool ends are 2-1/32" in diameter except for the one next to the rotor laminations, at which point the high tension electrode would be nearest ground. Here the spool rim is 2-15/32" in diameter.

The electrode proper is 7/64" wide by 1/16" thick.

Rotor Induction:

There are six inductors [illegible] wide and 1-31/32" long. The individual inductor spans an angle of [illegible]. The end laminations are 5/64" thick, the others .018". These are keyed to the shaft and held tight against shoulders and end washers.

Helical Spline:

This has three splines, each [illegible] wide on a diameter of [illegible]. The spline is 25/32" long on the shaft. This helical spline engages with a gear connected with the advance lever as later described.

Coils:

This being a dual magneto, it has two coils. They are tape-wound for finish and varnished. The coil core is [illegible] long and 29/64" high, giving a cross-sectional area of .382" sq. inches. The coil seat is 7/16" long at each end. In additon the bottom laminations are cut away for 7/32" of the height to give added seating.

The screw slots decrease the seating area by 9/32" x 13/64".

The end laminations are 1/16" thick, the rest .018".

The primary winding consists of an even number of layers, probably 6 layers of #18 enamel wire, since its resistance is .52 ohms. Great care is exercised in bringing out the starting lead which fits into a groove in the end lamination and is soldered for 1/4" along this groove. The end of the primary is soldered to a lug riveted to the terminal lead. The primary lead is then taken off this lug and goes to the grounding device.

The secondary could not be measured accurately because it has a series condenser wound over it. This condenser connects to a brush terminal 3/8" deep which probably has extensions by means of which it is taped down inside the coil. A brass brush and spring are inserted in the brush holder at the side of the coil winding, the last spring turn being spread to hold the brush in place.

The brush fits into a high tension connector of bakelite, which itself has a carbon brush riding on the slip ring of the high tension collector. The spacing to ground from the high tension points, is quite large, the minimum being 1-3/16" from the connector brush insert to one of the two holding screws used to hold each connector to the frame.

The coil terminal heads are made of .074" bakelized paper-base material. They are ellipses with axes of 2-21/32" and 2-9/32".

The winding space for the coil proper is 1-15/16".

Breakers:

There are four breakers in all, two for each coil. One of each set operates simultaneously with the opposite one of the other set. The contacts are alternately tungsten and platinum on the bars, and platinum and tungsten on the brackets, so that each breaker has one tungsten and one platinum contact. Evidently this is an attempt to avoid pitting. Each breaker is subjected to uni-directional current. The breaker bar is in reality a shaped steel riveted to a micarta piece. A contact is riveted at one end of this spring, the other one being curved and serving as the follower of the cam. The micarta serves as a bearing on a brass pivot 7/32" in diameter. A felt wick fits in a groove in the micarta, back of the spring steel follower. A sealed oil hole can be seen in the end of the micarta, lending to the pivot. No attempt is made to have contact between the oil wick and the cam. This lubrication takes place by creepage along the steel followerer. This avoids excessive oil pumping at the cam.

A washer and cotter pin through the pivot, hold each bar down in place.

The bracket contact can be adjusted for contact gap. It is held down by a screw working in a slot in the bracket. Another screw is an eccentric mounted in a metal piece below which serves as breaker plate. This plate can be shifted as a whole to enable synchronizing of one breaker with another. Here again there are two screws working in slotted holes. Two detents punched in the breaker plate fit in a groove to control the movement of the plate.

The followers are spaced so that two run at the front of the cam, two at the back, with a slight overlap to even up wear.

The contacts are .187" in diameter. Spring tension is about 24 ozs.

Advance Mechanism:

Advance is effected by the motion of a coupling member along a helical spline. This changes the relation of the drive shaft proper to the rotor shaft, without affecting E gap. A lever reaching through the housing has two micarta blocks mounted on lever arms connected to the advance lever. These blocks move in a groove cut in a pulley. The blocks shift the pulley back and forth. The pulley or coupling has a ball bearing in it which permits the outside to stand still while the inside rotates with the shaft, being driven by the helical spline.

Primary Condensers:

These are paper-wound, in round cans, and measure .27 afds.

Ventillation:

There are no ventillator screens used, as in the Scintilla magneto. But there are holes drilled at various points in the housing and covered with a crude sort of small cup which is held on by folding over two tabs fitting through holes much like a paper fastener. There are three ventilators for the breaker space, eight for the high tension space (found in the sealing cover which forms half of the cable outlets) and four at the drive end of the shaft, near the advance mechanism.

Advance Angle:

This is 25° on the rotor shaft. As the rotor shaft revolves half crankshaft speed, the corresponding crankshaft angle is 50°.

Weight:

The magneto assembly, minus distribution blocks, weights 14 lbs. 1.5 ozs.

Nameplate Data:

ZM12BE4

Gerat 9-4040C

Werk Nr. 143004

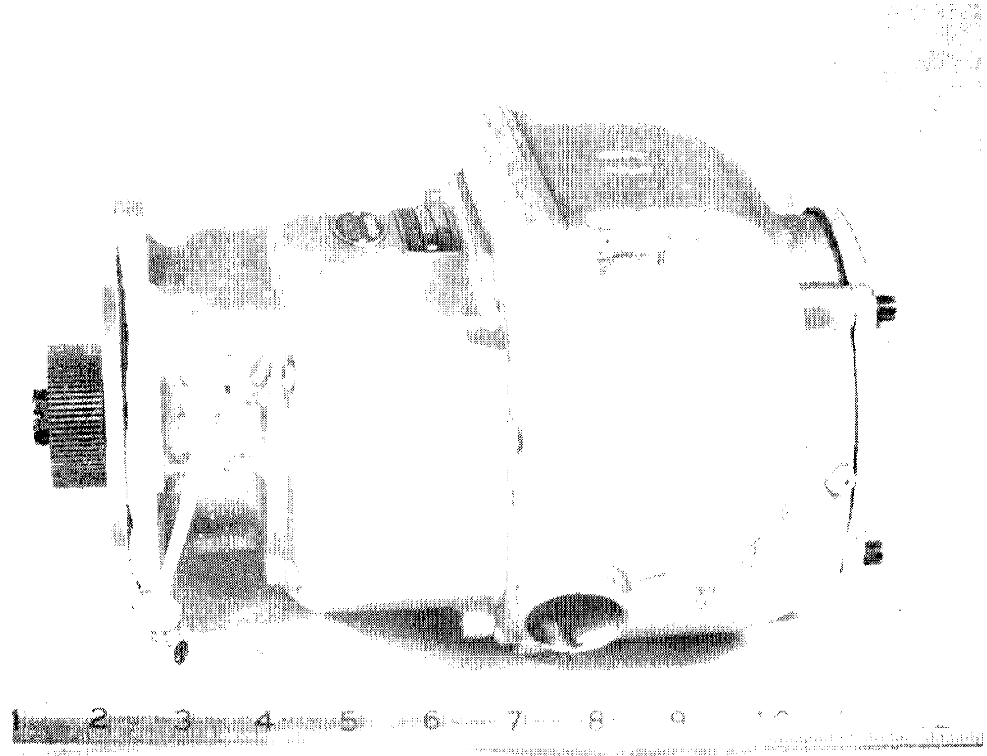
Photographs:

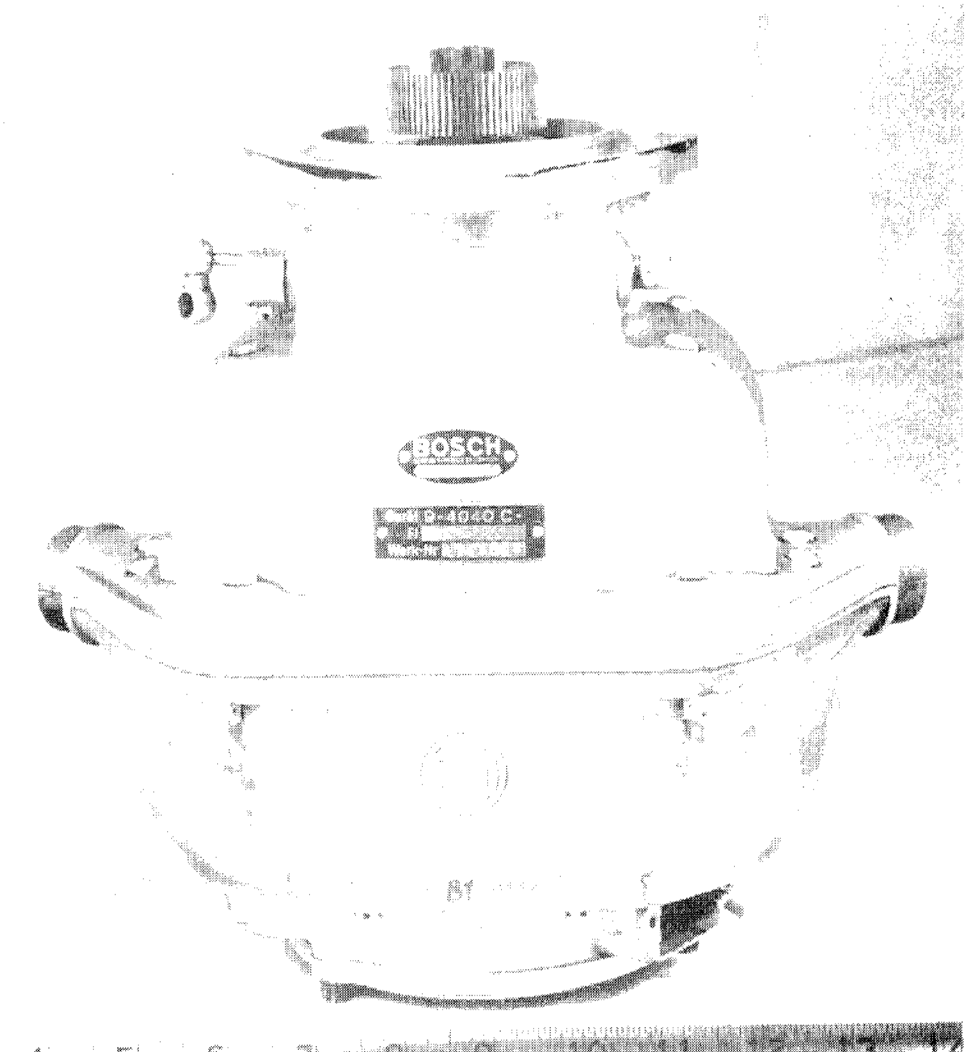
To the original of this report are attached ten photographs of the Bosch magneto.

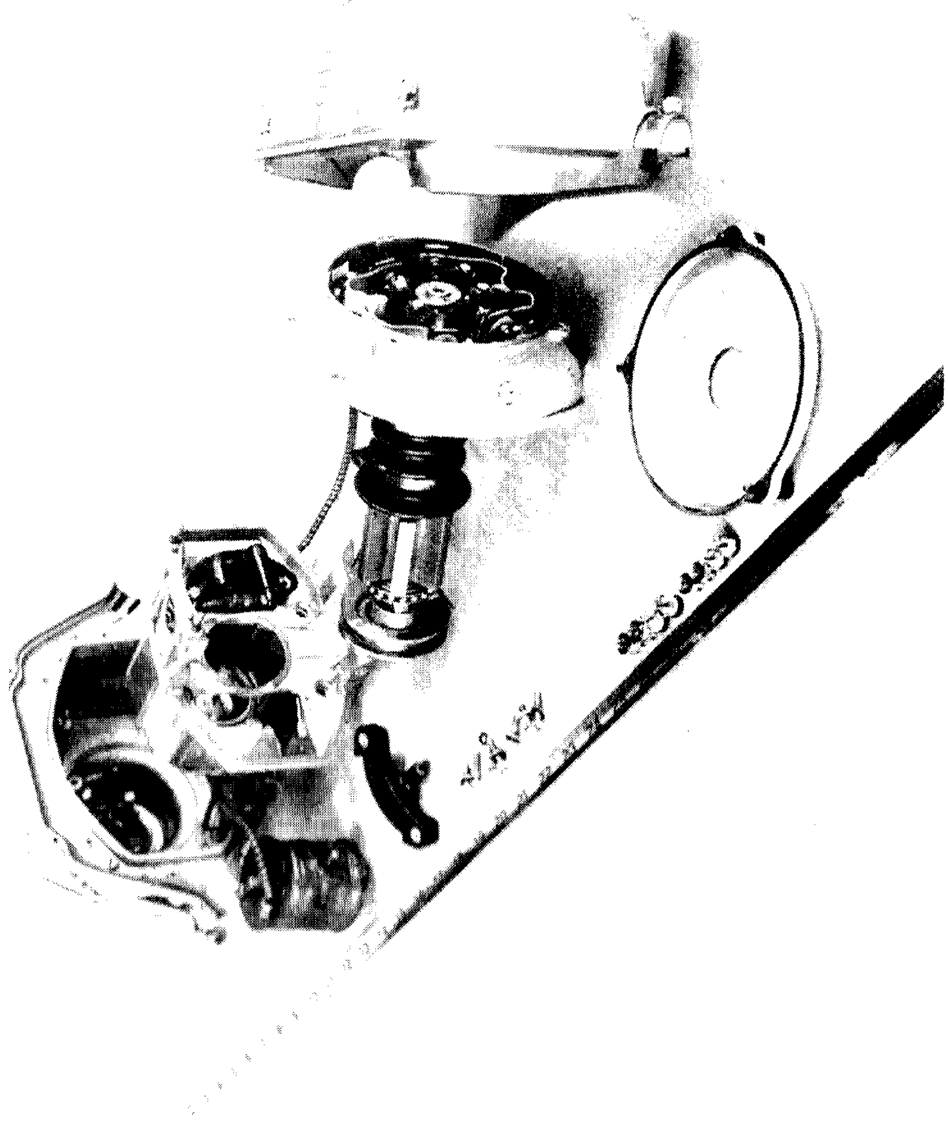
Voltage Curve:

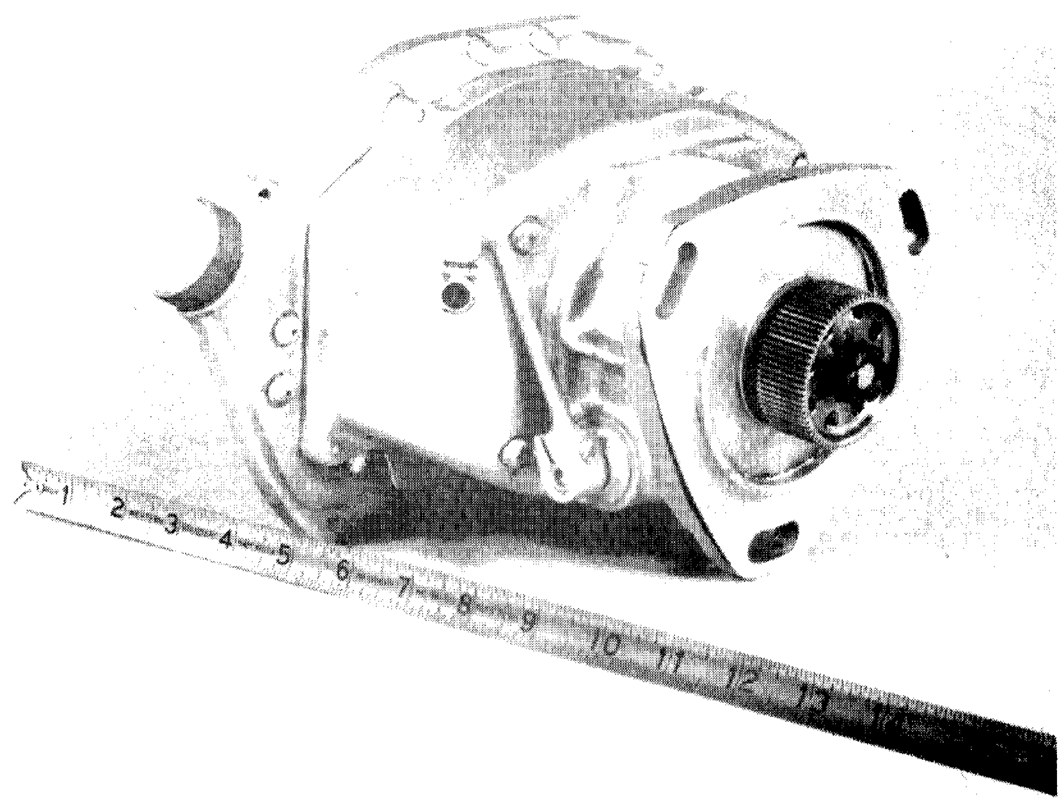
A curve was taken of voltage output of the magneto at various rotor speeds by determining the length of Navy gap the machine would fire steadily at each speed. This curve shows that the Bosch magneto does as well as the Scintilla magneto. It would probably meet Navy Specs. concerning voltage, although we were not able to run a test under load conditions. The magneto ran well at higher speeds than would be expected from the design, but the contacts flashed badly at 3000 R.P.M. The output began to drop off at 2800 R.P.M. but it levelled off first at 1500 R.P.M.

L. Jacobs




BOSCH

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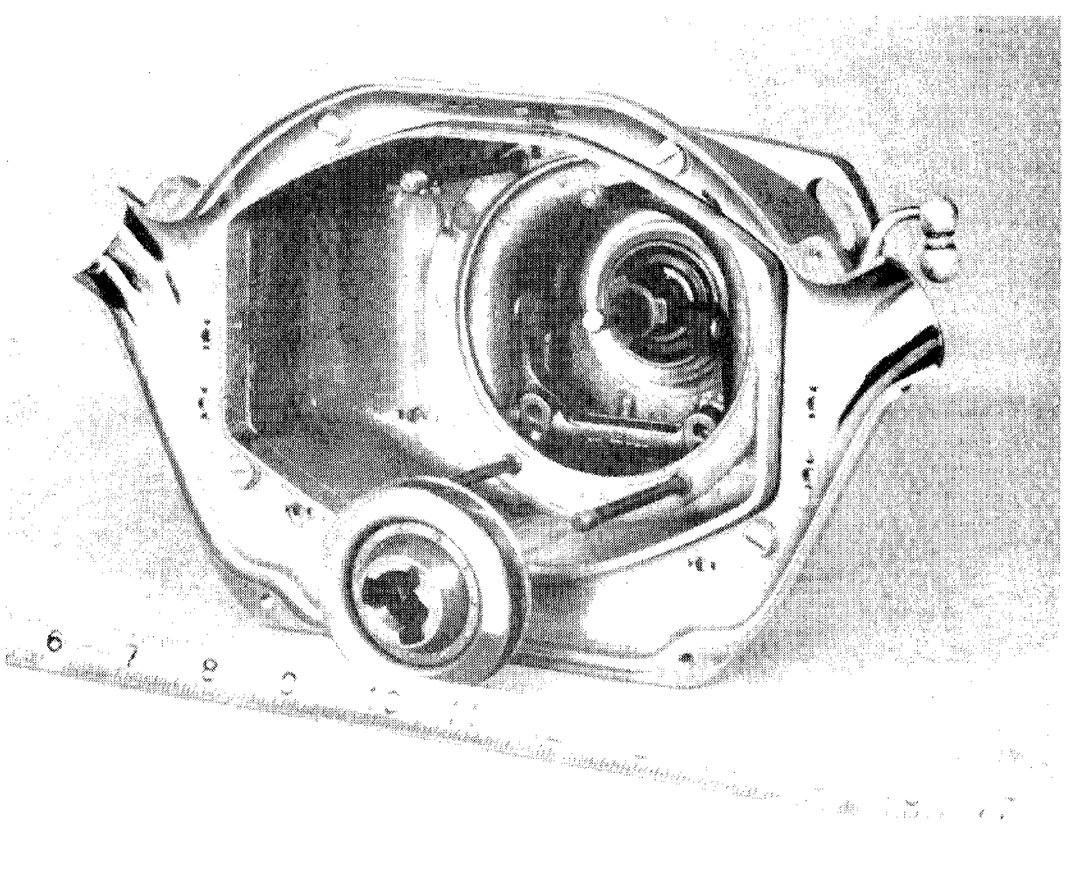
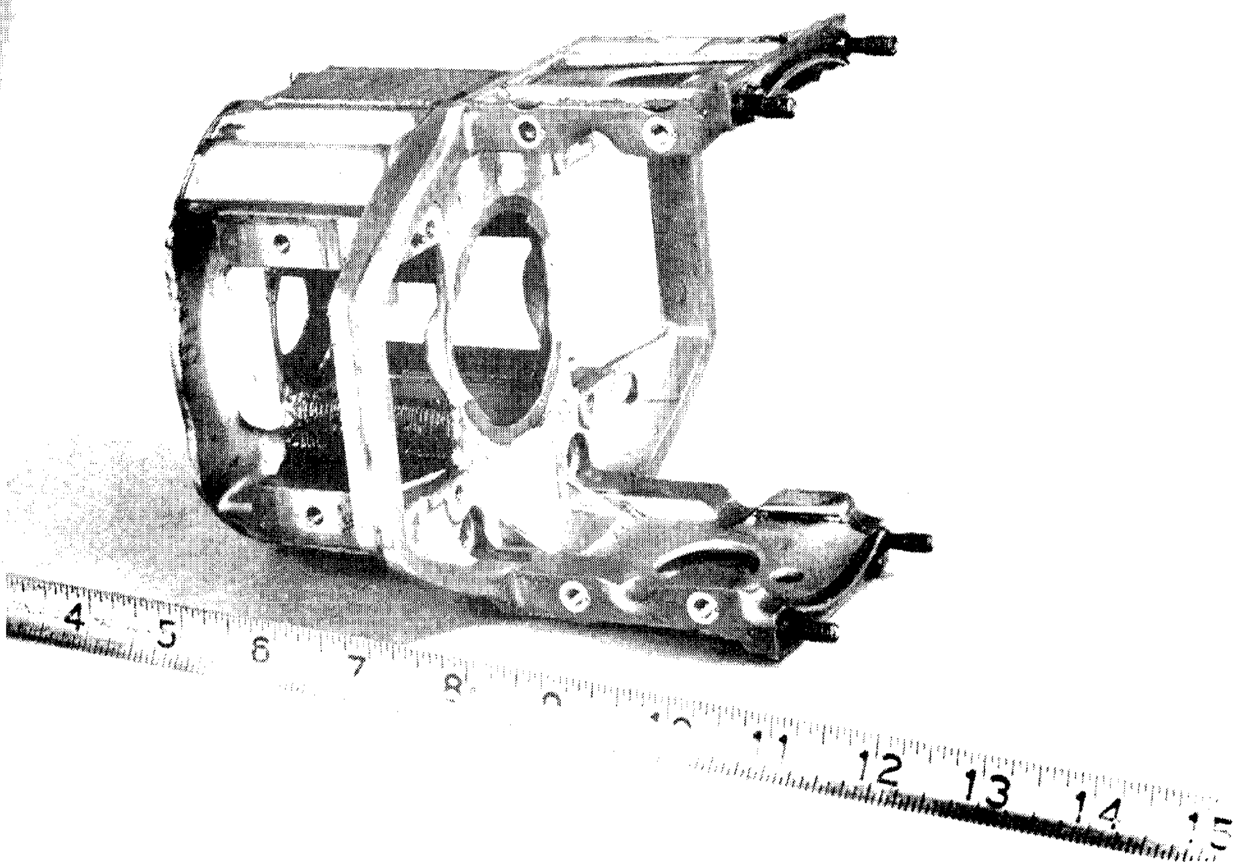
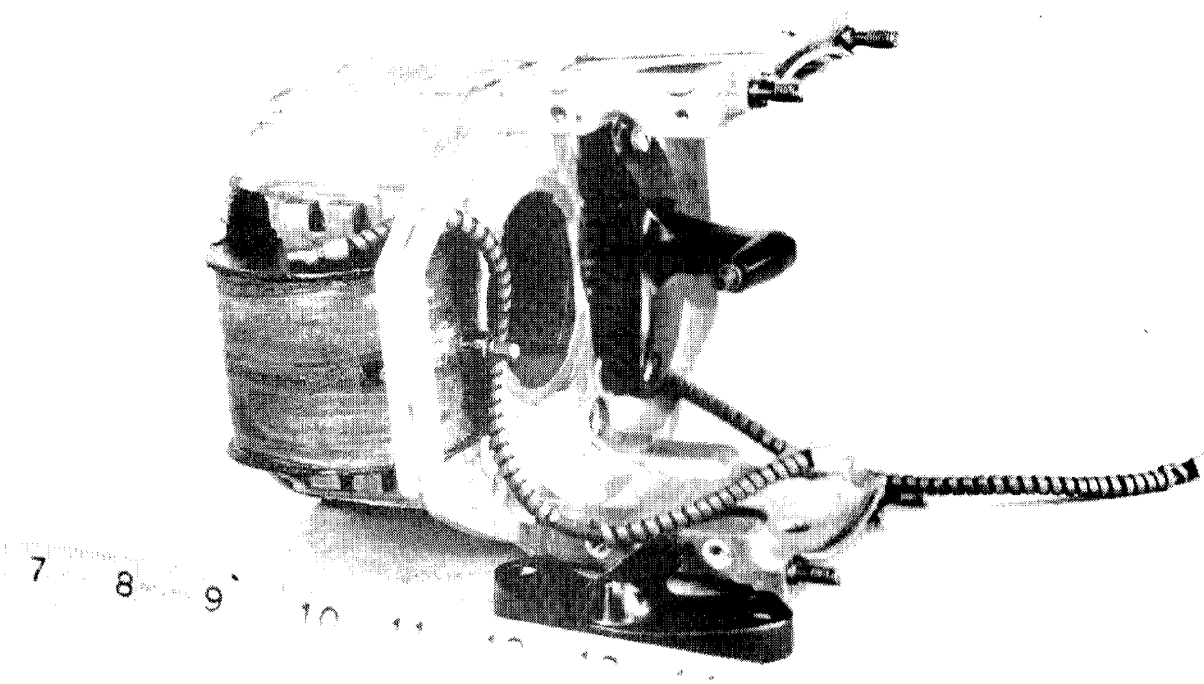
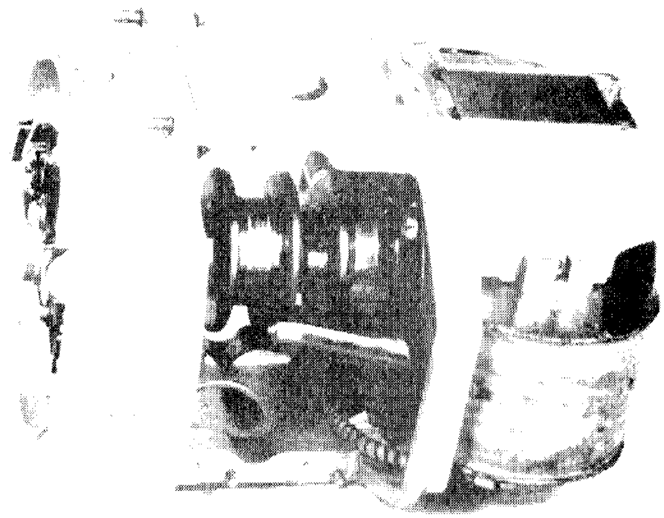
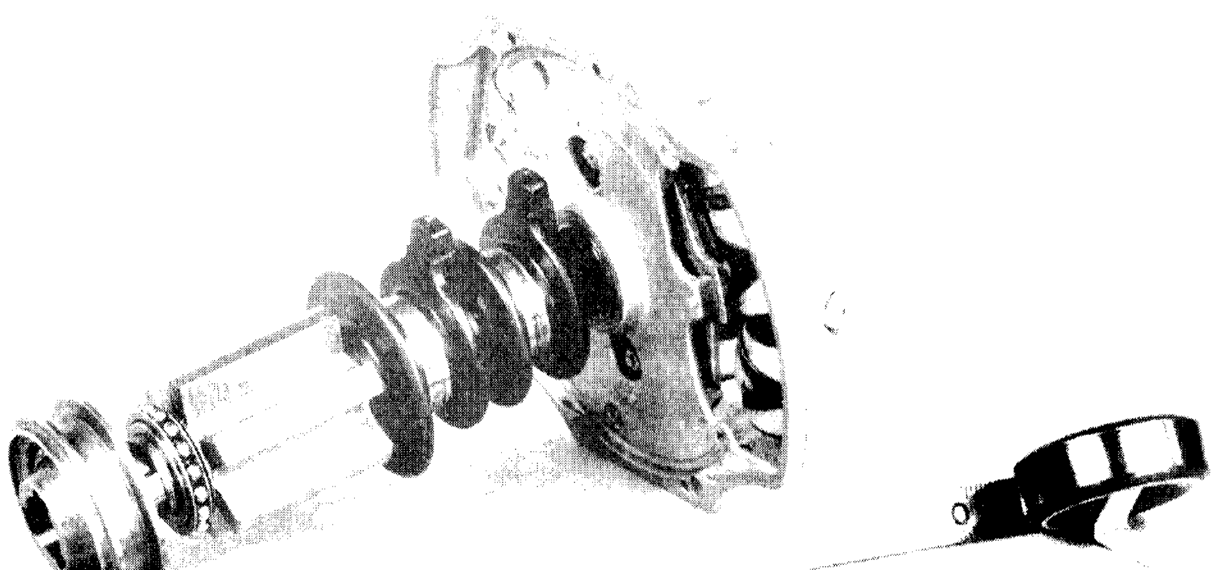

6 7 8

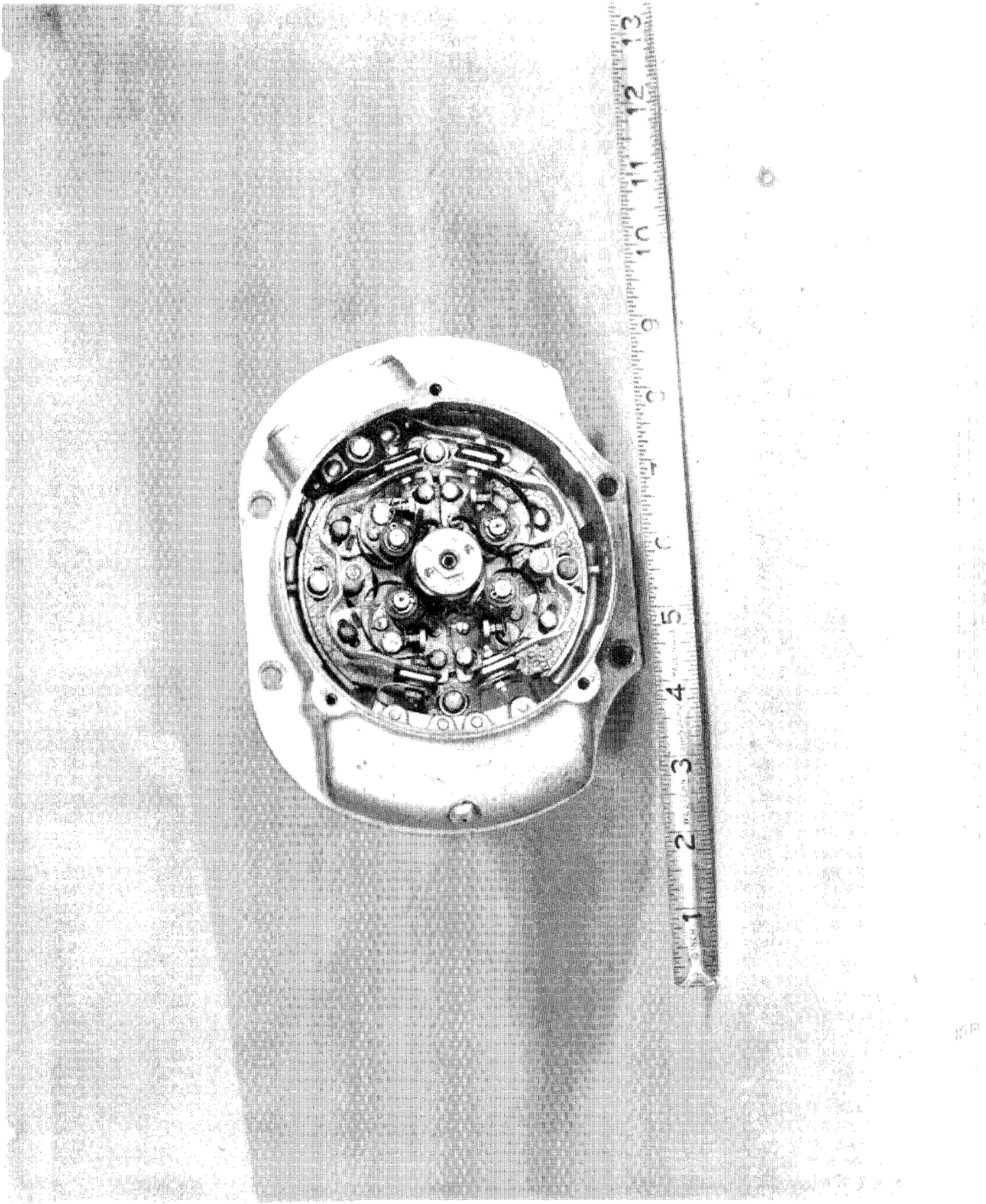






1 2 3 4 5





APPENDIX 2

GERMAN SHIELDED IGNITION HARNESS

Prepared by

THE B. G. CORPORATION

136 W. 52ND ST., N. Y. C.

REPORT COVERING GERMAN SHIELDED IGNITION HARNESS

This harness was received by our laboratory in very poor condition. Many of the spark plug leads were cut and many of the ceramic sleeves were missing. The manifold was very badly bent in one section, this damage resulting in our inability to make a complete test. The following is our study of this harness, both from the standpoint of observation, opinion, and technical data.

The harness is designed for an in-line engine and has twelve spark plug leads projecting from a metal manifold. The manifold joins at an elbow to a flexible antler pipe carrying the wires back to the magneto. This construction can be readily seen by referring to the accompanying photograph. The entire assembly as received by our laboratory weighed approximately 7½ lbs. (seven and one half pounds). The wires were pulled through the antler pipe and manifold to their individual spark plug leads, then through the leads around the elbow and into a ceramic terminal the entire length of the harness.

Dimensionally, the manifold was approximately 1 3/16" in diameter and 32" in length. The distance around the elbow at the end of the manifold was approximately 9½". The distance from the elbow to the end of the antler pipe was 29". The antler pipe was 1 11/32" in diameter under the protective covering of leather. The spark plug leads were spaced along the manifold at intervals of 4" and 3¼" alternately. However, at the end of the manifold two spark plug leads were brought out. This construction can be readily followed by referring to the accompanying photograph. The average length of the spark plug leads which were left intact on the harness as received was approximately 6", with the exception of the one long lead brought out at the end of the manifold, this lead was 12" in length. From a dimensional standpoint, this harness might be readily compared with the harnesses used in American practice on in-line engines.

All rigid metal parts such as the manifold, elbows, connections to the magneto and outlets to individual spark plut leads, were made of cadmium plated brass. The average wall thickness of this brass ran between .022" and .025". It was interesting to note that in no case were threads used to join various sections of the manifold together as is customary American practice. Where a joint existed, such as between the elbow and manifold, the sections were sleeved together with a clamp over the sleeve section. In order to insure tightness of the clamp bolt, a simple safety wire was passed through a hole in the bolt head.

The antler pipe leading from the elbow to the magneto was composed of flexible metal tubing with no apparent attempt to insure any water or air tightness. This flexible metal tubing was covered with an aluminum braid and analysis of this braid indicated that it was applied by a 24 carrier braider using wire approximately .0075" in diameter. The weave of this braid was not the American practice of basket weaving (one over, one under) but employed a two over, two under weave which can be more readily handled at higher production speeds. Each carrier of this 24 carrier braid contained 16 wires, thereby resulting in a loose braid. Such practice always permits the braiding machine to run at its maximum speed as far as feet per minute production is concerned. This practice is far inferior to the accepted American standards.

All fittings for spark plug leads were soldered to the manifold, as small projections to which were attached the braiding shield for the individual leads.

The spark plug leads (between the manifold and elbow) were protected only by the aluminum wire braid. This braid was produced on a 24 carrier machine using a two over, two under weave, having seven ends of .0075" wire per carrier. The braid was merely clamped to a small boss protruding from the manifold at one end and to another boss at the end of the spark plug elbow. There was no attempt made to solder the braid wires in place. The small clamp was held tight by a bolt having a safety wire through its head. The entire assembly showed evidence of low cost in production and high speed assembly. No particular attention was given to water-tightness and air-tightness. All places where the wire passed through the manifold or through the elbow, a small synthetic rubber grommet was applied around the wire to protect it against cutting of the lacquer covering or insulation by rough parts in the metal.

One sample of wire removed from the assembly was subjected to an electrical test. It was prepared by wrapping around a three-quarter inch diameter steel mandrel using a ten pound dead weight for a wrapping tension. The individual turns around the mandrel were spaced 1/4" apart and the ends of the wire were securely tied to the mandrel with suitable cords. Over the wrapped wire was placed a metal shield extending for the entire length of the wrapping. The metal shield and metal mandrel were both grounded and high voltage was applied to the ignition wire. At the start of this test 15,000 volts were applied for a period of three hours. The wire in this case showed no evidence of distress but strong corona glow was noted over the entire surface. The voltage was then raised to 25, 000 volts and held for thirty minutes with no apparent failure. The corona glow was increased to a rather excessive amount. At the end of this time the voltage was very slowly raised until 31,000 volts was reached. At 31,000 volts there was an immediate failure of the insulation on the outside of the bent wire. After the wire had failed in this particular test the outer braid and lacquer covering was removed and the insulation was examined for corona cutting. There was no visible evidence of cut rubber.

A sample of wire was removed from the harness and sent to the Collyer Insulated Wire Company, Pawtucket, Rhode Island, for detailed analysis of the rubber. The following is a report from the Collyer Insulated Wire Company.

Ignition Wire from German Plane

Construction:

1. 19 x .010" tinned copper.

2. Insulation of 3 layers, apparently strip-insulated.

   Inner layer, pink, approx. .025" thick

   Middle layer, black, approx. .050" thick

   Outer layer, pink, approx. .025" thick

   Diameter over insulation .245"

3. Close braid, 25 picks per inch, 5 ends per inch, 5 ends per strand about #50 or #60, 2 ply, yarn probably mercerized or glazed cotton.

4. Braid is coated with glossy black lacquer.

   Diameter overall .275".

Ozone Resistance Test:

The insulation was exposed to a mixture of ozone and air containing approximately .015% ozone by volume.

(a) In one case, the braid was removed and the insulated wire was bent around a mandrel. When bent around 2 times its own diameter, there was no ozone cutting, in a half hour exposure. When bent around its own diameter, the insulation cut badly within the first three minutes.

(b) In another test, the middle and outer layers of insulation were separated, samples were buffed smooth, then were exposed to ozone while stretched approximately 12%. Comparisons were made with standard rubber compounds, ozone resisting rubber, and rubber-like synthetics. In this test, the German insulation cracks within 4 to 6 minutes which is the same as standard insulations made from natural rubber. It shows no ozone resistance such as would be expected if it were a special ozone-resisting rubber or synthetic compound.

Oil Resistance:

Specimens of each layer of the German insulation were soaked for 10 days in #20 W motor oil at 70° C. in comparison with standard rubber insulation and two different synthetics.

The German insulation swelled and partially disintegrated in the same manner as standard rubber, whereas the synthetics were practically unaffected.

Analysis:

No complete chemical analysis of the German insulation was made. Ash and specific gravity are as follows:

Outer layer (pink)	Ash [illegible] Specific Gravity 2.14
Middle layer (black)	Ash [illegible] Specific Gravity 1.58

We estimate that the outer layer contains about [illegible] rubber and the middle layer about 30-40%.

Physical Tests:

Middle layer (black)

Tensile strength unaged	[illegible] lb. per sq. in.
Elongation "	[illegible]
Set	[illegible]
Tensile strength after	
4 days in air oven at 70°C...[illegible] lb. per sq. in. (19.6% loss)	
Elongation after aging	[illegible] ([illegible] loss)

Outer layer (pink)

Tensile strength unaged	[illegible] lb/sq. in.
Elongation	[illegible]
Set	[illegible]
Tensile strength after	
4 days in air oven at 70°C	[illegible] lb/sq.in. (47.3% loss)
Elongation after aging	[illegible] ([illegible] loss)

There was not enough material for a standard oxygen bomb test, but samples of both layers which had previously been stretched during one of the other tests were exposed to 300# oxygen at 70°C for 4 days and then examined visually. There was no visible effect of the oxygen, no brittleness and no tackiness.

Conclusions:

The insulation on this wire appears to be made of natural rubber. No tests were made which would prove this conclusively, but the tests are indicative of natural rubber, or of one of the Buna type synthetics so similar chemically to natural rubber that ozone and oil resistance are equivalent. The inner layer was too small to use for any tests by itself. The outer layer is a heavily loaded compound, probably intended to give corona resistance better than the middle layer. It probably gives slight protection, but we believe that the lacquered braid must be depended upon for the chief protection from corona effects.

The outer layer is a very poor aging compound. The middle layer ages fairly well, although not equal to similar rubber compounds used in American practice.

....

In concluding it may be said that the German practice is apparently to rely entirely upon the insulation of the wire for both mechanical and electrical protection. The shielding in no way protects the wire either against vibration within the metallic conduit or the attack of moisture, gasoline, oil, or other detrimental elements. The lacquer covering is the mainstay of the entire insulation in this particular case. The shielding harness itself provides very little mechanical protection for the product and serves only as an electrical shield.

H. M. Wilkoff
Project Engineer, Harness Division

APPENDIX 3

14MM GERMAN BOSCH SHIELDED SPARK PLUG

Prepared by

THE B. G. CORPORATION

136 W. 52ND ST., N. Y. C.

REPORT COVERING 14 mm. GERMAN BOSCH SHIELDED SPARK PLUG

This plug is of the ordinary two piece type of construction consisting of an insulator having a shoulder of sufficient diameter to accomodate an upper and lower copper gasket which are compressed during the assembly of the shell and shielding gland nut to produce a gas tight seal.

Dimensionally this plug has a 14 mm. external thread (.551) x 1.125mm. pitch and a 12mm. (.472) reach, 22mm.(.866) hex on the shell and a 19mm. (.748) hex on the gland nut. The dimension from the engine gasket seat to the top of the plug measures 2 1/16" as compared to 2½" now in use in this country. The upper **flashover** measures 25/32" as compared to 1" for American plugs while the lower flashover in the shielding barrel is 21/32" which compares to some domestic plugs made in this country.

The upper thread for the shielding elbow is 18mm. (.708) in diameter x approximately 1mm. pitch.

It is of interest to note that the ceramic sleeve extends to a point flush with the top of the shielding tube and is permanently cemented into place. This type of construction can be used due to the fact that the ceramic sleeve can be made much thicker and consequently stronger inasmuch as the elbow thread is larger in diameter as compared to American-made plugs. This additional wall thickness makes possible the permanent cementing of the sleeve, sealing the clearance between the O.D. of the ceramic sleeve and the I.D. of the shielding tube and less subject to cracking from engine vibration plus the additional dielectric strength.

The insulator of the subject plug has been given a qualitative spectrographic analysis and a petrographic examination under 990 magnifications. This report shows that the insulator consists of an alumina oxide base with the remaining constituents as follows: -

Alumina Oxide	Major -- (Above 5%)
Silicon	Minor -- (Minus 5%)
Magnesium	Minor -- (Minus 5%)
Manganese	Fractions of 1%
Calcium	Fractions of 1%
Iron	Fractions of 1%

Petrographic examination of the thin sectioned porcelain under 990 magnifications revealed coarse grained alumina of irregular shape. The average grain size is .025" to .30" millimeter in size. Some of the larger grains which are fairly evenly distributed throughout the mass measure as much as .075 millimeters. The alumina grains are bonded by interstitial glass.

From the spectrographic and petrographic analysis one may conclude that the original body mix prior to firing consisted of not less than 90% alumina oxide and accessory fluxes such as talc, magnesia, and titanium dioxide included to promote grain growth, bond and alumina into a vitreous mass, and increase the dielectric strength. This porcelain was probably fired to approximately 300°F.

The hot dielectric value (te value) was much lower for this insulator than one would expect, viz: 1320°F compared to 1795°F for the English Lodge "Sintox", 1360°F for AC LS85, 1620°F for Champion C345, and 1790°F for the ceramic insulators which B G is now experimenting with. The low te value for this insulator could be accounted for if it were possible to know the degree of purity of the base material (alumina oxide), as certain grades contain relatively high amounts of impurities which turn into glass during the firing cycle and automatically lower the te value.

The cement used to seal the center electrode and the ceramic tube into place consisted mostly of 325 mesh alumina plus a clay fraction and sodium slicate to "flow" and "set" the cement.

The center electrode consists of a mild steel threaded shank on to which is butt welded a nickel alloy extension approximately 11/16", long the whole assembly being slightly tapered to center the electrode in the insulator and force out the air voids in the cement during the cementing operation. This is a good feature but relatively expensive from a high production point of view. The ground electrode also consists of a nickel alloy and is secured into the shell by a crimping operation.

This plug has a novel gap geometry, and from the physical dimensions and the electrode alloys used it is assumed that the gap life would be relatively short as compared to domestic plugs with their large center electrodes consisting of tungsten alloys, and copper filled nickel electrodes. No tests for sparking voltages were made due to the badly corroded conditon of the gaps making it impossible to properly reset them for a test of this kind. However, the short flashovers allowed in the design of this plug plus the smallness of the ground electode prongs give strength to the belief that this unit has a low sparking voltage both hot and cold.

This plug showed up very well on engine tests conducted in a single cylinder coperative fuel research engine of 25 cu. in. displacement, injected fuel and supercharged. Shown on the attached graphs and test sheets are data pertinent to the subject plug relative to its performance. It is of interest to note that this plug has a firing tip or insulator exposure of 7/16" as compared to 1/4" and 3/8" for most American 18mm. plugs. However, the smaller thread size (14mm) and the high surface to volume ration accounts for the high I.M.E.P. which this plug shows.

CONCLUSION:

The subject spark plug is a well-designed and engineered unit, very light in weight, weighing 65.2 grams as compared to 100.9 grams for an ACLS85 and has been designed for mass production, low cost, conservation of materials plus easy original assembly and simple field servicing.

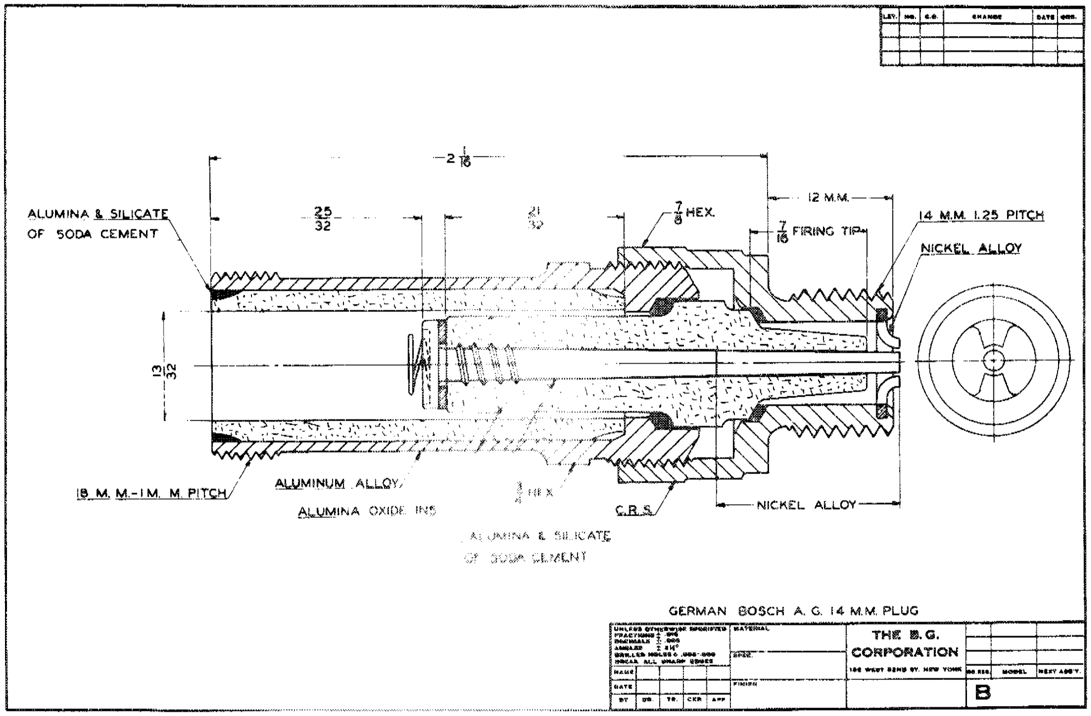
The design of this unit shows that every consideration has been given to use ceramics at their best, notably among these features is the ceramic shielding sleeve which has been designed to produce the best results regardless of physical dimensions, and other units have been changed to favor the use of ceramics which are necessary if a properly designed and durable plug is to be made.

E. Mosthaf

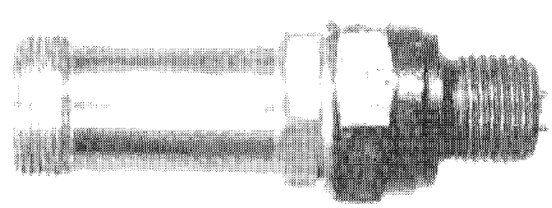
Ceramic Division

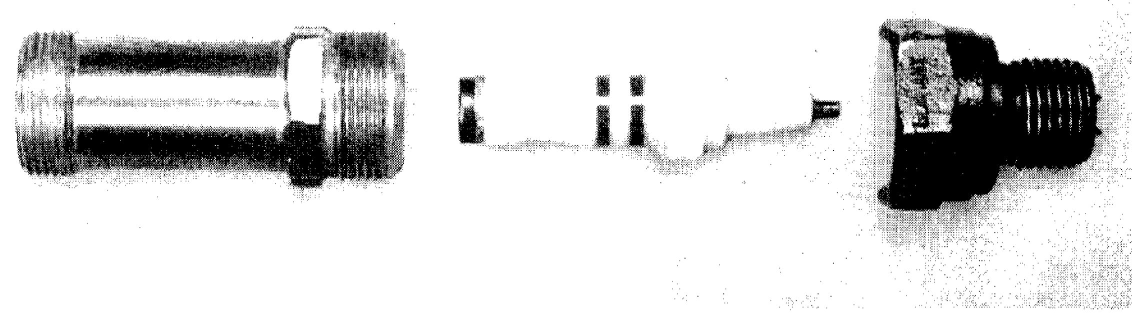
EM;AS

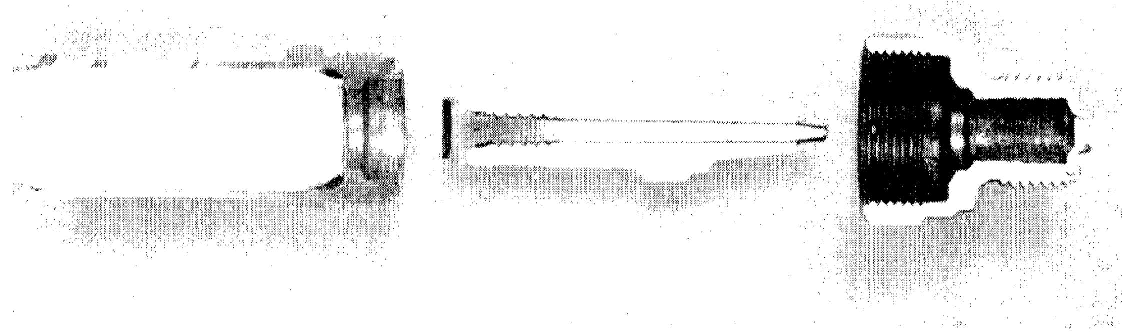
Enc.

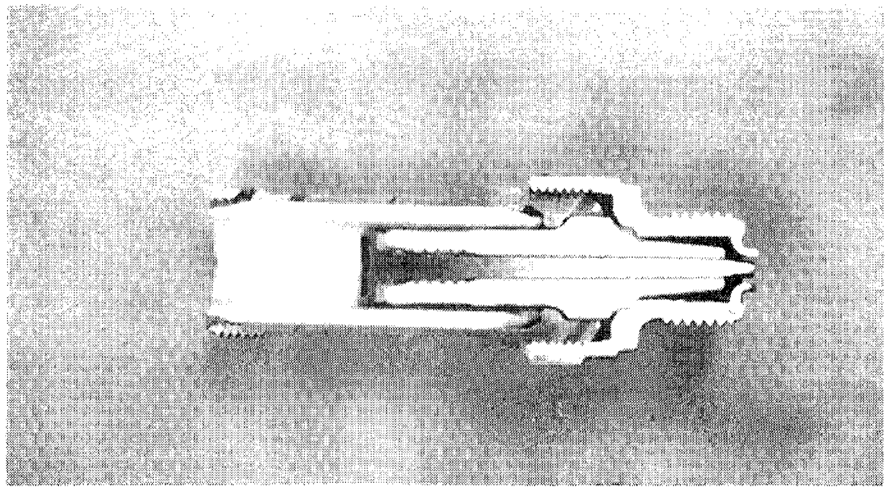


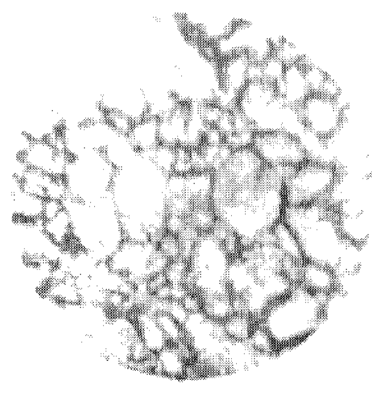
2 1/16
ALUMINA & SILICATE OF SODA CEMENT
25/32
21/32
7/8 HEX.
12 M.M.
7/16 FIRING TIP
14 M.M. 1.25 PITCH
NICKEL ALLOY
13/32
18 M. M.-1 M. M. PITCH
ALUMINUM ALLOY
ALUMINA OXIDE INS
3/4 HEX
C.R.S.
NICKEL ALLOY
ALUMINA & SILICATE OF SODA CEMENT
GERMAN BOSCH A. G. 14 M.M. PLUG
THE B.G. CORPORATION
B











B. G. CORPORATION

TEST SHEET NO.

C. F. R. Single Cyl. Test Engine

25 Cu. In. Displacement

2000 R. P. M. , 83 Octane Fuel

Fuel Injection

German Bosch 14 m.m. ceramic spark

plug to be rated.

C. R. 6.63 C. R. Setting .300"

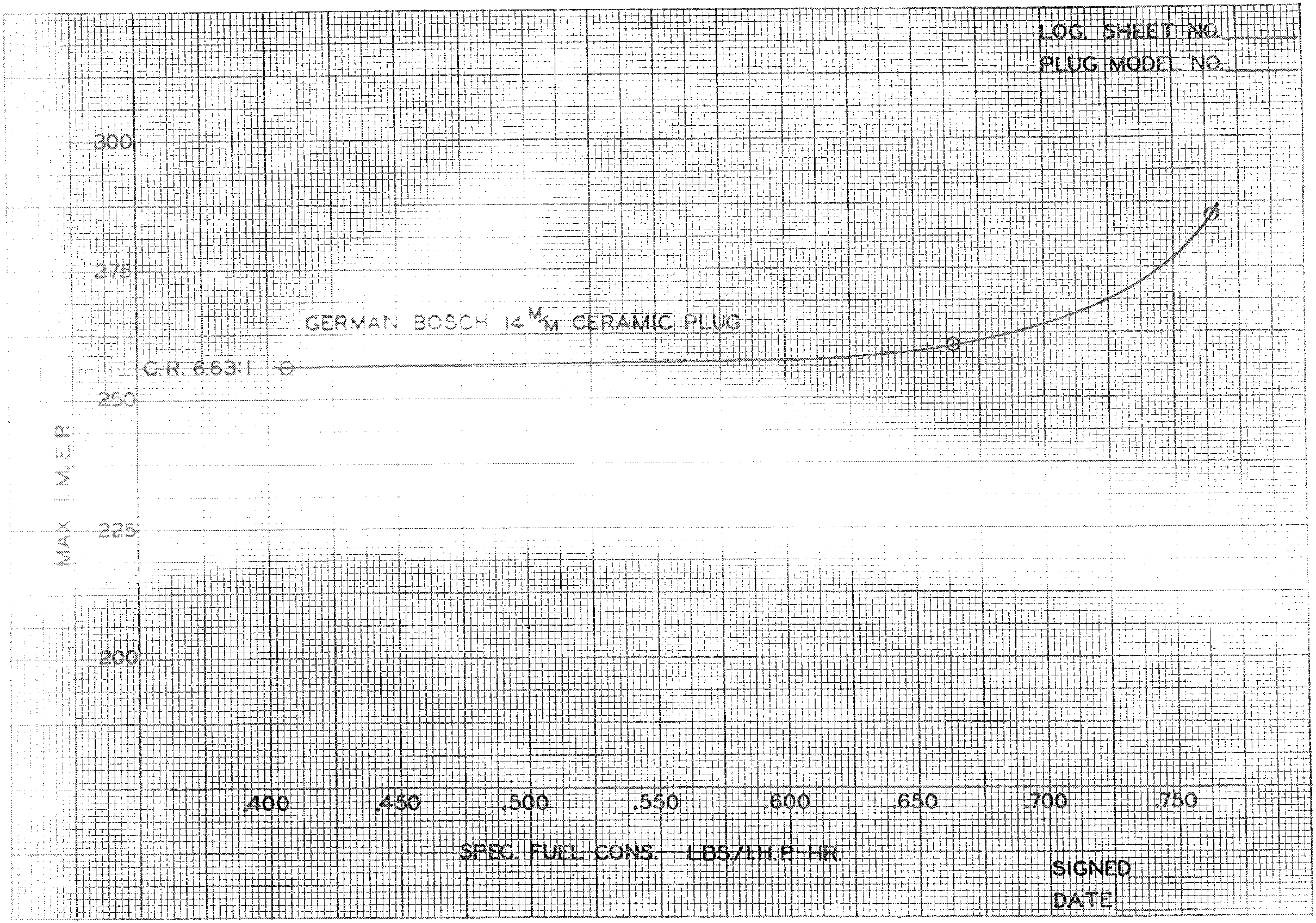
DATE

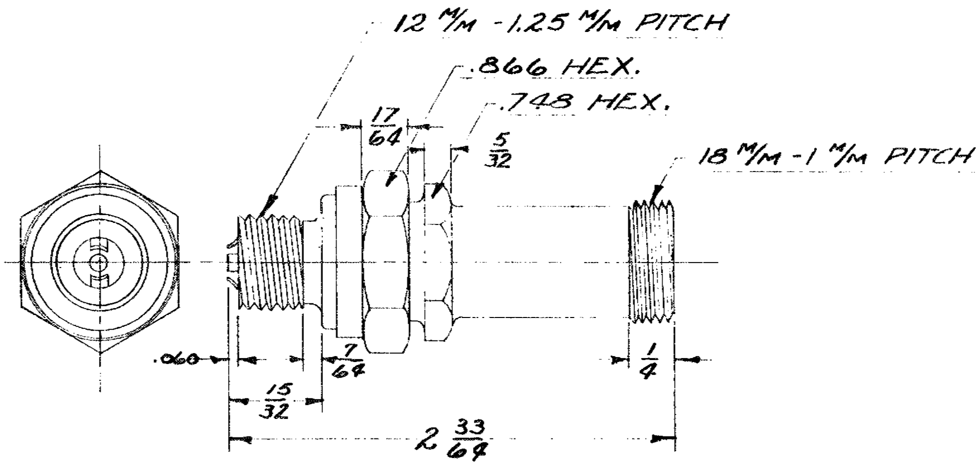
CONDUCTED BY ABS

Time	Deton.	Boost " Hg.	Brake Load	Frict. Load	Revs. ¼# Fuel	Spec. Fuel Cons.	I.M.E.P.	Micro. Set
1 10/15/41								
2 2:30		Start	Engine					
3 2:42	Med.	67"	25.3	7.2	4530	.408	256	.615
4 2:55		Shut	Down					
5								
6 10/16/41								
7 10:15		Start	Engine					
8 10:40	Heavy	69"	26.0	7.0	2720	.665	260	.515
9 10:55	Heavy	70" +	29.2	6.8	2175	.765	285	.450
10 11:05		Shut	Down					
				Remarks				

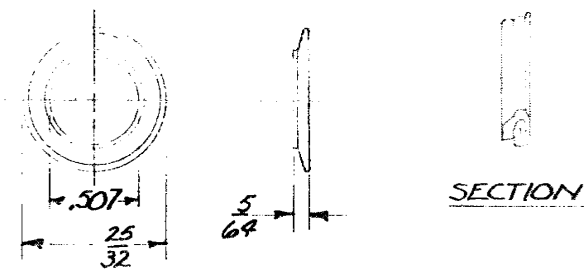
There was no leakage on either spark plug and after the run one leaked 2 7/8 c.c./min. and the other 4 c.c./min. @ 150 lbs./sq.in. All leakage was past the gasket seal on the shoulder of the ceramic insulator.

When put into pre-ignition the load falls off immediately, and when boost is lowered will not instantly recover.

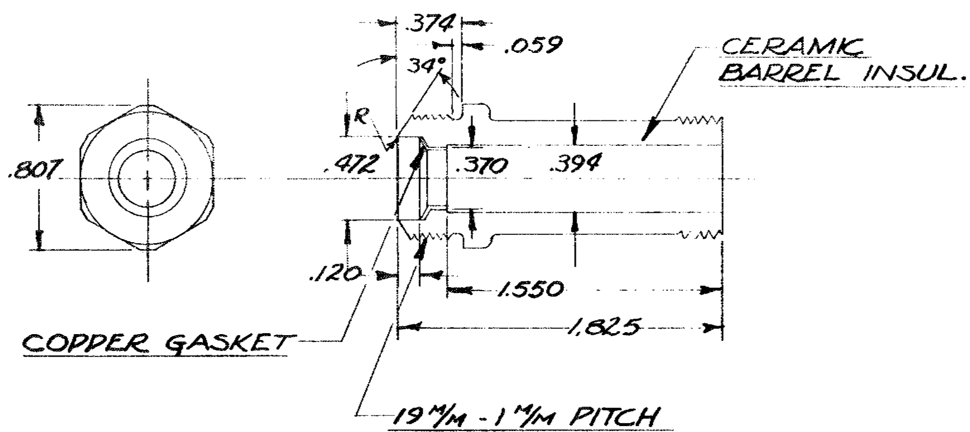

LOG. SHEET NO.
PLUG MODEL NO.
300
275
250
225
200
MAX I.M.E.P.
GERMAN BOSCH 14 M/M CERAMIC PLUG
C.R. 6.63:1
.400
.450
.500
.550
.600
.650
.700
.750
SPEC. FUEL CONS. LBS/I.H.P.-HR.
SIGNED
DATE



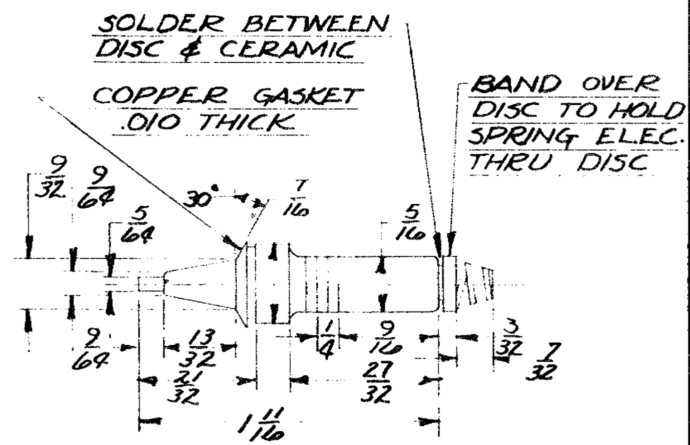
SPARK PLUG ASSEMBLY



CYLINDER GASKET
-STEEL-

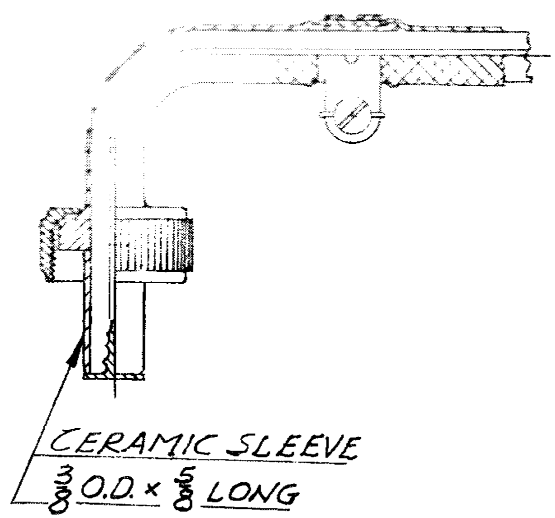


COUPLING NUT
-ALUMINUM ALLOY-



CORE
-CERAMIC-

	SPARK PLUG-GERM. BOCH.	
MATERIAL	B.G. CORPORATION 136 W. 52ND ST. NEW YORK	AS-149



NAME						ELBOW-GERM.BOCH	No. REQ.	MODEL	NEXT ASSY
DATE						B.G. CORPORATION 136 W. 52ND ST. NEW YORK	AS-150		
BY	DR.	TR.	CKR.	APP.	MATERIAL				

APPENDIX 4

WIRING FROM MESSERSCMITT Me110

Prepared by

ROCKBESTOS PRODUCTS CORP.

NEW. HAVEN. CONN., U.S.A.

REPORT OF TESTS AND EXAMINATION OF WIRE REMOVED FROM MESSERSCHMITT ME110 FIGHTER

Conducted by "Rockbestos Products Corp.",
New Haven, Conn. U. S. A.

In general, the workmanship and construction of all types of wires received showed excellent workmanship and high grade material. The general description of the various composite parts is as follows:

In all cases a bare copper conductor was used usually of flexible strand either bunched or concentric as is outlined under each type of wire described.

In all cases over the above conductor there was a blue cellulosic material tape used as a separator as well as a protection of the thin wall rubber used over it. This material is very similar to our cellophane tape and is apparently a viscose type of cellulosic material and smells like cotton when burning.

The primary dielectric consisted in most cases of two walls of a rubber compound applied by the strip process and consisted of many color combinations; in most cases, two different colored strips being used for a given wall. The thickness of these walls varied for the different types of cables as given in the description of each specimen examined. This rubber was very stretchy and apparently was equivalent if not a little superior to our standard 30% Hevea rubber.

In many samples a fibrous braid was included and was of a cotton type of yarn although in most cases was so well impregnated that its definite identity could not be ascertained. In general, the compound used in impregnating the fibrous covering was similar to a lacquer but completely impregnated the individual yarns as well as coating the surface of the fibrous covering. We are not able to ascertain the exact type of lacquer nor were we able to extract the material from the fibrous braid.

In some samples a cambric tape was applied with varying positive lays as an actual jacket to the cable. In other samples a tubed sheath of rubber was used as a jacket to protect the finished cable. Under the jacket, cotton threads were used as apparent manufacturers' marker and in most cases consisted of a red, green, and yellow cotton thread twisted together.

All cables had an aluminum armor of the basket weave type over the completed cable.

One of the samples had a terminal on it as follows: Terminal end of cable was protected by a sleeve consisting of 1" long cotton braided lacquered tube held in place by numbered aluminum band which also locked free end of aluminum armor. This sleeve was .024" thick and was located between terminal end of cable and end of armor and over the regular braid coat. The conductor was bonded at terminal end by means of a tinned copper sleeve approximately 3/4" long crimped over the conductor and flattened somwhat for fastening to the terminal.

Due to the short samples, extensive dielectric and ageing tests could not be made. However, dielectric breaks were taken on some samples with very uniform results. The small sized conductors such as used in specimen marked "48-M", the breakdown was 11,000, 14,000, 11,000, 13,000, and 12,000 volts whereas the large conductor such as the specimen #2, the voltage breakdown was 18,000 and 18,500.

The materials apparently were limited to a maximum temperature in the neighborhood of 60 deg. C., according to our methods of rating and it was found that in general the thin strips used in insulating were not well vulcanized together, i.e., the two halves would pull apart readily. However, we found no evidence of voltage breakdowns at these points nor do we believe that under water or moisture conditions these rubber walls would show to be defective.

DETAILED EXAMINATION OF SPECIMENS

SPECIMEN NO. 1 Marked "91-E" - This was an armored 3-conductor cable, red, yellow, and black. The conductor was approximately No. 18 AWG - 1512 C.M., and consisted of 42 strands of .006" bare copper, bunch stranding. The conductor was covered with the blue cellulosic material and had a dielectric of .050" over the tape.

Next was applied two layers of rubber by the application of four strips of rubber, a total thickness of approximately 14 mils, so that the O.D. of the conductor over the rubber was .080". One conductor was insulated with an inner strip of white rubber covered with red rubber; the second conductor, an inner wall of white and an outer wall of black; and the third conductor, an inner wall of black rubber and an outer wall of white rubber. These three conductors were cabled together and a black rubber sheath taped over the conductors. Under the sheath were two small cotton marker threads. The O.D. over the rubber sheath was .275". Next was applied a fibrous cotton braid, very close lay, which was thoroughly impregnated and coated heavily with lacquer. the O.D. over the lacquer coat being .298", then overall an aluminum armor of open weave with a final O.D. of .338".

<u>SPECIMEN NO.2</u> Marked "[illegible]". This is the sample which had the terminal end previously referred to. The conductor was approximately No. 7 AWG - 20356 C.M., and consisted of concentric stranding of 19 strands of .032". The O.D. of the conductor was .13[illegible]". Over the conductor was the blue transparent tape approximately 2 mils thick and [illegible]" wide and wrapped so that three thicknesses were around the conductor. O.D. over the tape was .165".

Next was applied two strips of white rubber approximately 16 mils thick over which two black strips approximately [illegible] mils thick were added making a total O.D. over the rubber of .233". A cambric tape backed with an adhesive was wrapped over the rubber with a 1/8" positive [illegible]. The tape was 9 mils thick and .854" wide making an O.D. over the tape of .2[illegible]". Over this there was a cotton braid impregnated and coated with a heavy lacquer material. This lacquer burns very readily, the O.D. over the lacquer coat being .284". An aluminum armor was applied over the red lacquer braid and consisted of 13 picks per inch using three ends of .008" aluminum. The diameter over the armor was .310" as an average although there was considerable variation varying between .310" and .325".

SPECIMEN NO. 3 A 14 - conductor cable. The individual conductor was approximately No. 20 AWG, No. 20 AWG, 877 C.M., and was made up of 29 strands of .0055" bare copper, bunch stranding. Over the individual conductors was a blue cellulose tape approximately 1-1/2 mils thick and 1/8" wide and applied to give a slight positive lap. The individual conductors were insulated by 4 strips of rubber with an average total thickness of 22 mils for the two layers of rubber strips. In all cases the inner layer of rubber was white. The outer layers varied, some being of all one color and others being made up by applying one strip of one color and one strip of another color. The color coding used is as follows: The outer rubber wall: consisted of two strips of the following colors: blue and black, red and black, green and black, yellow and black, blue and red, blue and blue, slate and slate, red and red, brown and brown, black and black, red and green, green and green, yellow and green, and yellow and yellow.

The diameter of each conductor over the rubber was .078". The 14 such conductors were cabled together, approximately a 4" lay, and had an O.D. of .340". Laid in with these conductors were also three cotton marker threads, one red, one green, and one yellow, all twisted together; also one cotton thread alternating in color between white and black, there being 3/8" for each color.

A 9-mil cambric tape 3/4" wide which was impregnated with a solvent rubber compound was applied over the cabled conductors with a positive lay of approximately 1/8". The impregnation of this cambric was apparently done after the wrapping operation. The O.D. over the tape was .358". A green fibrous cotton braid well impregnated and coated with lacquer was applied over the tape. The thickness of the braid being approximately 25 mils with a resultant O.D. of .408". Over this an aluminum armor using 8 picks per inch, 5 ends of 8-mil aluminum with a finished O.D.

of .467".

SPECIMEN NO.4 Consisted of two twisted cables under a common armor and then extending as single conductor cables each with its own armor.

One of the conductors was approximately 18 AWG 1548 C.M., and consisted of 43 strands of .006" bare copper, bunched, with a blue cellophane tape approximately 2 mils thick and .187" wide, applied with a slight positive lap giving an O.D. over the tape of .044". Over this tape was applied two strips of white and then covered with two strips of slate rubber, a total thickness of the two walls of approximately 17 mils with a resultant O.D. over the rubber of .077". Over this was applied a cotton braid approximately 30 mils thick which was impregnated and lacquer coated red with an O.D. of .118". Over the cotton braid the marker threads were one yellow, one red, and one green cotton. The aluminum armor over the braid was made of [illegible] picks per inch. 3 ends of 8-mil aluminum, with a resultant O.D. of [illegible].

The second conductor was lacquered black, was approximately No. AWG, 1512 C.M., and consisted of 42 strands of [illegible] bare copper, bunch stranding, and was covered with a 1-mil thick blue cellophane tape .150" wide and was applied with a slight positive lap, with an O.D. of [illegible]. Next was applied two strips of black rubber and over this two strips of white rubber, total thickness of the two being approximately [illegible] mils and the resultant O.D. over the rubber of .085". A cotton braid was next applied approximately .036" thick and impregnated and coated with a black lacquer. The cotton marker threads under the braids were yellow, red, and green threads twisted together. The diameter over the cotton braid was .150". Next was applied an aluminum armor consisting of 14 picks per inch, 3 ends of 8-mil aluminum, making a final O.D. of .183".

The above two cables were twisted together at a point about 12" from one end. The individual armors were ended and both conductors covered by a common shield consisting of an open basket weave aluminum armor bonded by aluminum band and covered by a rubber sleeve 5" long.

SPECIMEN NO. 5 Consisted of a single conductor cable, marked "54-B". The conductor was a little larger than our standard No. 16 AWG 2707 C.M. and consisted of 30 strands of .0095" bare copper, bunch stranding. These strands were covered with a blue cellophane tape 1-mil thick and .150" wide, and applied with a slight positive lap, the O.D. over this tape being approximately .060". Next was applied two strips of black rubber and then two strips of white rubber, the total thickness of the two layers being approximately 18-mils with an O.D. of .098" over the rubber insulation.

Next was applied a cotton braid approximately 23 mils thick which was impregnated and coated with a black lacquer giving an O.D. over the braid of approximately .161". A twisted marker consisting of one red, one yellow, and one green cotton thread was placed under this braid. The aluminum armor consisted of 11 picks per inch, 3 ends of 8-mil aluminum with the O.D. of the cable being .170".

Special Note: This cable protected at terminal end by yellow varnished cambric tube 1-1/2" long. This sleeve was held in position between the aluminum armor and the braid by a numbered aluminum band which was crimped on over the aluminum armor.

SPECIMEN NO. 6 No identifying number.

The conductor was approximately 18 AWG 1512 C.M. and consisted of 42 strands of .006" bare copper, bunch stranding. The strands were covered by a 1-mil thick blue cellophane tape, .140" wide which was applied with a slight postive lap, with an O.D. over the tape of .047". Next was applied two strips of white rubber and two strips of black rubber, the thickness of the two being approximately 22 mils or an O.D. over the rubber of .078".

Next was applied a 27-mil thick cotton braid which was impregnated and covered with a black lacquer. The typical marker thread consisted of one red, one yellow, and one green cotton thread. The diameter over the cotton braid was .129". The aluminum armor was 12 picks per inch, 3 ends of 8-mil aluminum with a finished O.D. cable of .170".

SPECIMEN NO. 7 No identifying number.

This conductor was a little larger than No. 16 AWG 2707 C.M., and consisted of 30 strands of .0095" bare copper, bunch stranding. The strands were covered with a 1-mil thick blue cellophane tape .220" wide and applied with a slight positive lap, diameter over the tape being approximately .059".
Next were applied two white rubber strips, then two black rubber strips, a total thickness of the two walls of rubber being approximately 16 mils or an O.D. over the rubber of .090".
Next a 22-mil cotton braid impregnated and lacquered black was applied. Under the braid was a red, yellow, and green cotton marker twisted together with an additional green marker thread. The O.D. over the braid was .132". The aluminum armor made up of 11 picks per inch, 3 ends of 8-mil aluminum. The O.D. of the cable being .168".

Note: The armor was fastened at 7" from end of conductor by means of cotton threads coated with varnish.

SPECIMEN NO. 8 This was an aluminum armored 5 conductor cable marked "48-M".

The conductor was approximately No. 18 AWG 1512 C.M. and consisted of 42 strands of .006" bare copper, bunch stranding. The strands were covered with a blue cellophane tape, 1-mil thick, .150" wide, and was applied with a negative lap, the O.D. over the tape being approximately .042". The conductors were then insulated with two strips of one colored rubber and then two strips of another colored rubber, the total thickness of the two layers being approximately 18 mils with a diameter over the rubber insulation of approximately .078".

The coding of these cables was as follows: One conductor, a layer of black rubber covered with a layer of white rubber, and the other conductors all first insulated with white rubber and then insulated with, one conductor black, another red, another green, another blue. These five conductors were then cabled around a core which was made up of a piece of cotton braid covered with two strips of green rubber similar to the strips used on the individual conductors. The thickness of this strip was approximately 8 mils. The cabled conductors were then covered with a cambric tape approximately 12 mils thick and .590" wide applied with a 1/8" positive lap. This tape is similar to surgical adhesive tape. Over this tape were the marker threads consisting of one red, one green, and one yellow cotton threads twisted together with an extra yellow cotton marker. The O.D. over the cambric tape was approximately .261". Next covered with a braid 23 mils thick which was impregnated and lacquered black. Between the cambric tape and the braid was inserted a single green cotton marker. The O.D. over the cotton braid was approximately .285".

The aluminum armor over this braid was made up of 11 picks per inch, 4 ends of 8-mil aluminum ~~and the~~ finished diameter of the cable was .320".

SPECIMEN NO. 9 Marked "30-B". - Aluminum armored 4-conductor cable. The conductor was approximately No. 17 AWG 2048 C.M., and consisted of 32 strands of .008" bare copper, bunch stranding. The strands were covered with a blue cellophane tape, 1-mil thick and .050" wide, and applied with a negative lap. The diameter over the tape was approximately .050".

The conductor was then insulated with two strips of one colored rubber and then two strips of another colored rubber, the total thickness of the two layers being approximately 20 mils and the diameter over the rubber insulation being approximately .090".

The coding for these cables was first white then black and this conductor carried a number identification of #1; another conductor, first black and then white with a number identification of #5; another conductor, white and then red, with identification #0; and the fourth conductor, white and then blue with identification #2. These conductors were cabled together and also had a marker thread, one red, one green, and one yellow cotton thread twisted together with one yellow thread in additon laid in with the conductors over which an extruded rubber sheath approximately 20 mils thick was applied. The diameter over the extruded sheath was approximately .275".

In this sample both the rubber used on the conductor as well as the rubber of the sheath appeared to be coated with a wax and apparently was one of the paraffins. Next was applied a cotton braid 17 mils thick which was impregnated and lacquered black. The O.D. over the braid was .315". The aluminum armor was made up of 10 picks per inch, 6 ends of 8-mil aluminum, with an O.D. overall of .350".

H. S. MOORE, Electrical Engr.
ROCKBESTOS PRODUCTS CORPORATION
New Haven, Connecticut

APPENDIX 5

GASOLINE GAUGE FOR MESSERSCMITT ME110

Prepared by

GENERAL ELECTRIC CO.

SUBJECT: Vultee Aircraft, Inc. - German Airplane Gasoline Gauge

Data Folder: #45784

Work Directed By: C. F. Savage

Tests Made By: R. G. Jewell, F. R. Sias

Report Prepared By: F. R. Sias

Report Countersigned By: I. F. Kinnard

Date Issued: December 22, 1941

CONTENTS

GERMAN AIRPLANE GASOLINE GAUGE

PURPOSE: These tests were made to determine the characteristics and construction details of a German gasoline gauge of the type used on the Messerschmitt 110 airplane.

MATERIAL TESTED: German gasoline gauge transmitter for a tank sixteen inches deep. No name plate is attached. The transmitter is similar to an Elektrischer Vorrats-Gober (Electrical Supply Transmitter) manufactured by Hartmann & Braun A.C., Frankfurt-Main. No indicator with which to check the transmitter is available, so such tests are omitted.

GENERAL DESCRIPTION: The transmitter consists of an anodized aluminum tube sixteen inches long riveted to a die cast anodized aluminum head which is used to mount the unit in a tank. A two and a three pin plug connector receptacle is machined directly on this die casting. This differs from general practice in this country where the receptacles are manufactured as separate units and attached to the case with screws. The connection pins are screwed into plastic insulators, which are held in the receptacle by a snap ring. Connections are polarized by making one connection pin larger in diameter and longer than the rest. The head contains the electrical transmitter mechanism which is coupled to a float mechanism in the tube section by a magnetic coupling. The two sections of the transmitter are separated by a gasoline-tight partition, or diaphragm which is secured to the head casting by means of a threaded ring screwed up inside the tube. Through the center of this diaphragm is a stainless steel post, staked in place. In each end of this post are holes which serve as bearings for the shaft which carries the brushes and the float shaft. The float mechanism consists of a metal float which slides on a square rod (float shaft) pivoted axially in the tube. A pin attached to the rim of the float engages a spiral slot in the tube which causes the float and square rod to rotate as the float is carried, by change of gasoline level, from one end of the tube to the other. Photographs

#172081 and 172082 show the external appearance.

THE TRANSMITTER ASSEMBLY: A general view of the transmitter assembly is shown by photograph #172080 and #172083. It consists of a stationary rheostat winding attached to an aluminum bridge. Over this winding travel two pairs of brushes. One pair is used to operate the indicator while the other is the low-level warning light switch. Normal rotation of the brushes, from empty to full, is 151 degrees. A stop limits the maximum to 164 degrees. These brushes are soldered to the ends of posts mounted on an aluminum plate by means of plastic insulating strips. To these posts are also attached connecting spirals which connect the brushes to the external circuit, there being no sliding contacts except those of the brushes themselves. The plastic strip holding the warning light brush is secured by screws passing through circular slots in the aluminum plate. These slots allow an adjustment range of 10 degrees in the setting of the switch operating position. The aluminum plate is pressed onto a brass bushing on a stainless steel shaft which has polished pivots at each end. To this plate is also attached the upper magnet of the magnetic coupling. One of the pivot bearings is a hole in the aluminum bridge, while the lower bearing (center of photograph #172083) is a hole in a stainless steel post in which a steel ball is pressed. This ball carries the thrust due to the weight of the transmitter rotating assembly, and the force of the magnetic coupling. The magnetic coupling force is more than sufficient to support the weight of the float shaft.

The transmitter winding is wound on a flat strip of soft metal similar to solder which is coated with a white pigmented layer. A layer of an oily material similar to vaseline covers this white coat, and on top of that is a layer of transparent flexible lacquer. The winding is enamel covered wire, close wound. No additional coat of lacquer is used to hold it in place. The wound strip is formed into a ring and two ends of laminated phenolic plastic, with grooves for the ring, are attached with screws.

The insulation is then removed from the contact surface of the wire. There seems to be little attempt to polish the contact surface. Some of it is quite smooth but a great deal appears to have been cleaned with fine sandpaper or a scraper. The enamel is not removed down between the wire, but has the same level as the contact surfaces. The wire itself appears according to a rough analysis of a very small piece, to be a silver-platinum alloy. The change in resistance of the winding for uniform change in float displacement shows a maximum departure from uniform of 1.12% as shown by Table 3.

The brushes are shown by photographs #172080, 172083, and 172084. They consist of two contact wires of .006" round platinum-iridium spot welded in two places to phosphor bronze springs. The springs are one-tenth wide, one inch long, and .003" thick, split at the contact end for 5/16 inch. The other end is wound in one turn spiral and soldered to the post.

The combined pressure of both contact wires on the winding is about 2 grams or 1 gram for each contact. Repeated tests of contact to the winding showed two points at which the contact momentarily opened up. This is considered to be low in view of the low brush pressure, high enamel between wires and considerable dust which had accumulated on the winding.

The connecting spirals consist of a spiral spring of seven convolutions made of .015" x .007" phosphor bronze. The outside diameter of the spring is 5/8 inch. These spirals are mounted between laminated phenolic spacers which prevent them from becoming tangled by covers vibration and shock.

The resistance spools are made of a thermo-plastic material with terminal pins molded into one end. The material becomes very soft at soldering temperature. These spools are secured to an insulating base by studs which are split at the outer end, the split end being spread like a cotter pin to hold the spools in place.

THE MAGNETIC COUPLING: The magnetic coupling consists of two similar magnets of material whose strength corresponds to that of modern high strength magnetic materials. These magnets are best shown by photograph #172083, 172084, and 172085. They are oval shaped and of uniform thickness, both oval faces being ground. A shallow U-shaped bracket of non-magnetic material is placed in the center of the oval, the ends of the U extending over the machined surface of the magnets to which it is soldered. In a notch in the ends of the U is also soldered a soft iron pole-piece. The U is provided with tapped holes by means of which the magnet is attached to the shaft.

Figure 1 is a graph of the torque in gram-mm. necessary to deflect one magnet of the magnetic coupling from its normal position while the opposite magnet is held stationary.

<u>FLOAT ASSEMBLY:</u> The float is nickel plated cylindrical brass box made in two parts and soldered together. Reinforcing ribs are pressed into ends. A one-half inch hole extends through the center of the float and has 1/32" thick brass plates with square holes to fit the shaft, soldered centrally over each end. These brass plates are the bearings on which the float slides over the square shaft and also serve to rotate the shaft when the float rotates. A stainless steel pin (shown at the lower end of the slot on photograph 172081) is screwed into a brass bracket soldered to the lower rim of the float. This pin engages the spiral slot in the large aluminum tuve and thus rotates the float as it moves from one end of the tube to the other.

The float shaft is a .255 inch square anodized aluminum rod with stainless steel pivots at each end. To one end a cross bar is secured to which the lower magnet of the magnetic coupling is screwed. There is a maximum play of .001 inch between the shaft and the float bearing surfaces which allows the float to rotate one degree without turning the shaft. The angle of static sliding friction between the shaft and float is 8-10 degrees. This angle for the complete assembled gauge is 15 degrees.

The stainless steel shaft pivots have a Rockwell "C" hardness of 35. The lower bearing bushing is also of stainless steel having a Rockwell "30N" hardness of 42 (21 Rockwell C).

The spiral slot (see photographs 172086 and 172082) which turns the float is carefully cut, the play between it and the float pin varying between .008 and .010 inches. Wearing surfaces are quite smooth and have been anodized. The slot is reinforced at 3 inch intervals with aluminum bridges which are riveted to the tube. These rivets, as well as those which hold the tube to the head are of the flush type with the heads on the inside.

ELECTRICAL CIRCUIT: The electrical connections are shown by figure 2. Since no indicator is available, its connections cannot be shown. The indicator probably is a ratio type to those used for positon or temperature indication. One-half of the winding is used for indication, the other half making up a warning light switch. All circuits are insulated from ground.

Based on circuits similar to those known to be in use, the 24 volt power consumption is between two and three watts. All electrical adjustments are made at the factory; there being no provision for, or necessity for adjustment in the field, since both end scales are fixed by the length of the unit instead of by the top and bottom of the tank as is usual with the float lever type of gauge.

WORKMANSHIP: The general workmanship of the transmitter is of the best quality. All soldered connections are painted with shellac. Adjusting screws inside the head are sealed with a black sealing material similar to lacquer. External screws are flat-headed and sealed by driving the aluminum in which they are seated into the screwdriver slot.

OPERATION CHARACTERISTICS: The electrical transmitter mechanism has a number of novel features, the most important being the precious metal and resistance winding. This combination would definitely provide better contact or allow lower brush pressure than other usual combinations. In this case, the brush pressure has been kept low (one gram) and the possibility of open circuit occurring due to the presence of foreign particles, etc., is reduced by dividing the brush into two contact shoes. The use of connecting spirals instead of sliding contacts to carry current from the brushes to the external circuit eliminates the possibility of poor contact at this point.

The pivots of the brush and float shafts are small compared with usual practice. Both pivots and bearings are made of stainless, the pivot apparently being heat treated to greater hardness.

Spiral slot type gauges have much less effective operating torque than float lever type gauges for equivalent float sizes. In this case, effective torque is only about 10 per cent of that of a float lever type.

SUMMARY:

Good Points:

1. Uniformity of calibration.
2. Good brush contact.
3. Low brush friction.
4. Low bearing friction.
5. No adjustment in the airplane necessary.
6. Easily installed.
7. Operation of float not affected by distortion of tank.
8. Not seriously affected by surging of fuel.

Bad Points:

1. Reserve gasoline supply (fuel remaining below empty) is determined by tank shape and must be measured for each tank.
2. Low torque to float buoyancy ratio.
3. Change in float sliding friction seriously affects torque.
4. Can be installed only in approximately vertical position.

5. Because of points 1 and 2, small amounts of wear make large changes in operation.

6. Because of small size of square float shaft, wear will make large changes in backlash and calibration accuracy.

TABLE I

MAJOR DIMENSIONS:

Overall length	17 5/16 inches
Tube length (from flange)	16 "
Tube diameter	2 7/32 "
Tube diameter over slot braces	2 11/32 "
Mounting flange (square)	3 1/8 "
Mounting hole spacing	2 1/2 "
Height of head from bottom of flange	1 5/16 "
Distance across receptacle	4 9/16 "
Slot width	5/32 "
Slot length (vertical)	14 "
Float travel (vertical)	13.9 "

TABLE II

Brush Pressure

Brush Pressure, Grams

	Both	Outer	Inner
Indicator Brush	2.0	1.3	1.0
Warning Light Brush	1.5	.8	.9
Mean	1.8	1.0	.95

Vibration Effect

Vibration amplitude at 150 cycles per second to lift brushes from winding second to lift brushes from winding .024 in.

Equivalent maximum acceleration 15.5 g.

TABLE III

Magnetic Coupling Torque

Deflection Degrees	Torque, Cm-mm
0	0

.2	14
2.0	129
6.1	301
13.8	473
22.7	588
34.4	703
39.9	760
54.5	875
Pull out torque	903

TABLE IV

Uniformity of Transmitter Resistance Change

With uniform change in float position

Float position	Ratio Res. 2 to 5 / 1 to 3 (Fig. 2)	Difference
0 - Empty -	395 / 605	
1	418 / 582	23
2	442 / 558	24
3	467.5/532.5	25.5
4	490 / 510	22.5
5	514 / 486	24.
6.	535 / 465	21
7	559 / 441	24
8	583 / 417	24
9	603.5/396.5	20.3
10 - Full -	626 / 374	22.5
		10 (231.0)

Mean		25.1
Maximum Difference		2.6
% Error	$\frac{2.6}{231}$ =	1.12%

TABLE V

Float Shaft Bearing Pressure

Wt. Float shaft and magnet	77.9 gm = .172 lb.
Wt. on upper pivot, shaft horizontal	59 gm = .13 lb.
Area, lower bearing thrust shoulder	.0035 sq. in.
Bearing pressure, lower bearing thrust *	49 lb./sq. in.
Pivot size, .059" x .050 long	
Area, projected, or upper pivot	.0035 sq. in.
Bearing pressure, shaft horizontal	37 lb./sq. in.
Hardness, lower pivot	35 Rockwell "C"
" bearing	42 Rockwell "30N"

* Under normal operating conditions the thrust is not carried by the lower pivot, but instead by the magnetic coupling as previously mentioned.

TABLE VI

Torque Characteristics

Connection spiral torque, 90 degrees	11	gm. mm.
Friction torque, brush assembly	3.5	gm. mm.
Volume of float	66	c.c.
Weight of float	29.5	gm.
Buoyancy of float submerged in .72 specific gravity gasoline = weight of gasoline displaced-weight of float	18	gm.

Radius, float driving pin about float shaft — 27.5 mm.

Angle of spiral slot with tube axis (α) — 11.9 degrees

Torque on float shaft produced by weight of float

Distance float falls, brush magnet held stationary — .9 in.

Total fall of float for 151 degrees rotation — 13.9 in.

Angle of float rotation for .9 in movement

$$\frac{.9}{13.9} \times 151 = \quad 9.78 \text{ degrees}$$

Torque for 9.78 degrees rotation of magnetic coupling

(See Figure 1) — 383 gm. mm.

Torque on float shaft produced by float buoyancy

$$\frac{18}{29.5} \times 385 = \quad 234 \text{ gm. mm.}$$

Calculated torque produced by float, neglecting friction

$$T = F \times E = \frac{WE}{\tan.\ \alpha} = \frac{29.5 \times 27.5}{.211} = \quad 3680 \text{ gm. mm.}$$

$$\frac{\text{Actual torque}}{\text{Calculated torque}} = \frac{385}{3680} = \quad 10.8\%$$

Torque of Lever Type Gauge

Length of arm of lever type gauge having 13.9 in.

vertical float movement (90 degrees lever movement--

29.5 gm. float, 151 degrees brush movement) — 9.9 in.

$$\text{Calculated maximum torque} = \left(9.9 \times 25.4 \times 29.5 \times \frac{90}{151}\right) = \quad 4470 \text{ gm. mm.}$$

Calculated minimum torque at "Empty" and "Full" positions

Movement arm of float lever = 9.9 sin. 45 degrees

= 9.9 x .707 = 7 inches

$$\text{Torque} = \frac{7}{9.9} \times 4470 = \quad 3160 \text{ gm. mm.}$$

Torque transmitting efficiency, geared type transmitter

(Experimentally determined)	87%	
Actual minimum torque = 87% x 3160 =	2750	gm. mm.
Ratio $\frac{\text{Actual torque, spiral slot gauge}}{\text{Actual torque, lever type gauge}} = \frac{383}{2750}$	.139	
Brush and brush shaft friction	3.5	gm. mm.
Connection spiral torque, 90 degrees	11	gm. mm.
Ratio – $\frac{\text{Actual torque, spiral slot gauge}}{\text{Torque, brush friction}} = 383 =$	109.5	

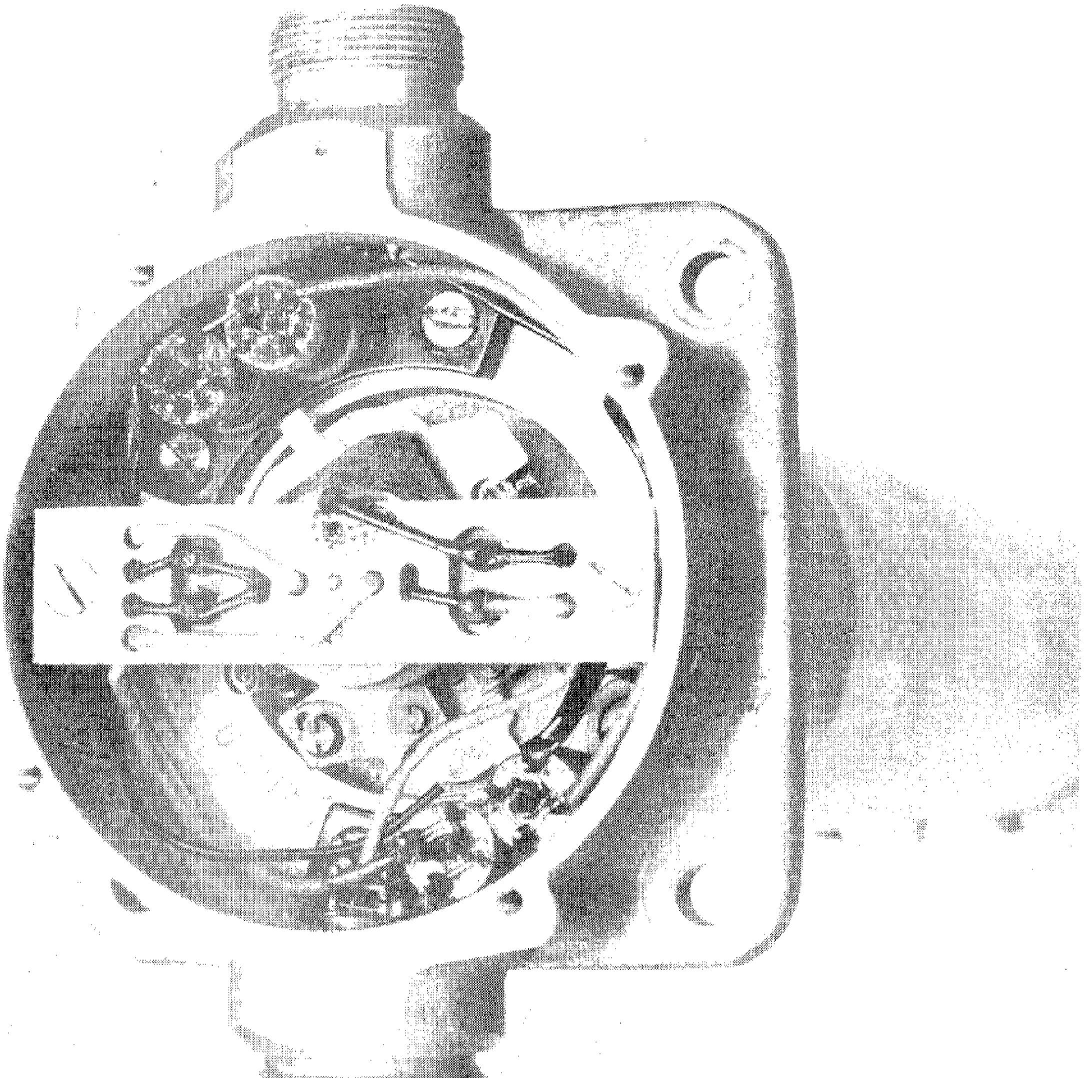
Effect of temperature change

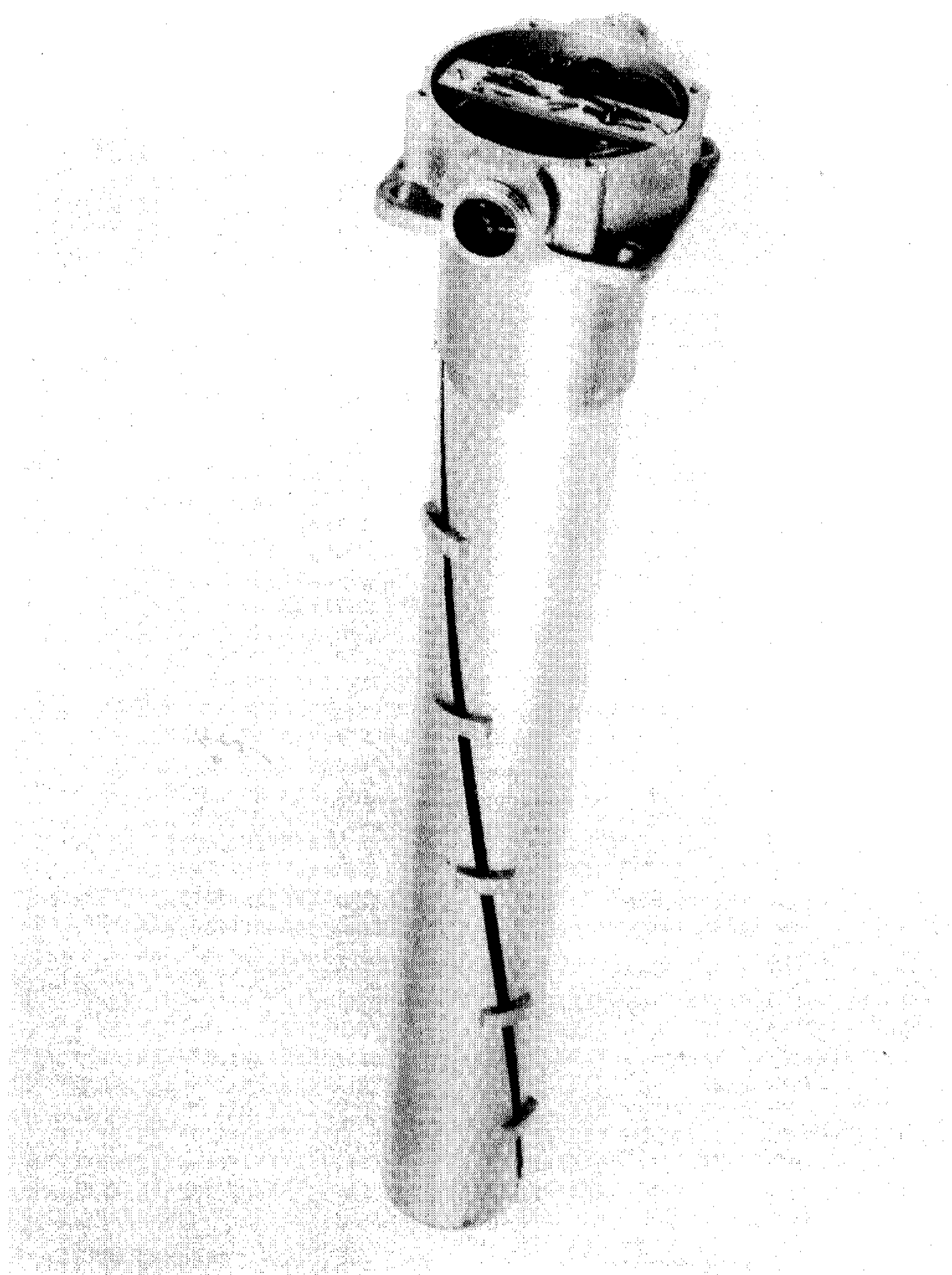
+ 70°C – bearing clearances slightly increased

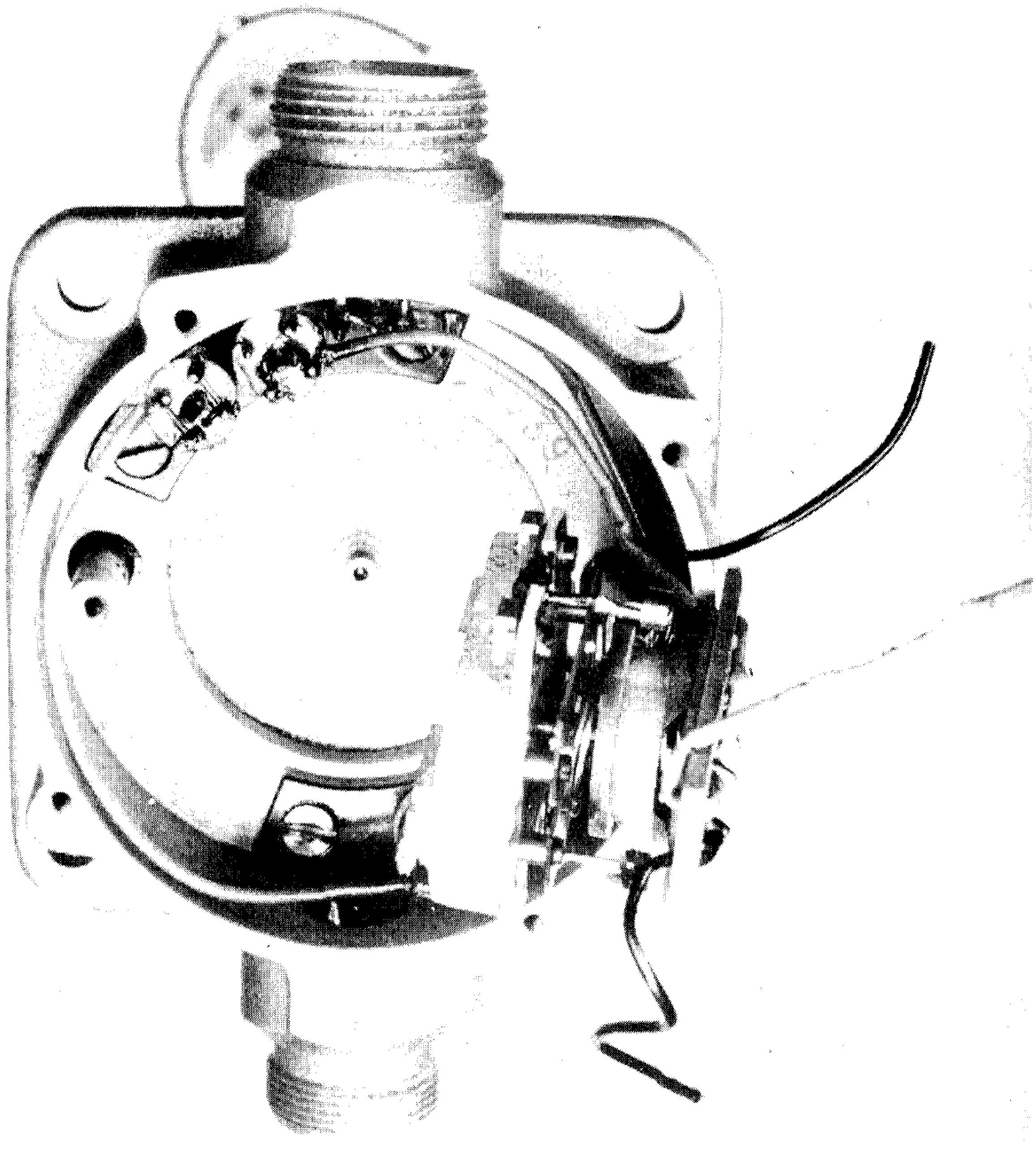
no change in friction

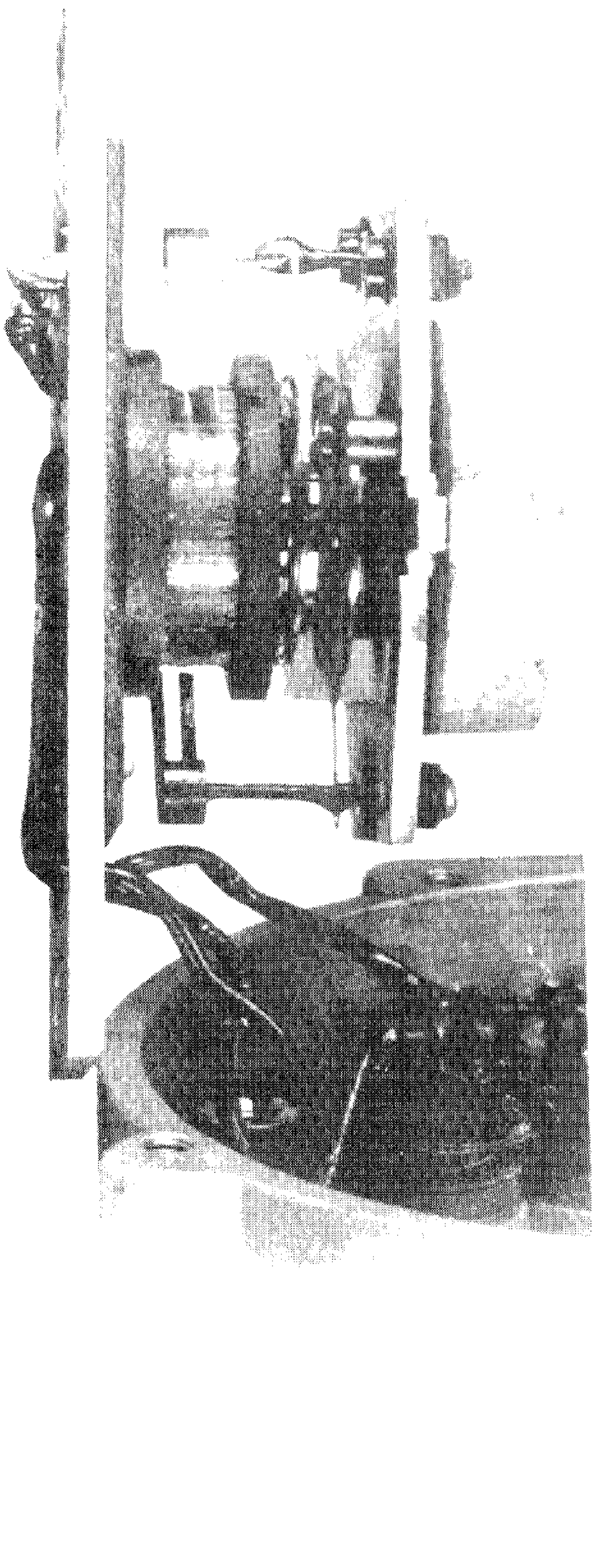
-40°C – bearing clearance nearly zero

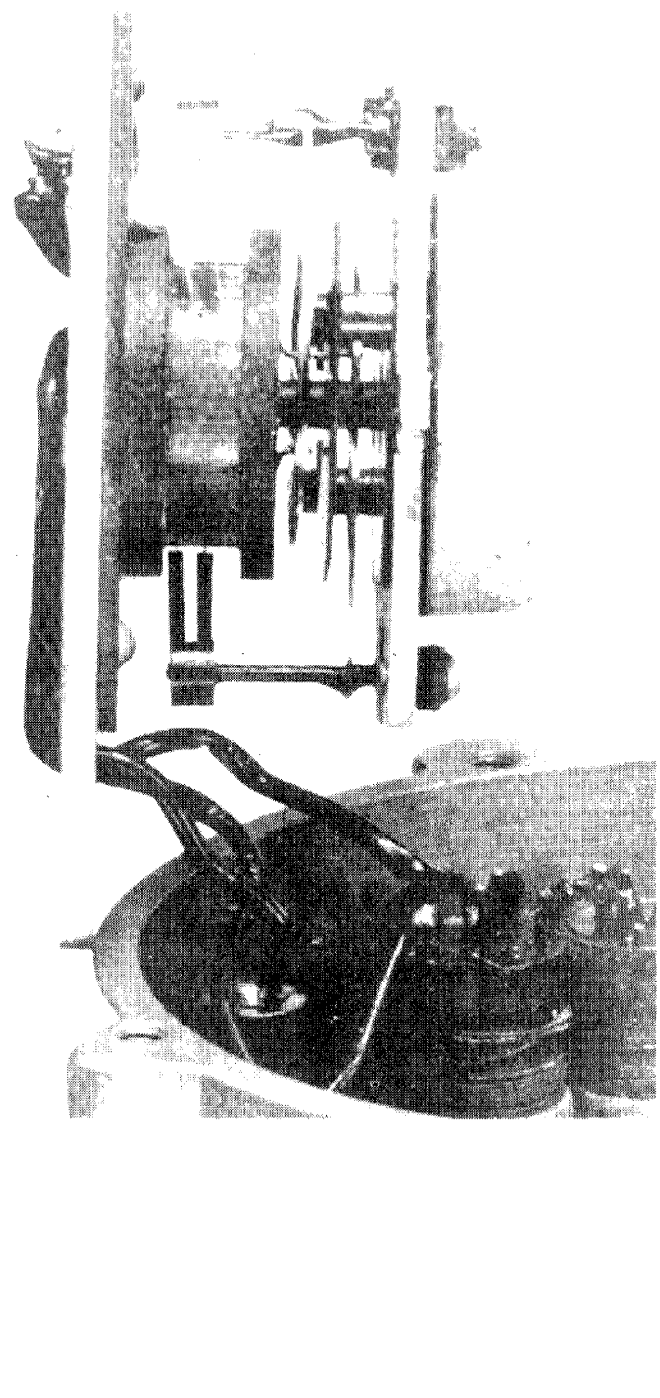
slight increase in friction

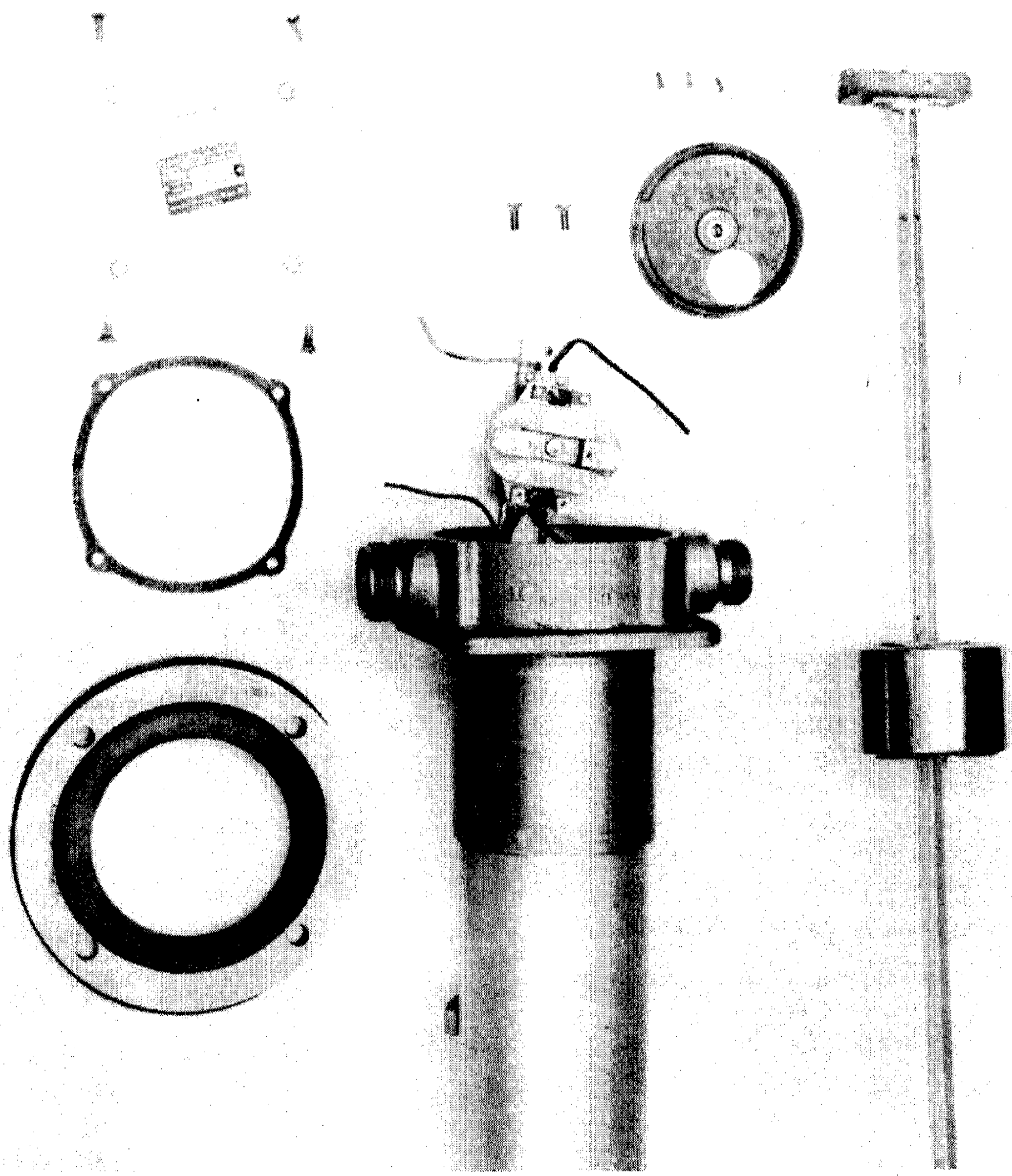


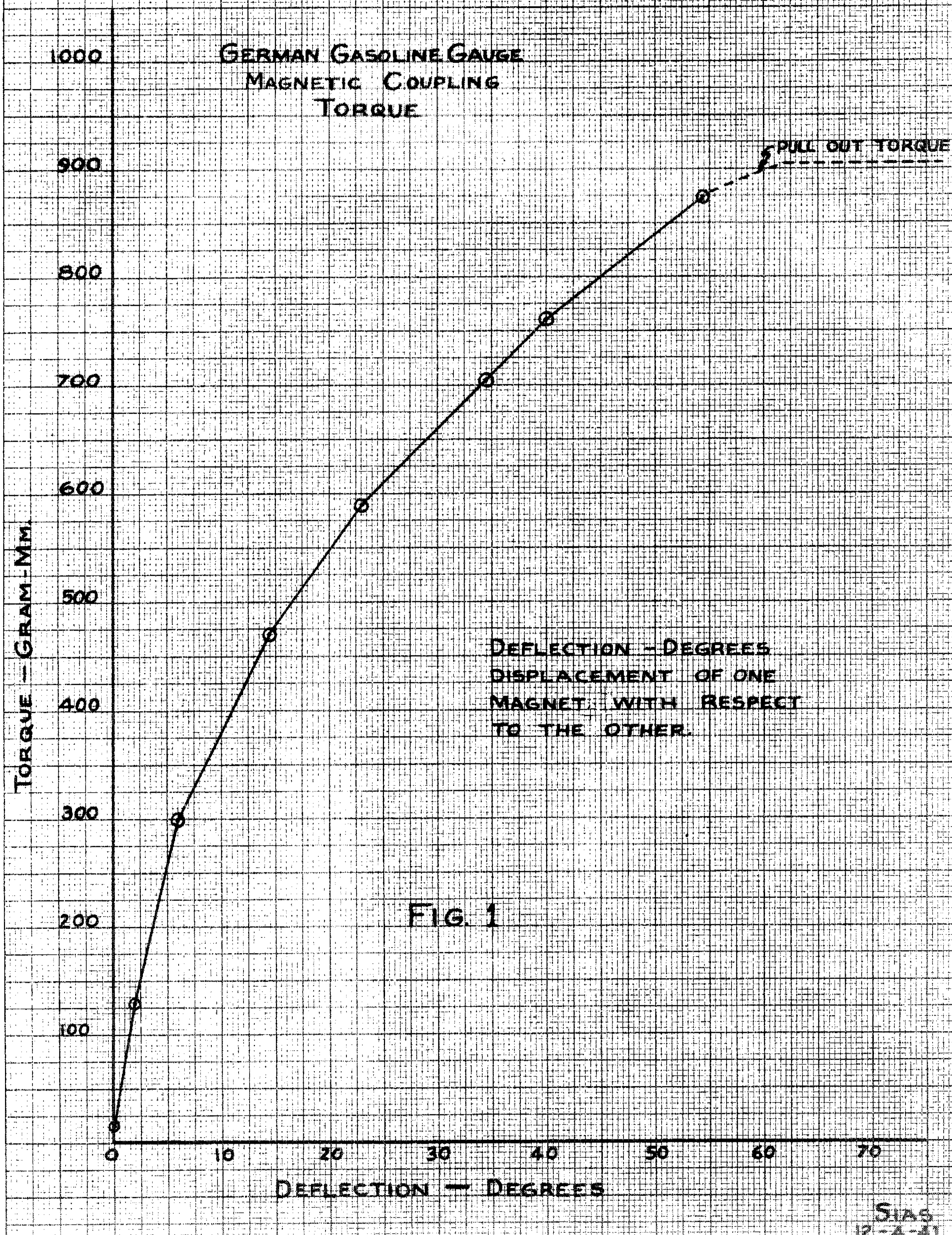






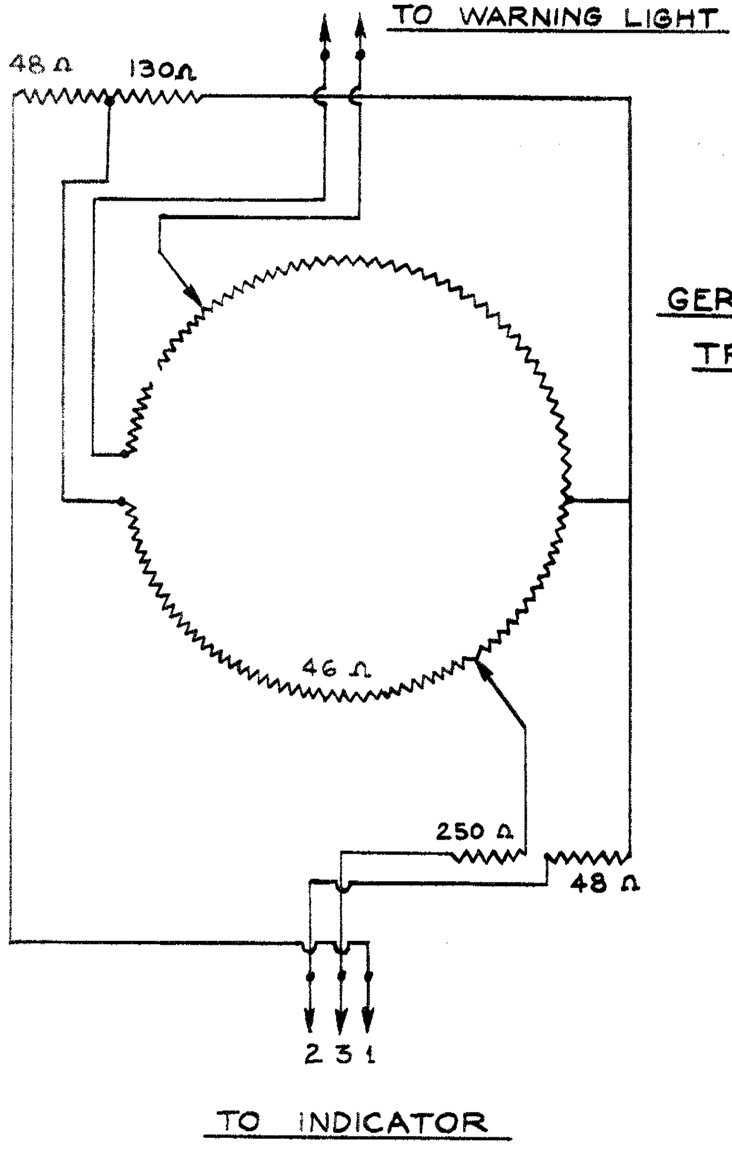






German Gasoline Gauge
Magnetic Coupling
Torque
Pull out torque
Deflection – Degrees
Displacement of one
Magnet with Respect
to the other.
Torque – Gram-Mm.
1000
900
800
700
600
500
400
300
200
100
0
10
20
30
40
50
60
70
Deflection — Degrees
Sias
12-4-41

Fig. 1



GERMAN GASOLINE GAUGE TRANSMITTER CONNECTIONS

FIG. 2

GERMAN ACCESSORIES

AS USED ON

MERCEDES BENZ "DB-601" INSTALLATIONS

IN

MESSERSCHMITT "109" AND "110" FIGHTERS

Reported By:
Eclipse Aviation Division
Bendix Aviation Corp.
Bendix, New Jersey
U. S. A.

SUMMARY

The accessories described in this report were removed from German aircraft which had been shot down during action over England and shipped to this country by the Royal Air Force.

From all available information, it is quite apparent that this accessory equipment is representative of that used in the latest German planes. If this is true, the American accessory manufacturers are somewhat ahead of the Germans at this time.

It should also be noted that none of this equipment showed signs of either poor materials or workmanship.

Although, as mentioned above, we appear to be ahead of the German accessory industry at this time, many helpful ideas have been brought out by the study of this equipment and we are grateful to both Wright Aeronautical and Vultee for the opportunity to study this equipment which they had obtained from the R. A. F.

STARTERS

The Bosch starter is the German version of the Series 11 and is manufactured under license from Eclipse Aviation.

It is a combination hand and electric inertia type and is quite similar to the Eclipse Series 11 insofar as operation is concerned.

This unit is also somewhat similar to the Eclipse Series 43 starter (however, the Series 43 is combination inertia and direct cranking, while the Bosch unit is purely inertia) in that the fly-wheel is mounted directly on the armature shaft and a brush raising device is incorporated in the motor to relieve pressure while cranking by hand. The brush raising mechanism actually lifts the brushes off the commutator by rotating the brush board, whereas, in the Series 43 starter, the brush spring pressure is relieved but the brushes may drag on the commutator. A special brush is used in the German starter, having a bridge over the top such that a small arm located under the bridge acts to lift the brush clear off the commutator.

The meshing solenoid is partially built in the motor somewhat as in the case of the Series 43 starter.

Other interesting features of this starter are as follows:

1) The hand cranking shaft support is externally adjustable so as to line up the hand crank bevel gears by means of a screw action.

2) Neoprene oil seal washers are provided on the meshing rod both before and after the jaw.

3) Instead of doubling the armature poles to convert from 12 to 24 volt operation, the same punchings are used and the armature length is doubled. (This does not seem to indicate a shortage of materials.)

4) Electrical connections are made by means of spring loaded screws which require no lock wire or washers. (This is standard on all German electrical connections.)

VACUUM PUMP TEST DATA

Weights		Dimensions
Complete	2 lbs. 13 oz.	**Rotor**
Rotor	219.5 grams	Dia. 1.7238"
Body	301.1 "	L. 3.342"
Sealing Ring	26.0 "	Vane Slots
4 Vanes	5.6 "	W. 0.042
Base	292.7 "	Depth 33/64
Shaft Assy	140.2 "	Oil holes-0.040" dia.
Oil Cover	29.2 "	Body to Rotor 0.003"
Bearing	22.2 "	**Body**
Oil Filler Screw	7.2 "	Dia. Drive 1.969, Mid. 1.9694, Opp. Drive 1.969
Gasket	0.3 "	Length 3.586
Inlet Air Screen	2.7 "	**Sealing Ring**
Inlet Port	91.05 "	Thick: 0.2367
Outlet Port	76.0 "	4 Vanes
Misc. Screws, Etc.	56.0 "	L: 3.347 to 3.3489
		W: 0.487 to 0.493
		T: 0.039 to 0.0405
		Eccentricity
		0.1195"

CAPACITY RUN

Pump allowed to level out four minutes for each setting

Speed	Inlet Suction	Outlet Press	Body Temp.	Air Out	Room Temp.	Rise	Dyn. Load	H.P. Cons.	Air Flow
R/Min.	"Hg.	" Hg.	°F	°F	°F	°F	#	H.P.	C.F.M.
1500	6.0	1.0	100	95	78	17	0.05	.019	1.49
"	6.0	4.0	114	107	78	29	0.10	.038	1.3
2250	6.0	1.0	114	117	78	39	0.10	.056	3.3
"	6.0	4.0	120	125	79	44	0.10	.056	3.37
3000	6.0	1.0	122	126	79	47	0.10	.075	5.09
"	6.0	4.0	127	132	80	52	0.15	.115	4.68
3750	6.0	1.0	127	128	80	48	0.15	.141	6.52
"	6.0	4.0	133	137	80	57	0.20	.187	6.26
4500	6.0	1.0	136	135	80	55	0.20	.225	7.9
"	6.0	4.0	140	143	80	63	0.25	.281	7.7
5280	6.0	1.0	140	139	80	59	0.20	.261	9.38
"	6.0	4.0	148	159	80	79	0.25	.330	8.95
5960	6.0	1.0	149	146	81	65	0.40	.595	10.5
"	6.0	4.0	156	156	82	73	0.45	.654	10.4

GENERATOR

The Bosch generator is a conventional four pole wave wound shunt unit rated at 30 volts, 50 amperes, with a speed range of from 4000 to 6000 RPM, and blast cooled with thirty liters of air per second.

Electrically, it is quite in line with American generator practice with the exception of its speed range which comes between the two domestic ranges.

There are, however, several mechanical features of this generator which differ from current domestic designs.

The most outstanding of these features is the method of retaining armature windings. Instead of banding the armature conductors, the conventional Bosch construction using hairpin conductors is used. These conductors are threaded in from the tail end and the armature punching at both ends and the center have holes rather than slots automatically providing banding. This method is quite satisfactory so far as operation is concerned but it is believed that assembly would be more complicated than is desirable.

The armature balance is obtained by milling slots in the punchings parallel to the conductors.

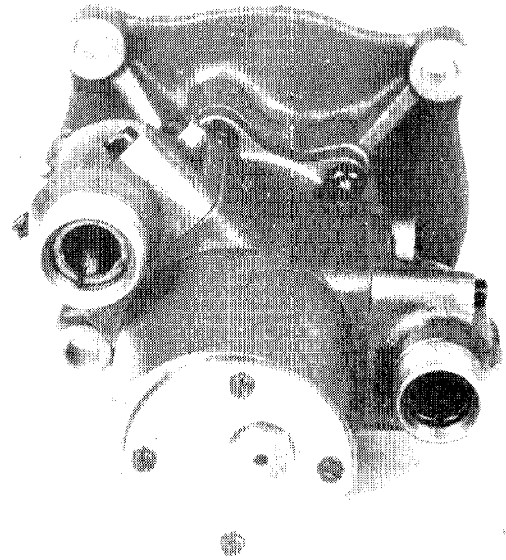
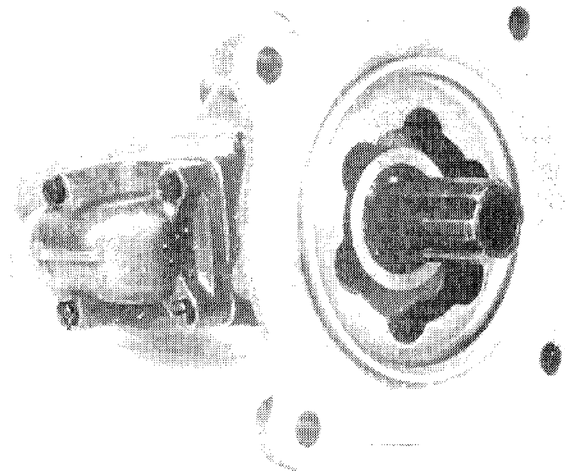
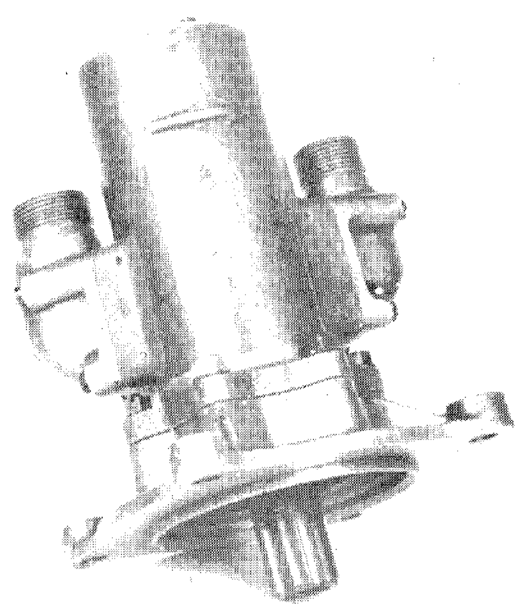
A rotatable arrow in the yoke is used to designate rotation.

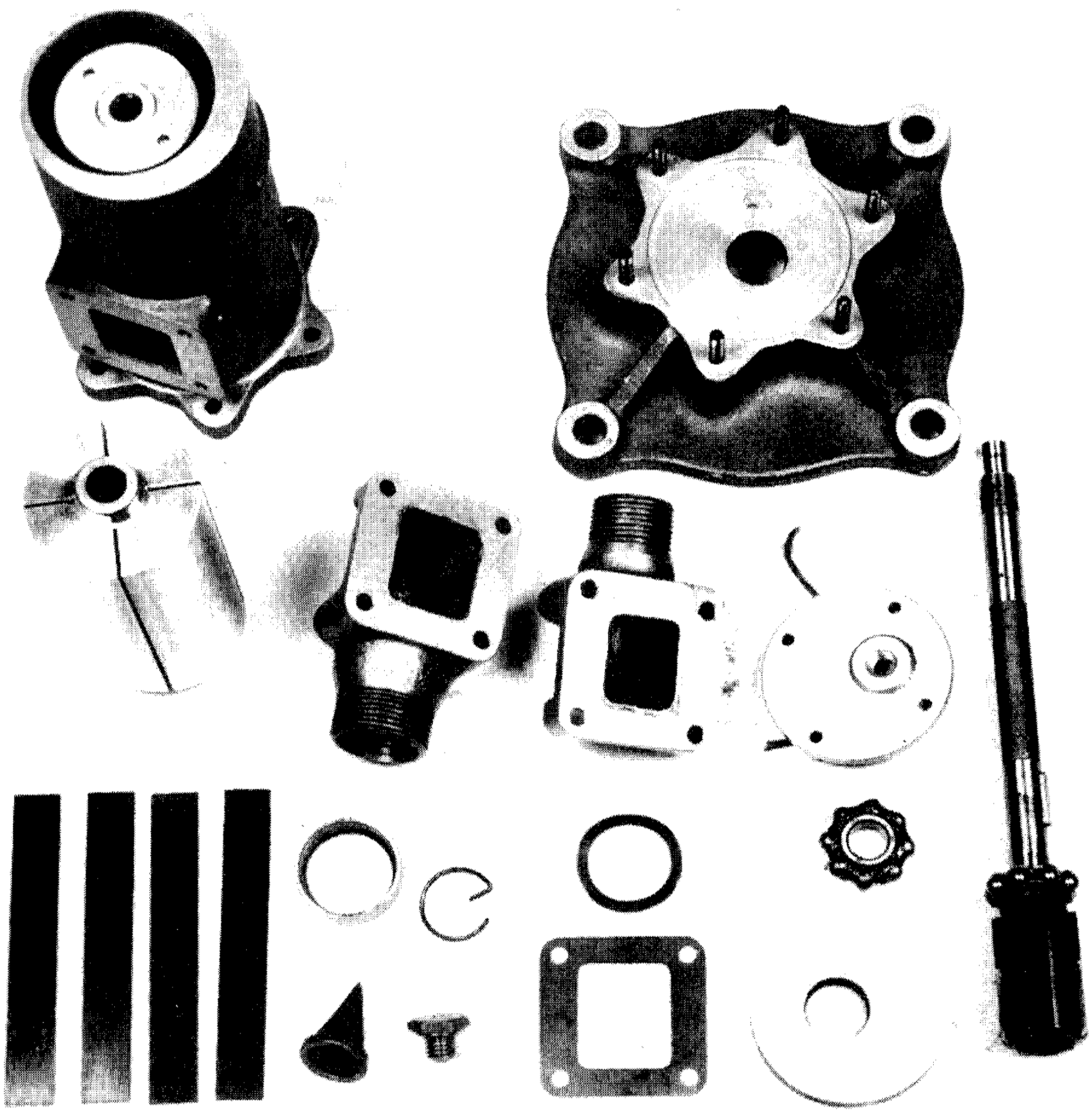
The ball bearings are retained by plates which must be centered and fastened after assembly.

Cooling is obtained by air blast and no fan is used.

A pencil drive shaft, quite similar to recent domestic generators, is used. This type shaft extends through the hollow armature shaft and drives the armature on the commutator end. Its main purpose is to compensate misalignment between the engine drive and generator.

The attached sheets show several views of the generator and component parts as well as data obtained from the test of two generators.



BOSCH GENERATOR DATA

Generator No. 1 - Removed from Mercedes Benz DB-601 engine (Messerschmitt 109 installation) and submitted by Wright Aeronautical Corporation for inspection and test.

Name Plate Data

Gerat	126 - 516D	LK	1200/24 CR10
FL	34215 - 1	Syst.	24V
Werk-NR.	32604	11.3 Kg. N Max. 1500 W-beiU30V	
J Max.	50A		
U/Min.	Min. 4000 Max. 6000	Zugeherig Regherkasten SSM72/1Z	
Kuhlung	30 l/sec.		

Weight	24 lbs. 7 oz.	Armature	57 slots, 57 bars
Rotation	C.C. on Commutator End	O.D.	3.265
		Fields	4 Poles Connected Series
Gap	.0165"	M.L. 3 17/32" I.D. 3.298"	

Field Resistance: 15.35 OHMS at Yoke Temp. of 28.5° C.
17.43 " " " " " 56° C.

Drops at 50 Amps. Cold

Total	3.7V
Arm. & Br.	3.5V
Arm.	2.55V
Brushes	0.95V

GENERATOR TEST RUNS

1. No Load Saturation

R. P. M.	E_T	E_F	I_F	Yoke T. (°C)
4000	8.3	3.3	0.2	34
"	11.9	4.6	0.3	34.5
"	15.8	6.4	0.4	35
"	19.4	8.1	0.5	35
"	22.8	10.0	0.6	35
"	25.3	11.4	0.7	36
"	26.5	12.3	0.75	37
"	27.4	13.0	0.8	37.5
"	28.5	14.0	0.85	38
"	29.5	14.9	0.9	39
"	31.0	16.8	1.0	41
"	32.5	18.5	1.1	42
"	33.4	20.5	1.2	42.5
"	36.0	25.6	1.5	45
"	36.6	27.4	1.6	46
"	37.3	29.4	1.7	46.5
"	37.8	31	1.8	47
"	38.4	33.4	1.9	48
"	38.6	35	2.0	49
"	39.6	39	2.2	49.5
"	40.5	44	2.45	50.5

2. Full Load Saturation

R. P. M.	E_T	I_L	E_F	I_F	Yoke T.
4000	11.2	50	8.7	0.52	41
"	14.2	"	10.0	0.6	42
"	17.5	"	11.8	0.7	43
"	19.8	"	13.6	0.8	44
"	21.9	"	15.5	0.9	45
"	23.6	"	17.3	1.0	46
"	25.3	"	19.0	1.1	48.5
"	27.4	"	20.9	1.2	51
"	28.5	"	23.0	1.3	52
"	29.5	"	24.7	1.4	54 Shut Down
"	31.1	"	26.1	1.5	50
"	32.0	"	28.0	1.6	51
"	32.7	"	30.0	1.7	53
"	33.0	"	32.0	1.8	54
"	33.6	"	34.5	1.9	56
"	34.0	"	36.7	2.0	57
"	34.6	"	39.0	2.1	59

3. Minimum Speed - Cold

R. P. M.	E_T	I_L	E_F	I_F	Yoke T (°C)
3480	28.5	50	28.3	1.77	31
3340	"	25	28.4	1.72	34
3110	"	0	28.4	1.70	36

4. Heat Run

Time (Min.)	R. P. M.	E_T	I_L	E_F	I_F	Yoke T	Ambient
0	4000	28.5	50	21.0	1.3	33	30

(cont'd.)

Time (Min.)	R. P. M.	E_T	I_L	E_F	I_F	Yoke T	Ambient
5	4000	28.5	50	21.8	1.28	41.5	30
10	"	"	"	23.5	1.28	52.5	"
15	"	"	"	24.9	1.28	64.5	"
19	"	"	"	25.5	1.28	74.0	"

Shut down because commutator bearing ran very hot. Nothing apparently wrong with it. Heat run under no forced cooling per requirement on cover. Commutator end left open.

Generator No. 2 - Removed from Mercedes Benz DB-601 Engine (Messerschmitt 110 installation) and submitted by Vultee Aircraft Corporation for inspection and test.

Name Plate Data

Gerat	126 - 516D	System	24V	Wt. 11.3 kg.
	Fl 34215-1	Watts	1500	30V
	Werk-NR.-60349	J Max.	50A	
	LK 1200/24 CR10	U/Min.	Min. 4000 Max. 6000	
	Kuhlung - 30 L/Sec.	ZUGEBORIG REGLERKASTEN SSM 72/12		

Wt.	24 lbs. 7 oz.	Armature 57 slots - 57 bars
Rot.	C.C. on Commutator End.	O.D. 3.265
Gap	0.0165"	Field - 4 Poles connected series M/L 3 17/32" I.D. 3.298"

Field Resistance at 27 °C : 14.63 OHMS

1. Cold Minimum Speed

R. P. M.	E_{DC}	E_F	I_F	I_L	Yoke (°C)
3120	28.5	28.5	1.82	0	31
3480	28.5	28.5	1.77	25	36
3680	28.5	28.5	1.74	50	37

a) Current limitator cut in at 47 Amps.

b) Main switch closed at 25.9 Volts.

3) With current limitator functioning, regulator had about 0.3 Volt droop at 4000 RPM between no load and full load.

2. Cold Regulation - (Current Limitator blocked out)

R. P. M.	E_{DC}	E_F	I_F	I_{DC}	Yoke (°C)
4000	28.5	14.3	0.90	0	
"	29.1	19.0	1.19	25	36
"	29.3	22.0	1.38	50	"
"	28.2	13.7	0.85	0	"
5000	28.3	9.4	0.58	0	"
"	28.9	11.6	0.73	25	"
"	29.3	16.1	1.01	50	"
"	28.3	9.3	0.56	0	"
6000	28.4	7.2	0.43	0	"
"	29.1	9.6	0.59	25	"
"	29.5	13.3	0.82	50	"
"	28.4	7.1	0.41	0	"
4000	28.0	13.7	0.84	0	50

3. Heat Run

Operation on heat run erratic - Variation as much as one Volt Hot field resistance - 17.7 OHMS Field Temp. Rise - 56°C

Time	RPM	E_{DC}	I_{DC}	E_F	I_F	Temps (°C) Yoke	Air In	Air Out
0	4000	29.4	50	24.5	1.58	34	33	33
5	"	29.1	"	23.9	1.49	44	"	36
10	"	29.5	"	24.3	1.42	56	"	38
15	"	29.5	"	25.6	1.48	63	"	39
20	"	29.7	"	26.4	1.49	68	"	39
25	"	29.7	"	25.8	1.44	71	"	40
30	"	29.7	"	25.6	1.42	74	"	40
40	"	29.8	"	27.4	1.50	77	"	41
50	"	29.7	"	27.8	1.52	78	"	42
60	"	29.8	"	27.6	1.51	79	"	42

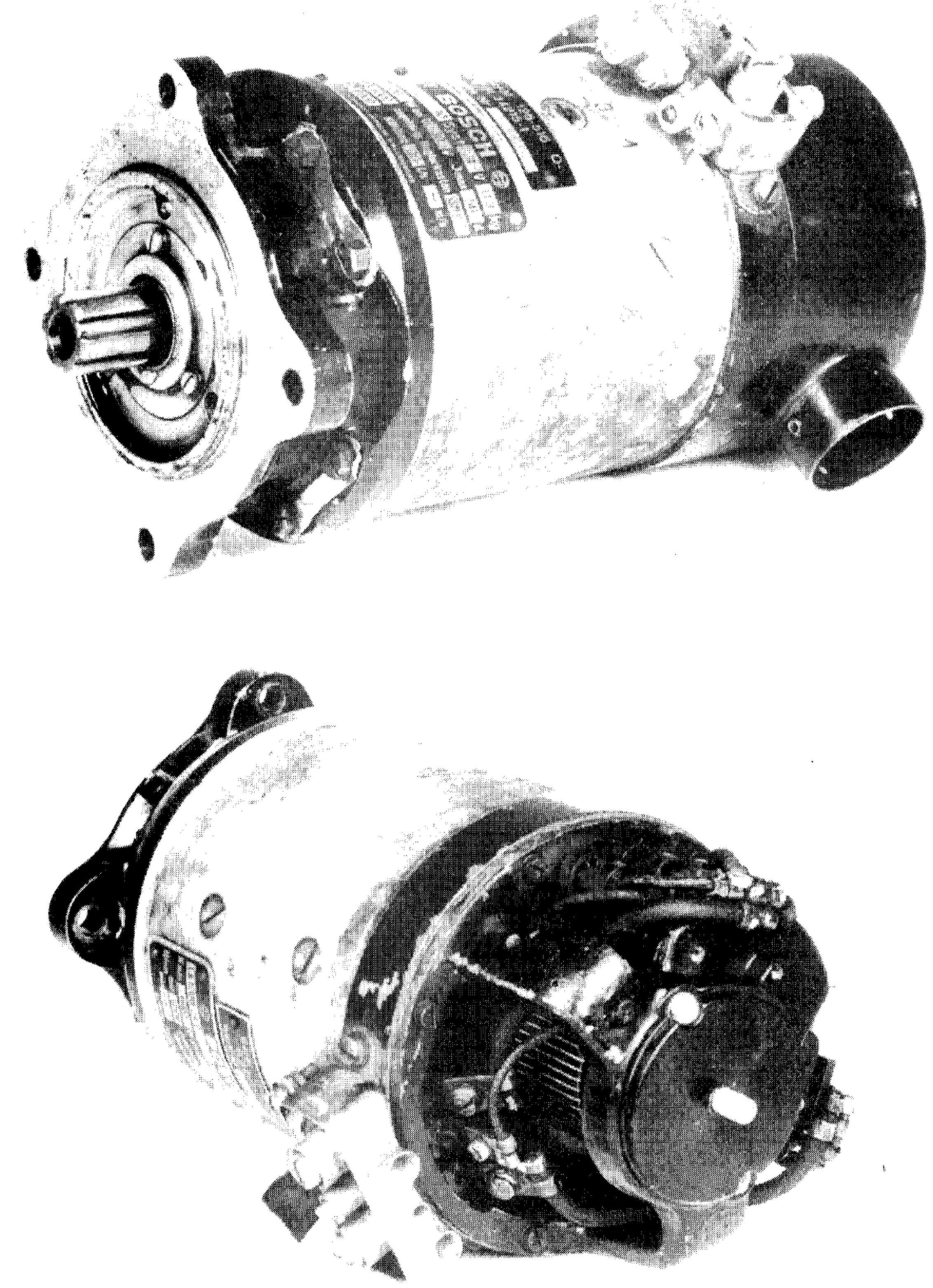
4. Hot Minimum Speeds

RPM	E_{DC}	E_F	I_{DC}	I_F	Yoke (°C)
3230	28.5	28.5	0	1.52	79
3540	"	"	25	1.51	79
3890	"	"	50	1.51	78

5. Hot Regulation

RPM	E_{DC}	E_F	I_{DC}	I_F	Yoke (°C)
4000	28.2	15.2	0	0.82	74.5
"	28.7	20.7	25	1.13	"

RPM	E_{DC}	E_F	I_{DC}	I_F	Yoke (°C)
4000	29.4	28.0	50	1.53	74.5
"	28.0	15.2	0	0.82	"
5000	28.1	10.0	0	0.54	74.5
"	28.7	13.2	25	0.72	74.5
"	28.9	17.8	50	0.98	74.5
"	27.9	10.1	0	0.54	74.5
6000	28.1	8.0	0	0.42	75.0
"	28.5	10.6	25	0.58	75.5
"	29.0	15.0	50	0.83	75.5
"	27.8	7.8	0	0.42	75.5
4000	27.8	14.5	0	0.79	75.5
"	29.0	24.7	50	1.37	75.5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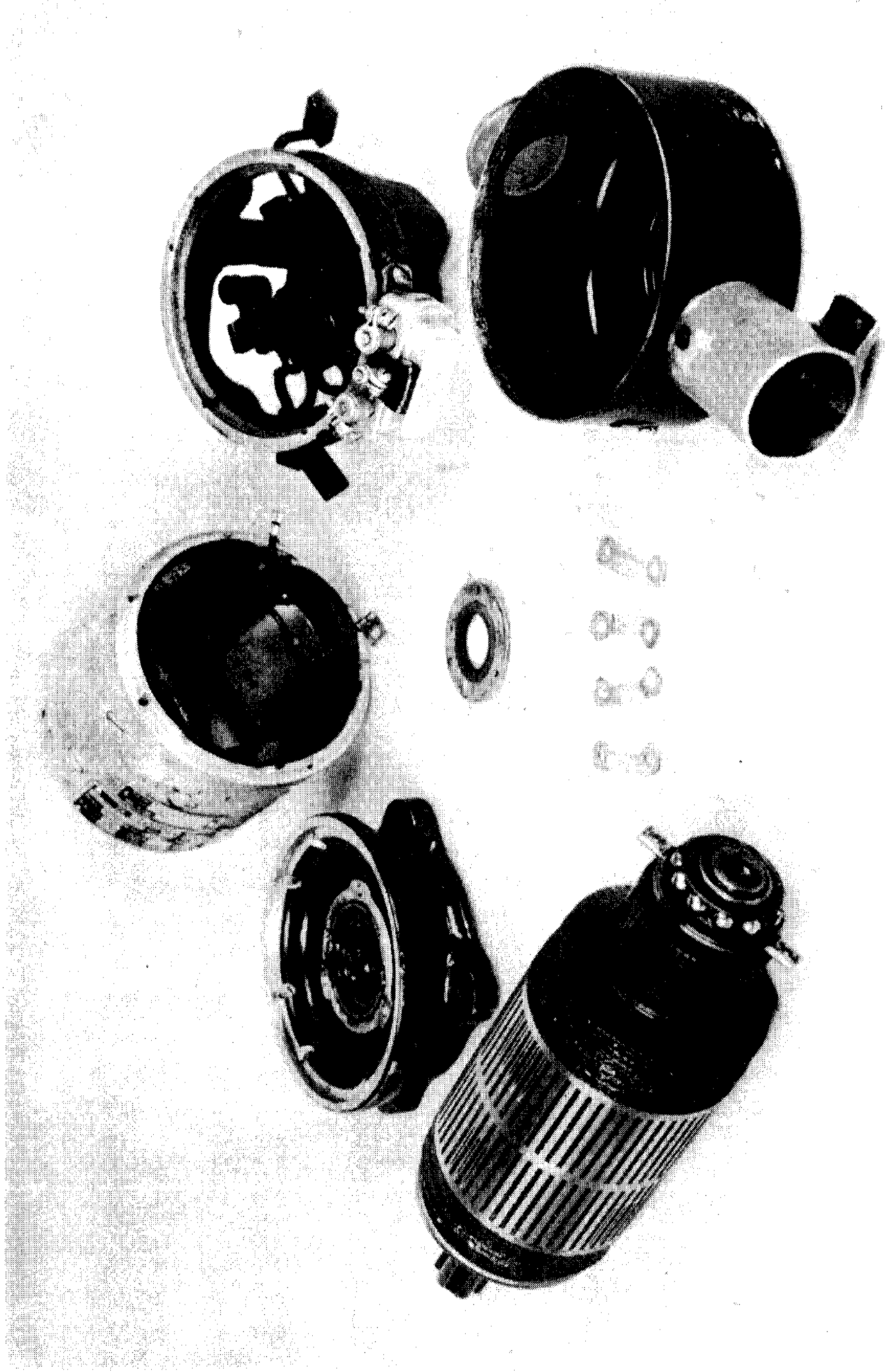
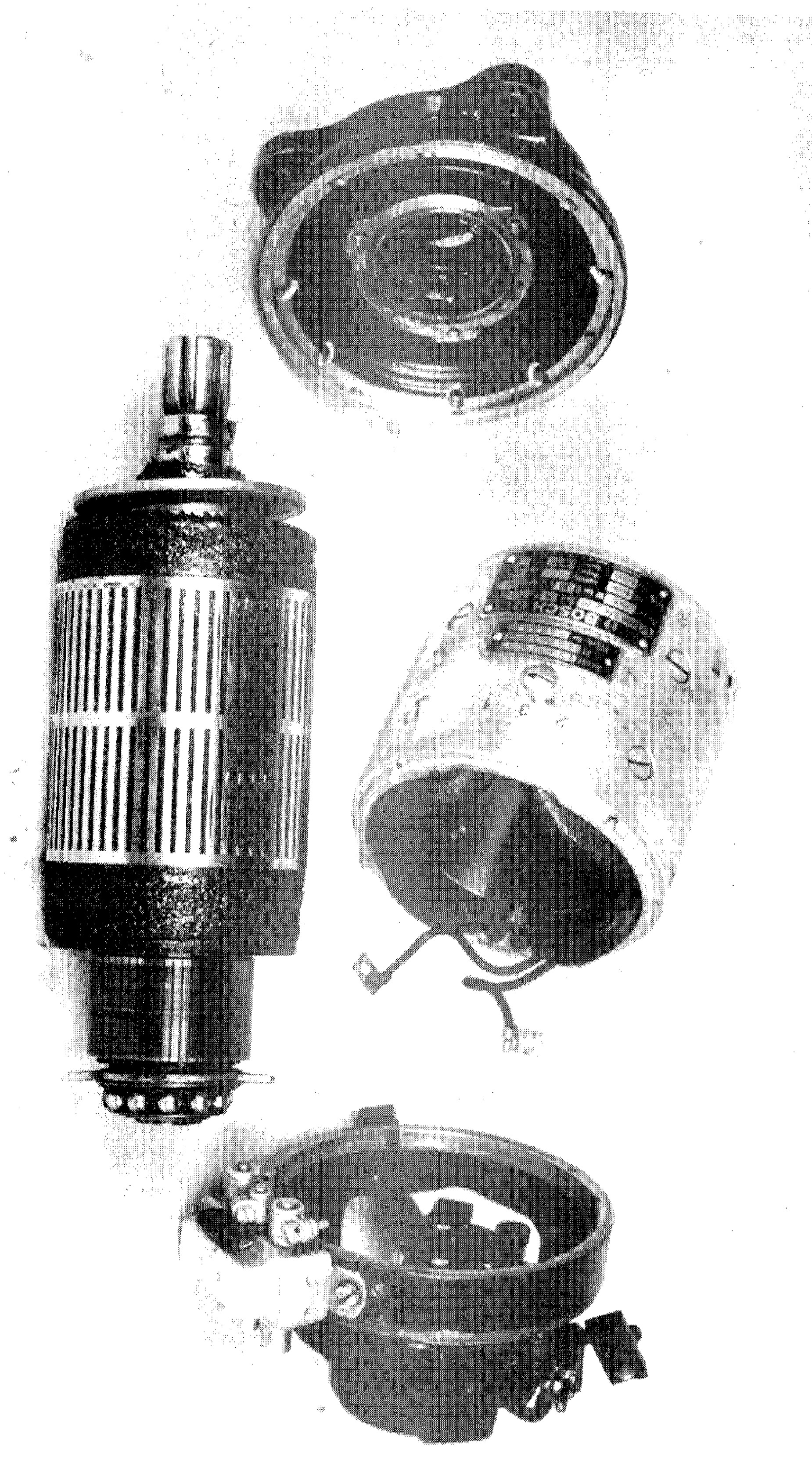
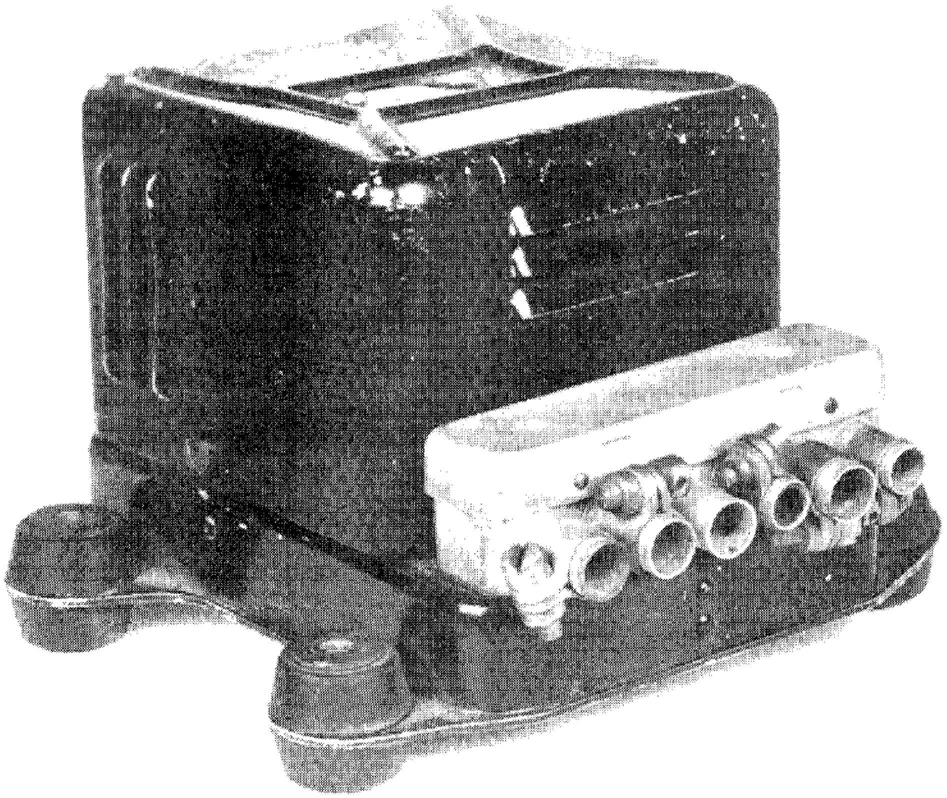


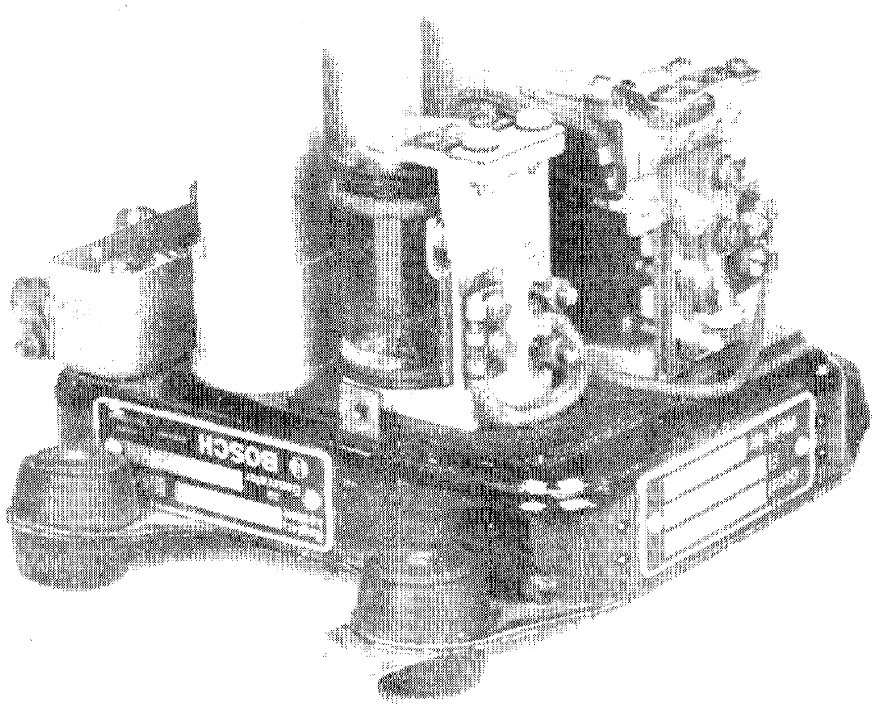


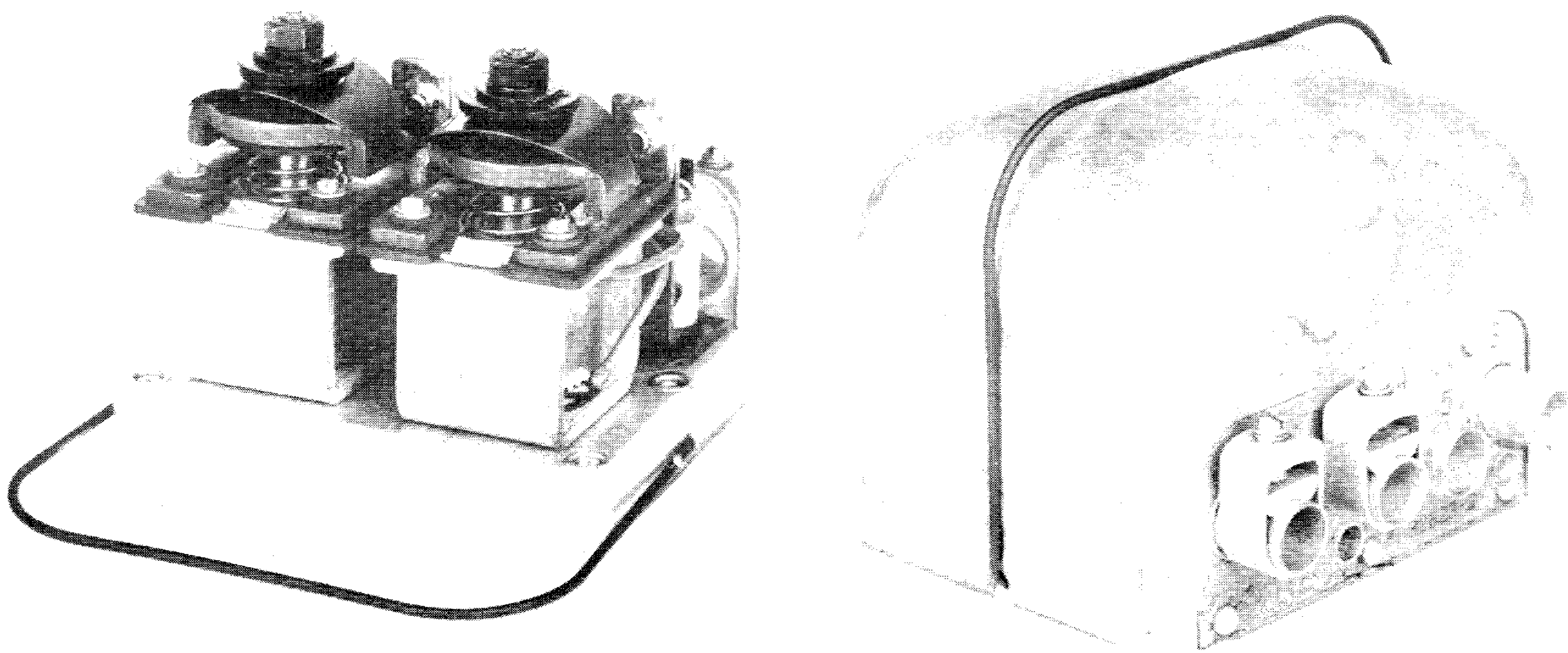
GENERATOR CONTROL BOX

The Bosch control box consists of a voltage regulator, current limiter, and reverse current relay. The voltage regulator is of the conventional tirrill type. The current limiter and reverse current relay are combined on the same magnetic circuit. There are two separate armatures on this part. When the current through the series coil exceeds the value to which the limiter is adjusted, one armature pulls down and introduces resistance on the generator field, thereby reducing the voltage as in current limiters of the conventional American design.

The weight of this unit is 2 1/4 lbs. complete. Test data of the control box is incorporated with the generator test data herein contained.




BOSCH



NOISE FILTER

The Bosch noise filter consists of two choke coils and two non-inductive wound condensers. One condenser and one choke coil are connected in each side of the generator line in an "inverted L" section.

SOLENOID SWITCHES

The Bosch solenoid switch unit for starters consists of two switches - apparently one for each side of the line. In this way, on two wire shielded systems as used on this ship, both sides of the line are isolated and radio interference is eliminated when the switches are open.

The complete weight of this solenoid switch unit is 1-1/2 lbs.

This switch can be used only with inertia starters as the movable contact removes metal from the stationary contact when opening two hundred amperes at 24 volts.

From the standpoint of standardization this solenoid switch would not be satisfactory in this country as it can not be used on direct cranking or combination inertia and direct cranking starters - the latter being the most widely accepted type starter for modern military aircraft.

The accompanying pages include pictures and test data obtained at Eclipse Aviation.

TEST DATA FROM BOSCH SOLENOID SWITCH

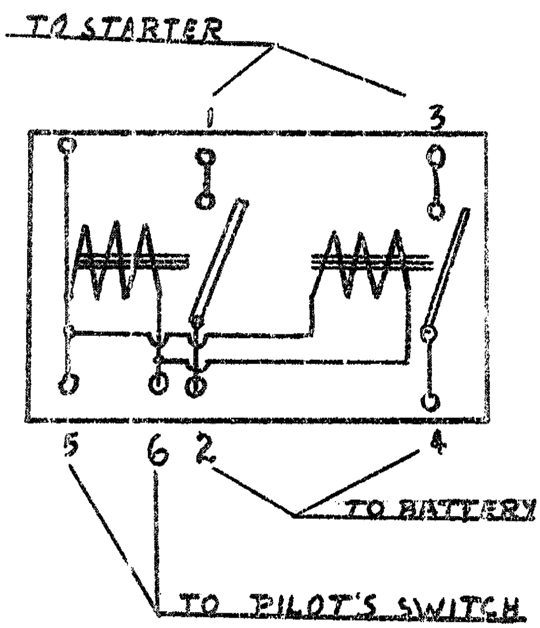


FIG. 1

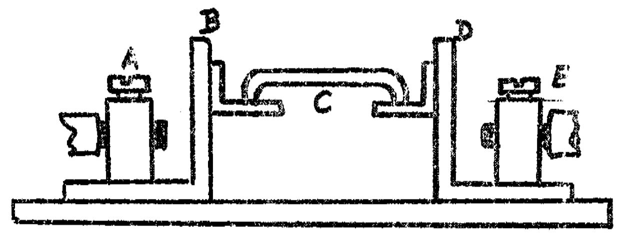


FIG. 2.

Note: Above wiring diagram shows both solenoids connected in parallel (Fig. 1). Therefore, all current readings are for total of both solenoids and each may be assumed to draw 1/2 the total given.

Closing Voltage: 11.4 Closing Current: 2.4 Amps.
Opening Voltage: 1.4 Opening Current: 0.3 "

Lifts at 24 Volts: 3 lbs. 3 oz. from extreme open to extreme close

Opening Force at 24 Volts: 18.5 lbs.
M. V. Drops (Fig. 2)

Switch No.	E_C	I_L	A–B	B–C	C–D	D–E	A–E	B–D
1	24	200	22	50	30	22	108	58
2	24	200	20	42	25	15	100	51

APPENDIX 7

LANDING GEAR SHOCK ABSORBERS

Prepared by

UNITED AIRCRAFT PRODUCTS, INC.

LOS ANGELES, CALIF.

MAIN GEAR SHOCK STRUT

MESSERSCHMITT ME-110

The main gear shock strut is of the common air-oil type, but incorporates many unusual features.

The strut contains a metering orifice device which is very unique as well as complicated, compared to the usual metering pin and orifice hole used in the United States. This device consists of a metering sleeve which fits inside of the piston tube and is held in place by the upper bearing. This sleeve has several slots of varying length and shape running longitudinally and cut through the sleeve wall. The piston tube and sleeve slide over an orifice piston with closed lower end which is attached rigidly at its upper end to the outer cylinder. A piston ring in the lower end of the orifice piston insures a close fit between orifice piston and metering sleeve. As the strut is compressed, the oil must flow through the slots in the metering sleeve to get into the upper chamber. The effective orifice area at any instant is determined by the position of the piston ring with respect to the sleeve and is the sum of the cross-sectional areas of the slots opposite the piston ring.

There is an additional snubbing device to absorb a portion of the rebound energy. During the compression stroke, oil flows readily past the upper flange of the upper bearing. This flange has considerable clearance between its outside diameter and the inside diameter of the outer cylinder, which allows oil to flow by rather freely during the compression stroke. The oil then flows through several holes in the lower portion of the bearing to fill the space between the piston tube and the outer cylinder. During rebound, the piston ring mounted on the upper bearing slides back against the upper bearing flange, thereby restricting the oil flow around the upper flange and forcing it through three small holes located in the upper flange.

The method used in filling the strut with oil is somewhat uncertain. It appears, however, that the strut is filled while in the fully-extended position by removing the air valve assembly and filling the strut with oil through this port, possibly using a special fitting screwed into the strut in place of the air valve. During filling, the plug in the end of the air bleeder valve is loosened so as to allow the trapped air to escape. The oil will then fill the strut until the oil level reaches the lower end of the oil level control tube, after which no more air will escape and any additional oil will rise in this tube until it eventually runs out of the bleeder valve fitting. Details of the filler plug and air valve are shown in the drawing of the strut.

The air valve is somewhat similar in operation to our standard Schrader-type valve. However, in case the valve develops a leak, the entire assembly must be replaced instead of replacing an inexpensive valve core, as can be done with the Schrader-type valve.

The packing is of unusual design. It consists of alternate leather and synthetic rubber-cord packing washers with adapters at each end of the stack to support the washers in the proper position. The angle of the washer surface with respect to the central axis is 45°. This type of packing probably only seals efficiently along the edge which is nearest the source of pressure; hence, two sets of packing must be used to seal the surfaces which are in contact with the inside and outside diameters of the packing. This probably accounts for the arrangement of packing shown on the drawing. When the gear is fully extended, the force tending to push the piston out of the strut is entirely supported by the packing, which is not considered good practice in this country. This type of packing has commercial applications in this country, but is not acceptable for air corps shock struts.

The torque links are quite conventional except for the bushings used at the apex of the links. The outer ends of the bronze bushings are finished to a spherical radius which fits a steel mating adapter ground internally to the same spherical radius. There is considerable clearance between the inside diameter of the bushings and the body of the apex bolt, which allows some rotation in any direction between the spherical surfaces, thereby correcting for a fair amount of misalignment at the bolts connecting torque links to the strut. This arrangement is quite unique and has a definite advantage.

The grease fittings used are very similar to those commonly used in this country.

Another unique feature is the self-aligning bushing used quite extensively for the connection of various parts to avoid line reaming. The outer race is pressed into the fitting. It has an internal spherically-ground surface. There are two slots cut in the outer race so that the inner race, which has a spherically-ground outer surface, may be inserted edgewise and rotated 90° to lock it in place within the outer race. In this position, the bushing is free to align itself properly with connecting members.

The manufacture of this strut is unnecessarily complicated and expensive. One example is the metering sleeve which has been previously mentioned. The use of a metering pin would have been much simpler. It would have been a great deal simpler to use a steel tube for an outer cylinder with necessary lugs and bosses welded in place, rather than use a solid forging and bore out all the material in the middle, as is the case in this strut. The piston tube was apparently made by boring a solid bar from both ends to leave a transverse wall across the interior to serve as an oil seal. The use of a straight tube with separate plug welded in place or held by other means would be much cheaper and better from a production standpoint. This strut has very little welding on it, and then only at points apparently subject to very low stresses.

This strut is connected to the airplane at four points. The upper end has a number of teeth cut, as shown in the drawing, which mate with a similar set of teeth in a cross arm running in the spanwise direction and connected to fittings on the wing spar. These teeth transmit all torque from the gear to the wing structure. These teeth also take a portion of the side and drag loads. Vertical loads, as well as the remainder of the side-and-drag components, are taken at the lugs mounted on the outer cylinder. The lug containing the self-aligning bushing is connected to the retracting strut.

The piston tube and axle are plated with what appears to be a very thin layer of hard chrome.

In general, the workmanship is very good, and hone and grind dimensions are very uniform. Bearing fits and the like appear good.

TAIL WHEEL SHOCK STRUT

MESSERSCHMITT ME-110

The tail wheel gear is made up of two main elements. These are (1) a shock-absorbing unit and (2) a centering mechanism. These two elements are contained in one housing, as may be seen in the assembly drawing of the strut.

The shock-absorbing unit consists of two steel springs, one inside of the other, and an oil snubbing device. The shock load of landing and taxiing is taken by the springs in compression. There are three holes drilled through the fixed or upper centering cam, which serve as an oil passage between the main interior space in the strut and the space between the inner cylinder and piston tube. The volume of this last-mentioned space varies with the position of the gear, being a minimum when the gear is fully extended and a maximum when the gear is fully compressed. There is no provision for filling the strut with air under pressure; hence, when the strut is fully extended the air contained in the strut is under atmospheric pressure only, but this pressure increases as the strut is compressed. During the compression stroke, oil is forced through the holes in the centering cam into the space around the piston tube partially by the increase in air pressure due to compression of the strut and partially by suction due to increase in volume of the space around the piston tube. The oil restrictor ring, located in the upper centering cam, moves away from the oil holes until it is restrained by the snap ring. In this position, with the oil restrictor ring free of the oil holes, there is little restriction of flow between the main body of oil and the small body of oil around the piston tube. As the strut extends during rebound, the restrictor ring drops back, covering the oil holes, thereby restricting the return flow of oil and serving to snub the gear by absorbing a portion of the energy stored during compression.

The exact amount of oil used in the strut is not known, as apparently some was removed before the strut was received by United Aircraft Products, Inc.

The small amount of oil found in the strut seemed to contain colloidal graphite.

The centering mechanism consists of a lower floating cam and an upper fixed cam. The floating cam slides within the inner cylinder, but is prevented from rotating with respect to the inner cylinder by an integral key which mates with a longitudinal internal keyway in the inner cylinder. The upper fixed cam is attached rigidly to the piston tube, which in turn is connected rigidly at its upper end to the outer cylinder. The construction of the cam is such that it can only center the gear with the wheel in a trailing position. The centering force is supplied by the compression springs, which act against the lower floating cam and force it into engagement with the upper fixed cam. Any swiveling action of the tail wheel is obtained by additional deflection of the springs, which allows the cams to rotate with respect to each other and partially separate. The gear is not steerable.

There are three bearings. A bronze bearing is attached to the lower inside end of the outer cylinder and supports the inner cylinder. A bronze bearing attached to the upper end of the inner cylinder slides over the piston tube. The upper cam and piston assembly which is attached to the piston tube slides against the inside surface of the inner cylinder.

There is quite a bit of welding used on this assembly as compared with the main shock strut. Mounting lugs and bosses have been welded to the outer cylinder. The tail wheel fork is made by welding formed plates together, as shown on the assembly drawing. This seems to be an expensive procedure for mass production as compared with a forging. This unit apparently is one of the early models and may account for the fabrication methods used.

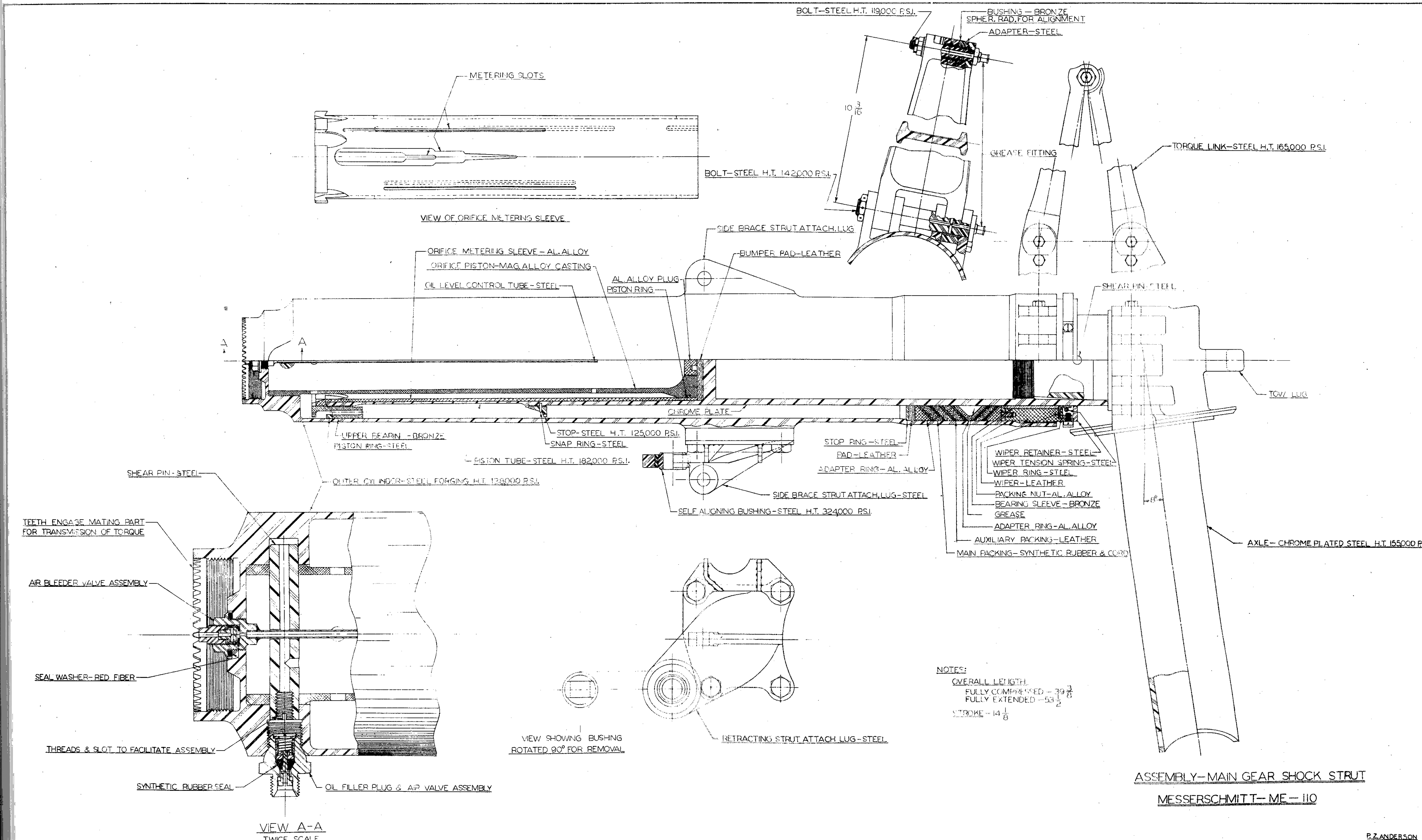
The inner cylinder, which is welded to the tail wheel fork, is chrome-plated. The plating appears to be quite thin. Internal sliding surfaces are ground. On the whole, the workmanship seems to be rather good, with cylinder bores and piston surfaces being very uniform and of good fit.

Thread pitches are often much finer than used in this country. This is sometimes necessary when threads occur in thin-walled tubing.

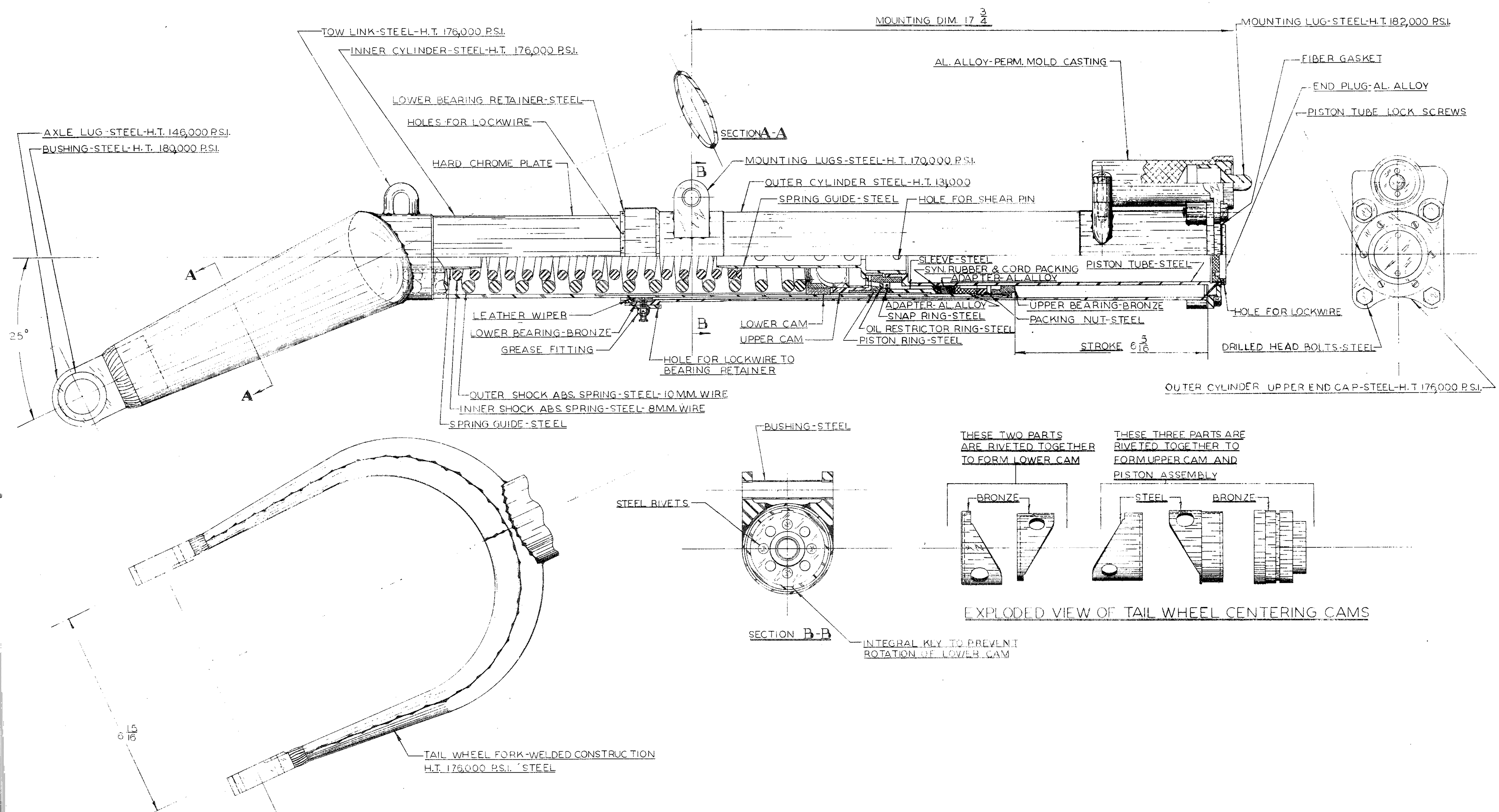
The tail gear is attached to the rear monocoque section of the airplane at two points. The lower lugs take the full axial load of the gear and some of the fore and aft load as well as all torque. An adjustable plug at the upper end takes the remaining fore and aft load. This adjustment feature corrects for any variation in the distance between mounting points in the monocoque section. The casting into which the upper plug screws is rather peculiar. From its shape, it appears to have originally had a different purpose, as there are projections and bosses incorporated in the casting which have no use whatsoever in this application.

The packing is of a pressure-sealing type. The main body of the packing consists of cord impregnated with rubber which probably is synthetic. The inner lip is of solid synthetic bonded to the main body.

In general, this design is not as efficient or modern as tail wheel gears made in this country for similar applications. However, it must be remembered that this design is about four or five years old, and hence this type of design may no longer be in evidence in newer airplanes.



BOLT-STEEL H.T. 119,000 P.S.I.
BUSHING - BRONZE
SPHER. RAD. FOR ALIGNMENT
ADAPTER-STEEL
10 3/16
GREASE FITTING
TORQUE LINK-STEEL H.T. 165,000 P.S.I.
METERING SLOTS
BOLT-STEEL H.T. 142,000 P.S.I.
VIEW OF ORIFICE METERING SLEEVE
SIDE BRACE STRUT ATTACH. LUG
ORIFICE METERING SLEEVE - AL. ALLOY
BUMPER PAD-LEATHER
ORIFICE PISTON-MAG. ALLOY CASTING
AL. ALLOY PLUG
PISTON RING
OIL LEVEL CONTROL TUBE-STEEL
SHEAR PIN-STEEL
A
A
TOW LUG
CHROME PLATE
UPPER BEARING - BRONZE
PISTON RING-STEEL
STOP-STEEL H.T. 125,000 P.S.I.
SNAP RING-STEEL
PISTON TUBE-STEEL H.T. 182,000 P.S.I.
STOP RING-STEEL
PAD-LEATHER
ADAPTER RING-AL. ALLOY
WIPER RETAINER-STEEL
WIPER TENSION SPRING-STEEL
WIPER RING-STEEL
WIPER-LEATHER
PACKING NUT-AL. ALLOY
BEARING SLEEVE-BRONZE
GREASE
ADAPTER RING-AL. ALLOY
AUXILIARY PACKING-LEATHER
MAIN PACKING-SYNTHETIC RUBBER & CORD
SHEAR PIN-STEEL
OUTER CYLINDER-STEEL FORGING H.T. 138,000 P.S.I.
SIDE BRACE STRUT ATTACH. LUG-STEEL
SELF ALIGNING BUSHING-STEEL H.T. 324,000 P.S.I.
AXLE-CHROME PLATED STEEL H.T. 155,000 P.S.I.
TEETH ENGAGE MATING PART
FOR TRANSMISSION OF TORQUE
AIR BLEEDER VALVE ASSEMBLY
SEAL WASHER-RED FIBER
THREADS & SLOT TO FACILITATE ASSEMBLY
SYNTHETIC RUBBER SEAL
OIL FILLER PLUG & AIR VALVE ASSEMBLY
VIEW A-A
TWICE SCALE
VIEW SHOWING BUSHING
ROTATED 90° FOR REMOVAL
RETRACTING STRUT ATTACH LUG-STEEL
NOTES:
OVERALL LENGTH
FULLY COMPRESSED - 39 3/8
FULLY EXTENDED - 53 1/2
STROKE - 14 1/8
ASSEMBLY-MAIN GEAR SHOCK STRUT
MESSERSCHMITT-ME-110
P.Z. ANDERSON



ASSEMBLY-TAIL WHEEL SHOCK STRUT

MESSERSCHMITT - ME-110

R. KLEIN

APPENDIX 8

ME110 MESSERSCHMITT

RADIATOR AND OIL COOLER

Prepared by

AIRESEARCH MANUFACTURING CO.

INGLEWOOD, CALIF.

INTRODUCTION

An oil cooler and an engine coolant radiator removed from the Me-110 at Vultee Aircraft were sent to Airesearch Mfg. Co. for test and examination. Only the coolant radiator was tested as the oil cooler was damaged so badly that repair for test was impossible. The radiator was punctured by a bullet in one place and apparently damaged in landing on the face of the radiator, necessitating blocking off a total of five connected tubes.

ENGINE COOLANT RADIATOR

Method of Testing. A photograph of the test set-up is shown on page 7. The radiator was tested with water heated in an open tank with live steam. The flow of water was weighed by diverting the return flow into a tank by means of a swing pipe.

The air flow was measured by a Pitot tube in a calibrated duct.

Temperatures were measured by means of mercury thermomoters, one each in the inlet water, outlet water, and the inlet air stream. No outlet air temperatures were taken and therefore no heat balance obtained. Similar arrangements, however, on smaller coolers when the exit air temperature was measured after passing through a mixing box gave good heat balance.

The air flow was measured in a 12" duct which joined the radiator through an adapter provided with distributing vanes. The vanes were initially shifted until a uniform air flow was obtained over the entire core face. This position of the vanes also corresponds to the lowest air pressure drop across the core. This pressure drop was measured through small openings on all four sides of the radiator in a straight piece of the adapter four inches upstream from the core.

The water pressure drop was measured at the inlet and outlet to the radiator by means of a calibrated Bourdon gauge.

A copy of the test results is on page 8.

Results. The heat dissipation is shown on Graph PC-72-1 on page 4. It is evident that very little will be gained by increasing the coolant flow above 800 lbs/min., -- the capacity of the pump used during the test.

Coolant pressure drop is shown on Graph PC-72-3 (page 5), the points shown being average readings.

On PC-72-4 (page 6) is shown the cooling air pressure drop and the total pressure at the face of the radiator. The latter is obtained by calculating the velocity pressure for standard air for an area equal to the face area of the radiator and adding this to the pressure drop for standard air. In calculating the pressure drop $^{\circ}\Delta p$ the average pressure and average temperature of the air through the radiator was used.

DESCRIPTION OF COOLANT RADIATOR

Figs. 1 and 2 on page 9 show 3/4 views of the radiator, the entrance and exit of the bullet being clearly visible. Fig. 3 page 10 shows the damge to the face near the top of the picture. Fig. 4 is a 3/4 view of the bottom.

Fig. 5 on page 11 is an end view with the tank removed showing the break in the header plate around inlet and outlet coolant connections and the in-line tube arrangement. Fig. 6 is an inside view of the end tank showing that the tank is divided into two parts with a valve housing being located in the inlet section of the tank. The valve itself was missing.

Fig. 7 on page 12 is an isometric view of the radiator giving dimensions and materials. The following is supplementary:

Fins: Copper - .004" x 6-13/16" wide x 13-1/2" (full length)
.004" x 6-13/16" wide x 8-1/2" (shortest length)

Six heavy brass fins (.012") are distributed evenly across the face (probably to give rigidity).

Tubes: Seamless brass - 3/4" long O.D. x .067" wide O.D.
.008 to .009" wall.

Tube Arrangement: In-line (7 rows)

Tube Spacing: .357" in no-flow direction
1.00" in cooling airflow direction.

Tank Ends: Brass.

Side Plates: Steel, ribbed and spotwelded to tanks.

Photographs show method of support and reinforcement.

Face area: 3.31 sq. ft.

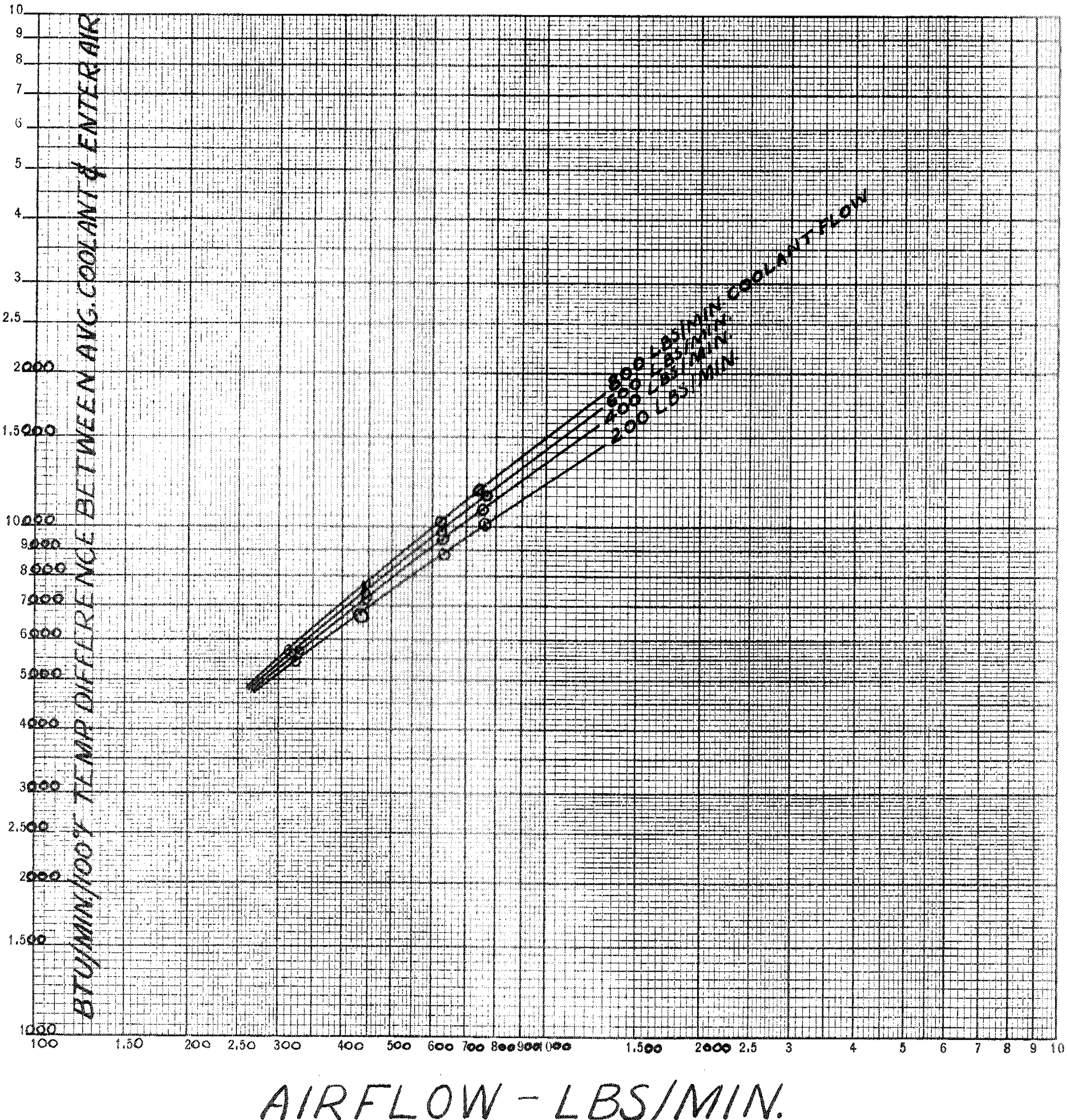
Number of fins: 293 full length
50 11.0" average length

Number of connected tubes: 259

Internal surface of tubes	97.0 sq. ft.
External surface of tubes	100.0 sq. ft.
Net fin surface	372.0 sq. ft.
Total external surface	472.0 sq. ft.
Ratio of external to internal	4.866
Ratio of external to face area	142.5
Weight	135.5 lbs.

MESSERSCHMITT ME-110 RADIATOR

÷ HEAT REJECTION ÷

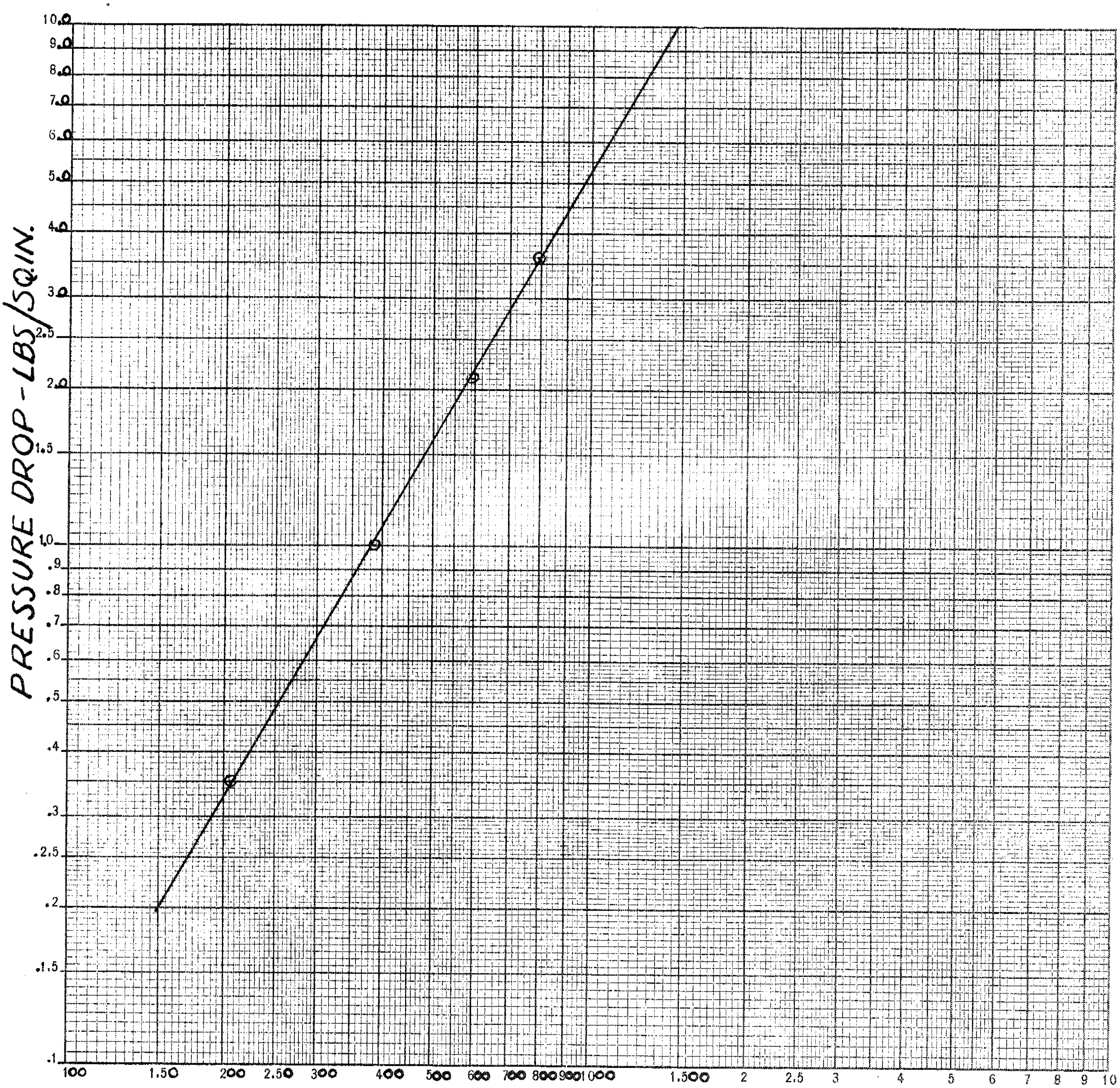


AIRESEARCH MFG CO.

12-19-41

MESSERSCHMITT - ME-110 RADIATOR

COOLANT (WATER) PRESSURE DROP THROUGH CORE



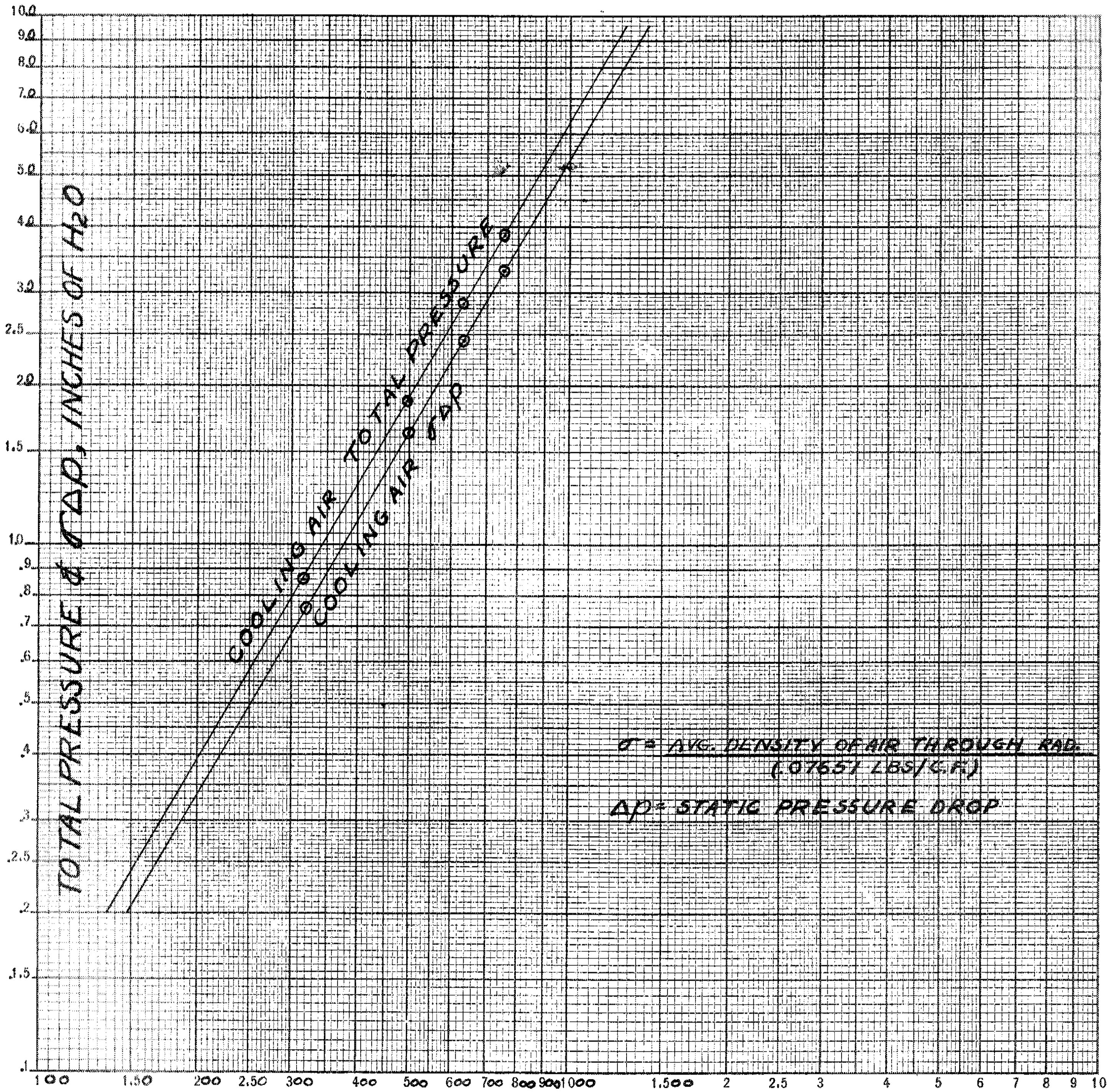
WATER FLOW-LBS/MIN.

AIRESEARCH MFG. CO.

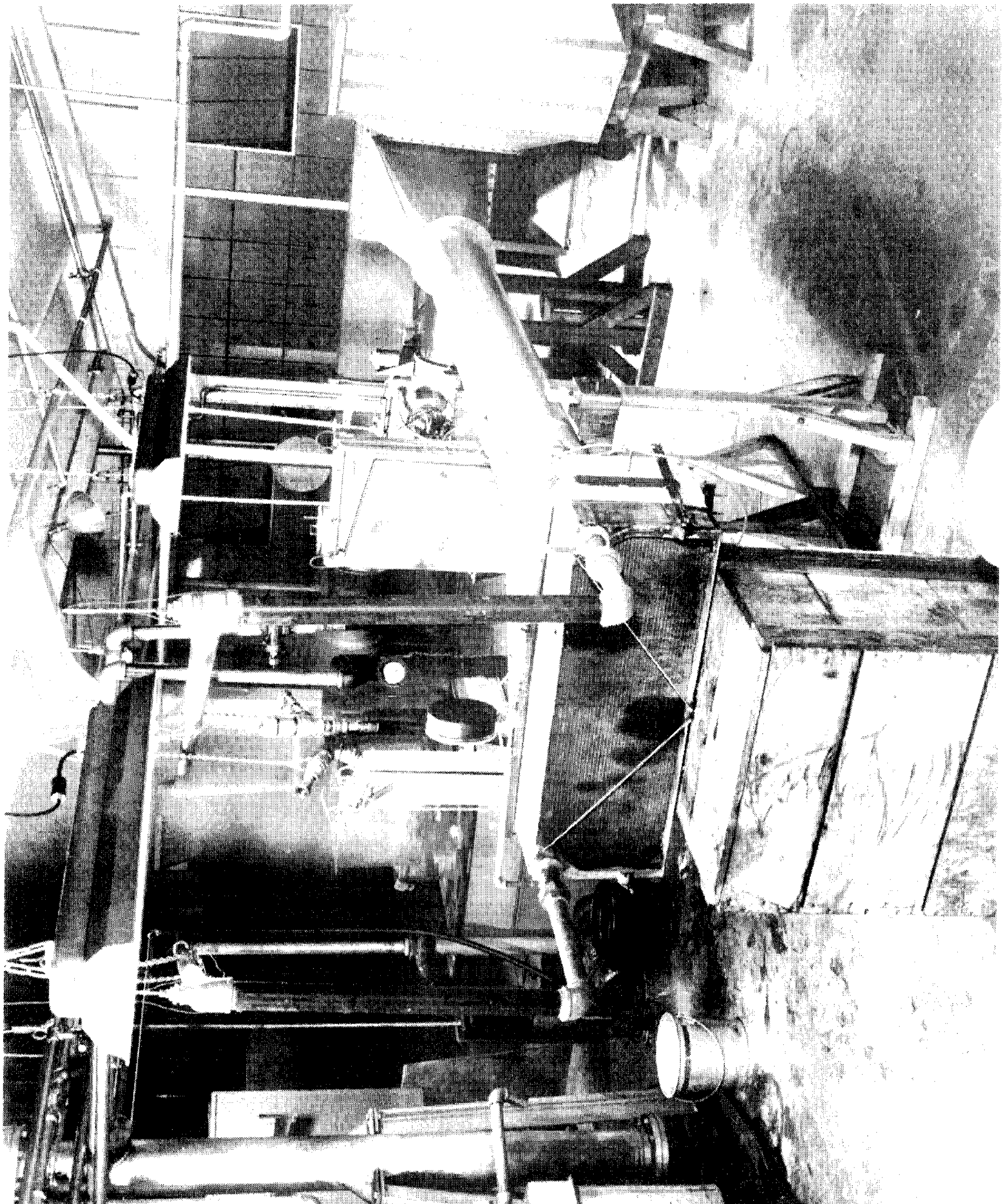
12/19/41

MESSERSCHMITT ME-110 RADIATOR

RESISTANCE TO AIRFLOWS



AIRFLOW - LBS/MIN.

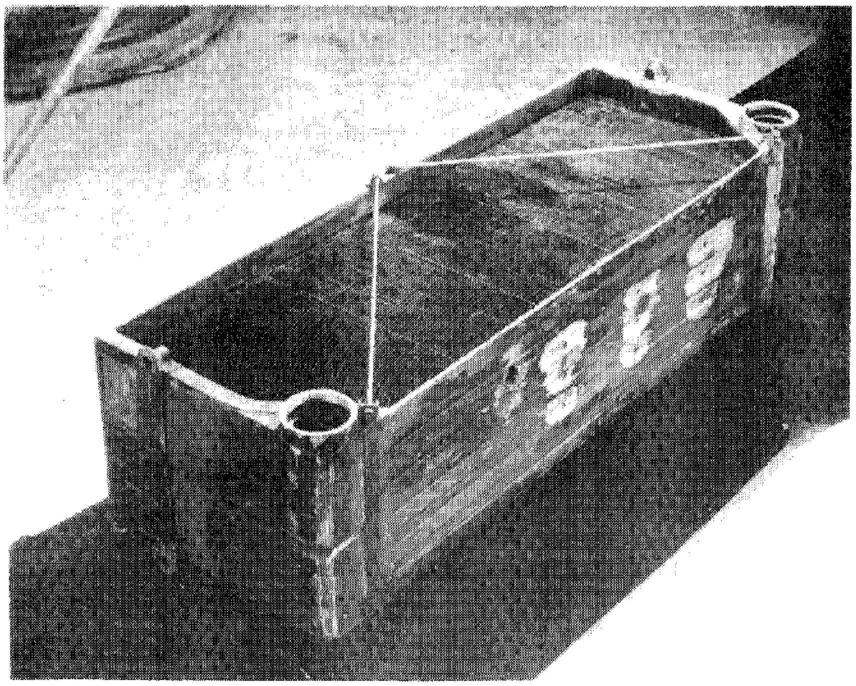


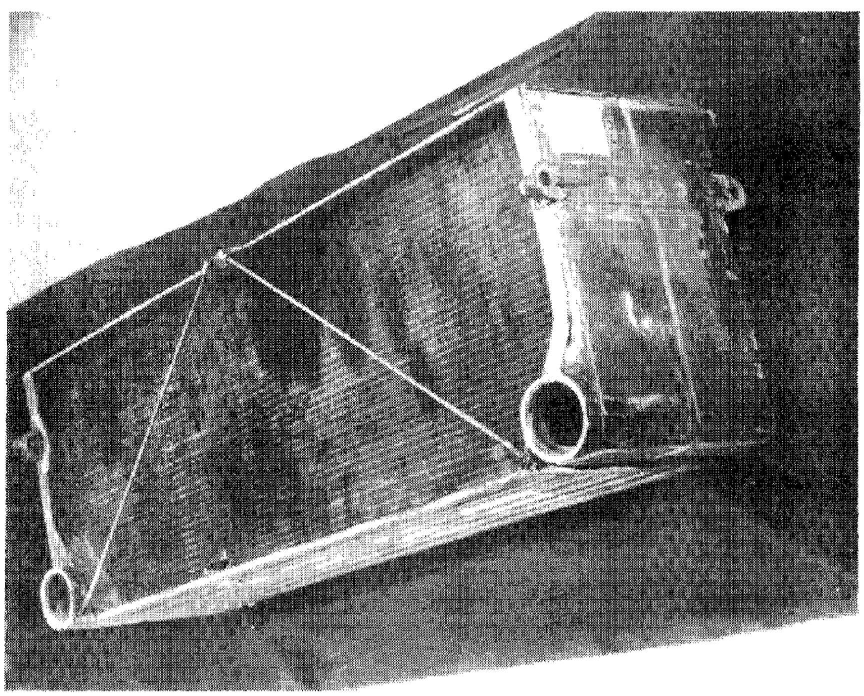
AIRESEARCH MANUFACTURING COMPANY

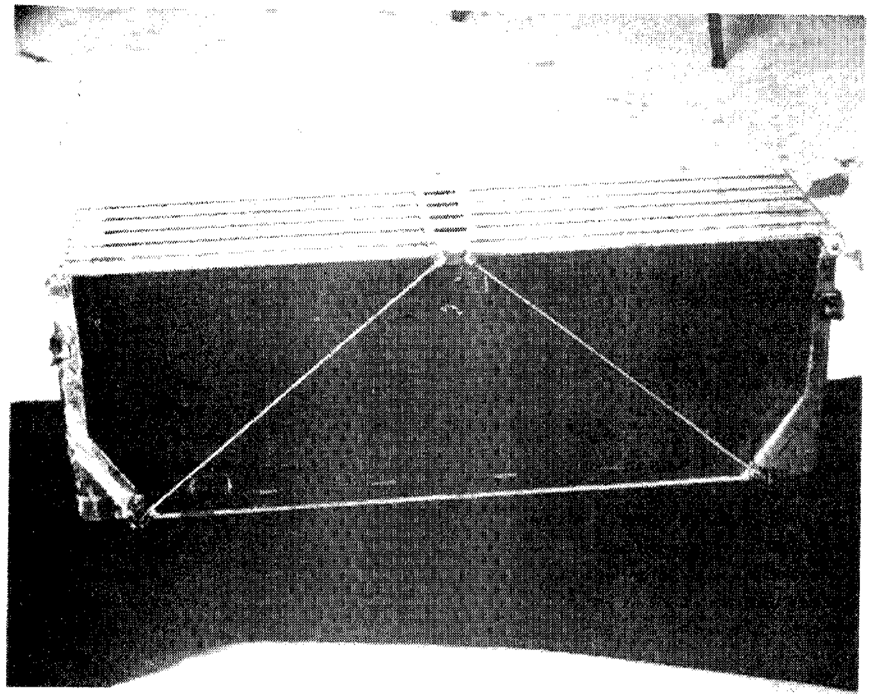
12/12/41 Bar. 30.14"

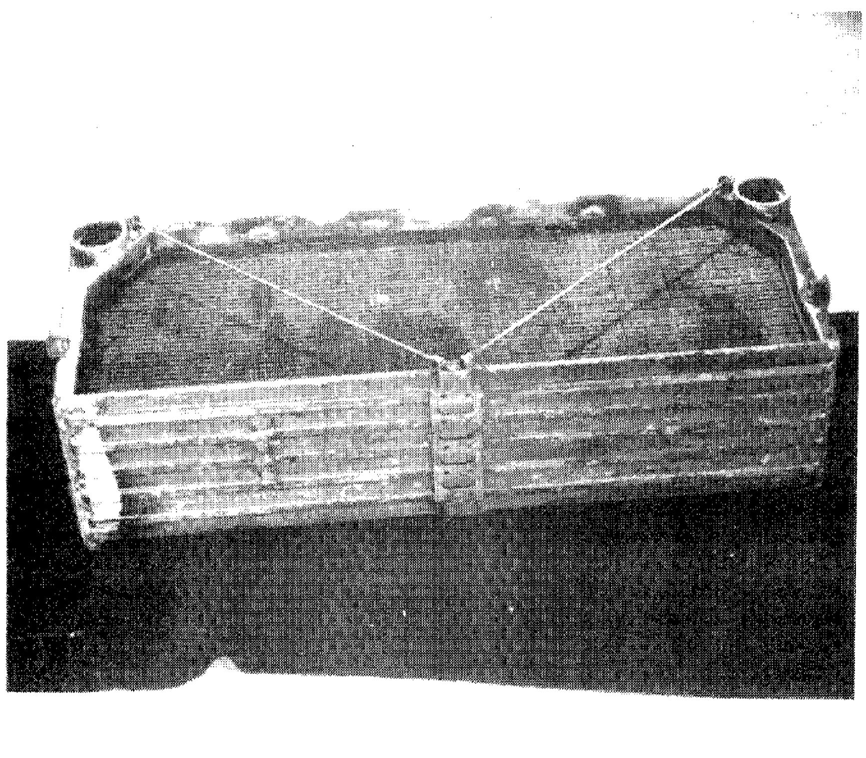
HEAT DISSIPATION of ME 110 RADIATOR (WATER)

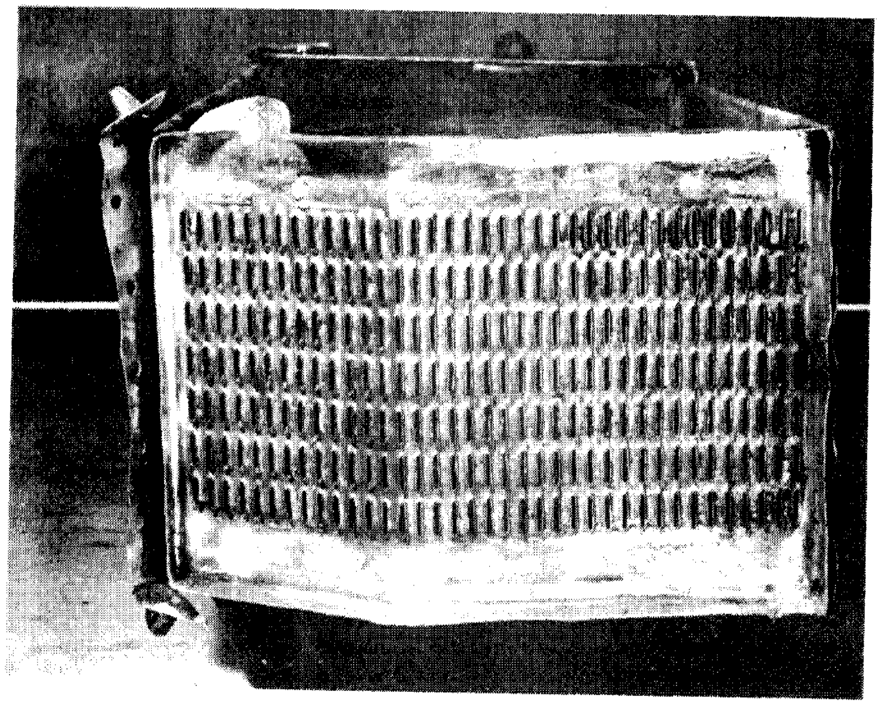
Run	°F TEMPERATURES				AIR READINGS			WATER FLOW				
	Inlet		Outlet					Lbs/Sq.In.Pres.				
No.	Air	Water	Water	Room	V.P.	St.P.	Δ p	In	Out	Lbs.	Sec.	Lbs./Min
1	93.0	209.5	163.8	89.0	12.9	-.07	3.6	.875	.525	206.0	60.	206.0
2	93.0	207.4	162.5	89.0	12.9	-.07	3.6	.875	.525	205.0	59.9	205.7
3	92.5	204.0	177.0	89.5	12.8	0.00	3.65	2.25	1.25	195.0	30.0	390.0
4	91.0	203.3	175.5	90.5	12.85	0.00	3.65	2.25	1.25	190.5	29.9	380.2
5	93.0	196.5	177.8	91.0	12.85	-.04	3.70	4.625	2.50	200.5	20.1	599.8
6	93.5	195.6	177.3	91.0	12.85	-.02	3.70			199.5	20.1	595.5
7	88.5	194.0	179.8	91.0	13.15	-.03	3.78	7.75	4.125	199.0	15.0	795.2
8	88.0	192.6	178.5	91.0	13.15	-.02	3.78			200.5	15.1	798.5
9	85.0	193.5	180.5	87.5	8.95	+.14	2.68	7.875	4.125	199.0	15	796.0
10	84.0	194.5	181.4	87.0	8.95	+.15	2.69			199.0	15	796.0
11	85.5	196.8	179.7	87.5	8.95	+.14	2.66	4.40	2.30	197.0	20.05	590.0
12	85.0	198.5	180.9	87.0	8.90	+.15	2.69			148.0	15.05	591.5
13	84.0	205.2	178.9	86.5	8.95	+.15	2.69	2.25	1.25	194.0	30.0	388.0
14	85.5	206.0	180.0	86.5	8.85	+.14	2.66			193.5	30.0	387.5
15	85.0	207.0	162.5	86.5	9.10	+.10	2.695	.875	.525	197.5	60.0	197.5
16	85.0	206.8	162.0	86.0	9.25	+.10	2.70			196.0	60	196.0
17	80.0	210.0	172.0	83.0	4.25	+.20	1.36			193.0	60	193.0
18	80.0	202.3	168.0	81.0	4.25	+.19	1.38			208.0	60	208.0
19	80.0	190.5	171.8	81.0	4.45	+.21	1.405			201.5	30.1	402.0
20	79.0	190.0	171.5	80.5	4.40	+.21	1.40			201.5	30.1	402.0
21	79.0	200	186.0	80.5	4.35	+.23	1.41			199.5	20.1	596.0
22	79.0	200	186.0	80.0	4.35	+.21	1.41			200	20.1	597.0
23	78.0	198	187.2	80.0	4.40	+.22	1.42	7.875	4.1	201.5	15.1	800.0
24	78.0	195.6	185.9	80.0	4.41	+.22	1.42	7.875	4.1	200.5	15.1	797.0
25	76.2	204.5	195.5	78.8	2.25	+.24	.83	7.87	4.125	198.0	15.1	787.0
26	75.0	204.0	195.0	78.8	2.26	+.235	.83	7.87	4.125	198.5	15.1	789.0
27	74.2	207.5	195.8	77.2	2.24	+.235	.83	4.4	2.375	202.0	20.15	602.0
28	74.0	207.4	195.5	77.0	2.25	+.235	.83	4.4	2.38	201.0	20.1	600.0
29	74.0	209.2	190.4	77.0	2.25	+.230	.825	2.25	1.25	183.5	30.2	364.0
30	74.0	210.3	192.5	77.0	2.27	+.230	.825	2.25	1.25	197.0	30.1	393.0
31	74.0	210.9	178.2	76.5	2.23	+.220	.81	1.00	.75	198.8	60.0	198.8
32	74.0	211.4	178.4	76.5	2.21	+.210	.80	1.00	.75	201.0	60.0	201.0

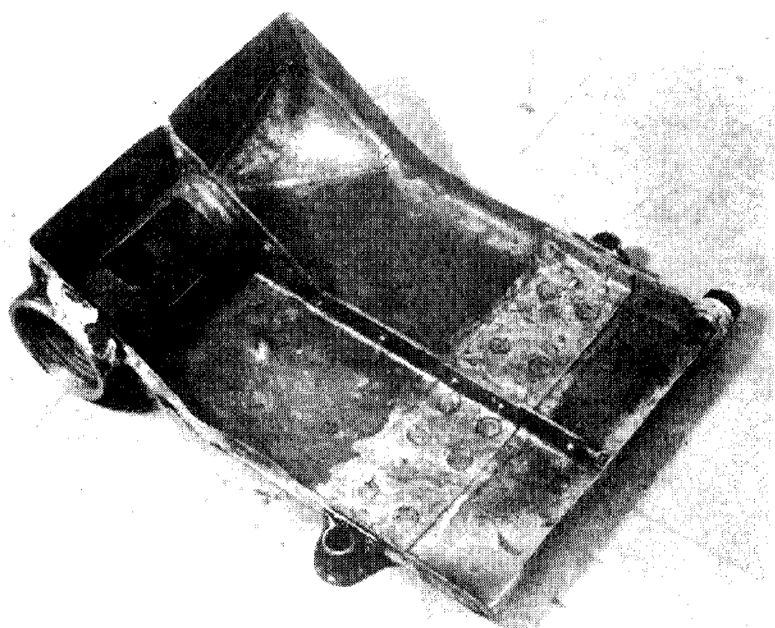


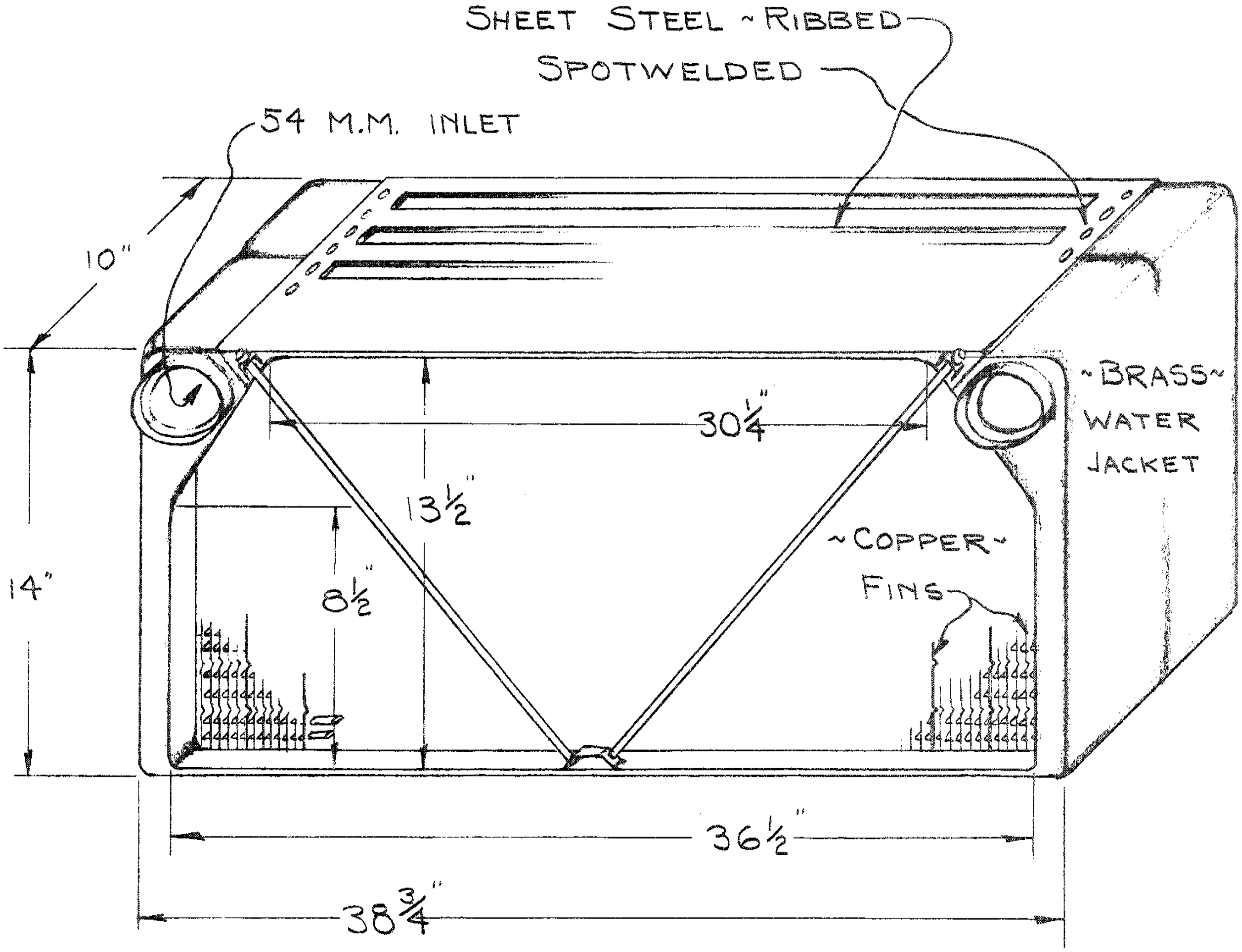












CALCULATED BY			ISOMETRIC VIEW ME-110 RADIATOR	
TRACED BY				
CHECKED BY				
APPROVED BY			AIRESEARCH MANUFACTURING CO.	
APPROVED BY			INGLEWOOD, — CALIFORNIA	

OIL COOLER

The oil cooler was damaged so badly that repair for capacity test was deemed impossible.

DESCRIPTION OF OIL COOLER

The oil cooler is of the cartridge tube type:

Length of tube (overall)	9.85"
Tube diameter - outside	.177
Tube wall thickness	.006"
Length of hex.	13/32
Distance across flats	.204"
Composition:	
Copper	67.8%
Zinc	32.2%
Yield Point:	
Actual load in pounds	200
Pounds/sq. in.	66,600
Tensile Strength	
Actual load in pounds	230
Pounds/sq. in.	76,600
Elongation in 2"	2%

Photographs of the oil cooler appear on pages 15 to 20. As will be noted, the cooler is annular in shape, the radius of the curvature being 21" on the outside and 16" on the inside. The dimensions of the core face are approximately 22" outside, 17" inside and 5" wide. The core is divided by radical baffles into eight sections, each section having approximately 280 tubes.

The photograph on page 15 shows bottom and face of cooler. The tubes have been removed from one of the sections. Photograph on page 16 shows a top and end view. The fitting shown gives access to the by-pass valve. On the left hand side of the top a series of tubes is clearly visible. These form a by-pass circuit and are in close metallic contact with the top of the radiator. The contact is accomplished by sweating the tubes to the cooler shell.

The photograph on page 17 is a top view from the opposite end. The photograph on page 18 shows top, face and both ends. One of the by-pass tubes was apparently torn off in landing. The patches where it was sweated to the shell are visible.

The photograph on page 19 is a view of one of the passes with tubes removed. The baffle construction and the means of fastening it to the shell is plainly shown. In addition to the large openings in the baffle at the top there are three 1/8" holes in the baffles at the opposite end. These holes are apparently for the purpose of establishing flow through the core when the oil in it is congealed. The photograph on page 20 is a view of the other baffle in the same pass.

The face area of the core is 90 sq. in. or .625 sq. ft. or somewhat less than a standard 11" cooler. The weight is approximately 50 pounds, which is 45% more than the 11" cooler.

The heat rejection to this cooler based on the report of R. W. Young of WAC is 3900 BYU/Min at an airflow of 97 lbs/min. with oil entering engine at 155°F, i.e., the cooler should reject this amount of heat at an average oil temperature of

$$155 - \frac{3900}{97} = 195^{\circ} \text{ F.}$$

Such performance is only obtained by passing an enormous amount of air through the cooler and by rather high oil pressure drops. The latter is borne out by the fact that the relief valve is set to open at 31 to 32 lbs/sq. in.