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ELECTROMAGNETIC PROXIMITY FUZE FOR MORTAR SHELL

Supplement to final report on contract N-02-MWP-A-54

by

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C O N T E N T S

ELECTROMAGNETIC PROXIMITY FUZE FOR MORTAR SHELL

Supplement to final report on
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1.0 INTRODUCTION

This report is a supplement to the final report T-141 A (hereafter denoted by FR), issued December 31st, 1956. At that time, there were still unsolved problems, which will be briefly reviewed before we go into the detailed solutions.

1.1 The need for improvement regarding shock resistance of complete fuze

According to FR, pages 51-52, the complete fuzes will have to be shock tested in a bumping machine, giving 8000 g's for a very short duration. In FR, page 57, mention is made to the cause of prematures and duds during the last firing test made before FR was issued. One of the main reasons showed to be lack of sufficient shock resistance during firing with high charge numbers. The weak points in the construction proved to be:

a) During shock tests the open end of the amplifier housing was deformed by the generator bearing fixture, resulting in a deficient electrical contact, as well as loosening of the threads joining the turbine housing to the amplifier housing. This would give rise to noise voltages into the amplifier, with prematures as a result.

b) The generator bearing fixture showed deformation due to acceleration forces from its own weight. As will be known from FR, this component has been weakened considerably by a recess for the gear mounting plate.

c) During some of the shock tests, the worm wheel in the generator unit, connecting to the arming shaft, showed a tendency to break due to excessive stresses in a corner. This would, in the case of breakage during firing, result in a dud, with generator and oscillator functioning, but with neither the proximity fuze nor the impact substitute arrangement functioning.

d) During shock tests, some of the polyethylene rings on the fuze base (antenna gaps) showed a tendency to develop small cracks, due to sharp-edge-stresses in the material. This might result in duds or prematures, according to the severity of the cracks.

1.2 <u>The changes in detonator resistance due to shock tests and climatic cycling</u>

As has been described in FR, pages 42 and 43, the shock tests and climatic tests with the detonator resulted in a considerable increase in detonator resistance. This was caused by the connection between ring and detonator tube becoming loose and giving poor electrical contact, as well as offering an effective point of attack for corrosion. Further, the brass contact pin would have to be substituted by a pin of another material to increase chemical stability of the unit (not mentioned in FR).

1.3 <u>The need for supplementary firing tests</u>

The results of firing test no 16 (referred to in FR, page 57) were not satisfactory. We did not find it advisable to conclude the project without having a few more tests with fuzes changed in accordance with the experience gained in test no 16. More firing, especially with charge 5 were required. We also needed more data as to burst heights and the correlation between laboratory sensitivities and the observed heights. No attempt would, however, be made to fire laboratory fuzes over land. We found it advisable, with our small production capacity, to perform all firings above sea water and not to introduce new variables at this stage. To obtain representative sensitivity data over <u>land</u>, we will have to fire larger batches than practically possible with only a laboratory production available.

1.4 The need for extended terminal ballistic tests, especially above snow-covered ground

In FR, page 58, the advantage factors for VT-fuzed rounds above snow-covered ground as compared to PD-fuzed rounds had only to be roughly estimated. We found it therefore advisable to perform terminal ballistic tests above different types of snow, to determine this advantage factor experimentally. As deep-snow conditions occur in Southern Norway only during the first 3-4 months of the year, these tests had to be postponed until after FR was issued.

2.0 TECHNOLOGICAL CHANGES IN CONSTRUCTION

A detailed discussion will now be given on the constructional changes introduced. It will be noted, however, that the main construction has in reality been "frozen", so only modifications having direct influence on the difficulties mentioned in chapter 1.0 have been introduced.

2.1 Elimination of noise caused by loose connection between generator housing and turbine housing

As may be noted from Figure 2.1 a, the generator in its housing rests directly on the thin rim of the amplifier housing. Tight connection is ensured by means of threads in the turbine housing. During shocks the compressive forces on the amplifier housing exceed the limit of elasticity of the Dural, which is very low, and as a consequence, the tightness of the threaded connection will decrease. This may bring about defective fuzes, due to faulty ground connection between units or broken lead wires. There were two possible ways to cure this deficiency, firstly to ensure that the top of the amplifier housing was absolutely plane, with no burrs whatsoever, secondly to make an arrangement whereby the permanent compression of the Dural could be tolerated, without the threaded connection loosening. Both methods are now being applied, as will be seen from Figure 2.1 b. Here a wavy steel spring is inserted between turbine housing and amplifier housing. The spring allows a compression of the Dural of about 0,5 mm, which is more than sufficient. With the spring inserted during mounting, a torque of 1 kgm is applied to the turbine housing. After repeated shocks, this torque never reduces to less than 0,6 kgm, assuring a tight mechanical and electrical connection. Small modifications have therefore been introduced in:

> Turbine housing, formerly dwg. 84T1-103, superseded by new 84T1-103S1,
> Wavy steel spring, new drawing 84T1-115S1.

The new drawings are included in this supplement.

2.2 Improved shock-resistance of generator bearing fixture

The bearing fixture, formerly dwg. 84T1-102, has been made of brass. Our reason for using brass was its easy machineability in small production, and no difficulties regarding material strength had previously been observed. However, the nylon gear mounting plate, 84T1-201, is a relatively new improvement, and has at a recent stage made a simpler production of the bearing fixture possible. Formerly, the gears were mounted directly into recesses in the brass bearing fixture. Owing to the nylon insert, the bearing fixture has been mechanically weakened, and consequently, during extended shock tests the central part of it bent permanently towards the back, into the amplifier. The forces acting on the fixture are only due to its own weight. This would have two dangerous consequences, firstly the risk of cracking the amplifier potting, secondly the risk of an eccentrical or at least not coaxial roller bearing for the generator rotor shaft. Two methods were possible to eliminate these points, either to increase the dimensions of the bearing fixture or to change the type of material.

The latter method was used successfully, and steel was chosen instead of brass. No measurable deformation can then be seen after tens of shock tests at 10 000 g's.

2.3 Improved shock-resistance of base assembly

Shock-tests also revealed another constructional weak point, viz the polyethylene half of the base assembly, dwg. 84T1-501.

Cracks might occasionally occur here, these obviously were caused by too high stresses in the moulding due to sharp corner-effect. Figure 2.3 shows the critical points, and the obvious way of avoiding these is to round off the sharp edges.

2.4 Improved shock-resistance of gear in generator

The worm wheel, dwg. 84T1-204, also showed a tendency to develop small cracks in the junction between wheel and stem. This was remedied by rounding off sharp edge (in mould) and affording sufficient clearance in the gear mounting plate, 84T1-201, Figure 2.4 shows a sketch of these critical points.

2.5 Simplified and improved composition detonator

In the original detonator the contact between ring and tube was apt to be unstable after rough handling or storage at extremely varying temperatures. In the modified detonator (dwgs. 84T1-508S1 and -509S1) this tendency is avoided by making ring and tube in one piece. Another improvement is that the detonator pin previously made of brass, is now made of aluminum, due to the risk of hydrolysis of the lead azide whereby hydrazoic acid is formed which will react with copper alloys producing a sensitive salt. It will be noted that the total length of detonator has increased by 1 mm, consequently the bore depth in the arming rotor, dwg. 84T1-505, has to be increased from 13 to 14 mm.

The filling operation is performed as before, the explosive is covered with an aluminum disk and finally the tubing is folded over the disk.

The shock resistance of the modified detonators was tested in the same falling weight apparatus previously used giving a set-back of 10 000 g. 25 detonators were tested. After three shocks the maximum increase of resistance was 60 % and the average 25 %.

Accelerated climatic storage trials were again performed by keeping the detonators alternating one day at + 60°C and one day at + 40°C. Twenty detonators were tested. After 20 days 11 detonators showed an increase of resistance of less than 100 %, 5 from 100 to 200 % and 4 from 200 to 300 %. It seems unlikely that further storage will result in a critical increase of the resistance as the main increase is limited to the first few days.

It may therefore be concluded that with these modifications the stability of detonator resistance achieved is satisfactory, the increase of resistance by rather severe handling and storage being far from critical with respect to dependability as well as to safety.

2.6 Investigation on the detonation of the main charge

At the firing tests 12/4-57 it was observed that only one of the 15 firings resulted in detonation of the main charge, all the others gave a much weaker explosion indicating that only the booster detonated. It was then realized that this failure also occurred at the firing tests 5/4-57 and 19/2-57, whereas the main charge positively detonated with full strength at the firing tests 17/12-56.

It seemed very difficult to explain this discrepancy, but a possible reason might be variation of the tooling pressure by the production of the booster pellets, and the relation between tooling pressure and initiating power was therefore investigated.

The tooling pressure for the booster pellet was originally specified to 700 kg/cm^2. As the pellets were apt to crack by too high pressure, there was a tendency to lower pressure, but it was supposed always to be at least 600 kg/cm^2.

A new pressure tool was produced which allowed us to increase the pressure to 2000 kg/cm^2. The relation between pressure and specific gravity was then determined, with the following result:

Tooling pressure, kg/cm^2	400	600	800	1000	1200	1400	1600	18
Sp.gravity, g/cm^2	1.512	1.556	1.596	1.618	1.634	1.650	1.658	1.67

A rapid decrease of the specific gravity (and hence of the detonation velocity) with decreasing pressure is thus revealed in the actual pressure range.

Bursting trials were then performed with boosters produced by varying the tooling pressure. The booster was initiated by the usual detonator. Simplified arming rotors and fuze bases were used, but this simplification would not affect the results. 33 trials were performed with the following results:

Tooling pressure, kg/cm^2	400	600	800	1000
Number of shells with complete detonation:	4	5	7	10
Number of shells with incomplete detonation:	4	2	1	0

The results confirm that the pressure previously used was too low to ensure complete detonation of the main charge. On the other hand it is quite improbable that such results should occur as at the firing trails 19/2, 5/4 and 12/4-57 if a tooling pressure of 6-700 kg/cm^2 was used. A satisfactory explanation for this discrepancy is difficult to find. The most reasonable one seems to be that the tooling pressure has been far too low caused by either a human or an instrumental error.

Two measures are to be taken for the future to avoid failure of detonation. The booster pellets are to be produced at a tooling pressure of 2000 kg/cm^2, and the specific gravity of the pettets are to be controlled to make sure that the right pressure has been used.

We feel convinced that these precautions will secure complete detonation of the main charge.

2.7 Other small modifications not mentioned above

To rationalize production, the connection of the ring magnet (84T1-111) to the rotor shaft (84T1-112) which has hitherto been performed with Araldite, has been modified. A far easier method, which also gives better shock-resistance to the finished rotor units, involves applying "Cerromatrix" metal which is molded at 170°C in the same special jig as was used earlier. Upon cooling, this material shows a slight expansion, so assures a firm bound between rotor and shaft. No difficulties have arisen due to the fact that rotor and shaft are now electrically on the same potential, in contradiction to the construction reviewed in FR, with electrically insulated ring magnet.

The arming spring, dwg. 84T1-504, has been slightly modified by pressing a short tubular rivet onto the smaller end of it, at the same time increasing the coil number. This assures a lower friction between arming rotor and spring, thereby avoiding some tendency for the sharp end of the steel wire to stick to the arming rotor, which is made of Dural.

The protruding part of the turbine insert after machining, dwg. 84T1-110, has been increased by 0,4 mm to ensure an easier fit, as difficulties occurred during mounting due to the turbine rim touching the generator housing in some cases.

2.8 Review of mechanical modifications and superseded drawings

In the following table, a short survey on the changes in drawings of FR will be given.

Text	No in FR	New No
Assembly drawing	84T1-1	84T1-1S1
Generator Bearing Fixture	84T1-102	84T1-102S1
Turbine Housing	84T1-103	84T1-103S1
Turbine	84T1-110	84T1-110S1
Wavy Circular Spring	-	84T1-115S1
Gear Mounting Plate	84T1-201	84T1-201S1
Worm wheel	84T1-204	84T1-204S1
Fuze Base	84T1-501	84T1-501S1
Arming Spring	84T1-504	84T1-504S1
Arming Rotor	84T1-505	84T1-505S1
Detonator Casing	84T1-508	84T1-508S1
Composition Mix Assembly	84T1-509	84T1-509S1

3.0 RESULTS OF NEW FIELD TESTS WITH LABORATORY MODELS

To check the modifications mentioned above, and also to gain more data as to reliability and reproducability of this fuze model, new firing tests were performed, one in February 57, and two in April 57, as well as supplementary terminal ballistic tests above snow. The results of these tests will be briefly reviewed.

3.1 Firing test 19/2-57

10 rounds were fired with 5 supplementary charges. Sensitivities of amplifier units were reduced, the amplifier needing 35 mV_{rms} for fire, compared to 25 mV_{rms} for amplifier from FR.

Seven rounds were successful, two prematures and one dud occurred. The burst heights showed a good mean coincidence, but a far larger dispersion than observed in the sensitivity test box, owing to variations in angle of impact towards the sea. The reasons for the prematures and the dud are not quite clear, but it seems natural that this type of construction will necessarily give a certain percentage of misfirings at maximum charges. The main reason is the generator, where especially the roller bearings are strained to their limits both as regards shock and rotational speed.

3.2 Firing tests 5/4 and 12/4-57

After the successful firing in February, we felt it convenient to invite representatives from the Norwegian Forces to Horten to observe a test firing. A new series of 20 proximity fuzes were produced, and after a preliminary firing on April 5th, with no visitors, where 4 out of 5 rounds were successful while fired with charge 5, the "demonstration" test firing was arranged April 12th with 15 rounds. All of these rounds were successful, and this batch also gave mean heights of burst in accordance with predicted data from box. However, dispersion in height was far larger than predicted. As stated above, all of the 15 proximity fuzes were successful, and gave air bursts between 2 and 11 metres above sea level. However, only one round resulted in complete detonation from booster to main TNT-charge in the mortar shell, and this effect has also showed up during the tests of 19/2 and 5/4. This faulty explosive train has been dealt with separately in chapter 2.6 of this report.

3.3 Supplementary terminal ballistic studies

An investigation on the effect of 81 mm mortar projectiles on snow-covered ground has been carried out during the winter 1957. The purpose was to determine the relative effectiveness of the proximity fuze and the impact fuze M52. The investigation consisted of firing tests and fragmentation tests.

It was obvious that the snow conditions would have a great influence on the results of the trials. It was therefore desirable to perform the tests under varying snow-conditions. As the winter 1957 has been very deficient of show, however, it has been impossible to carry through the testing program in a completely satisfactory way.

The compactness of the snow was measured by a penetrating apparatus of Swiss construction. The snow quality was also judged more subjectively, classifying the snow as wet or dry, as new and more or less granulous, and as light or heavy.

The <u>firing tests</u> were carried out in order to determine the depth of detonation below the snow surface for projectiles with fuze M52. The projectiles were fired at three different elevations, 50, 60 and 70^{o} and with increment charges ranging from 0 to 6. Other shells were detonated with electrical ignition without actually firing the projectiles. By varying the bursting depth of these shells and by comparison of the form and the size of the craters and by other observations it was possible to determine the bursting depth of the fired projectiles. Most frequently this method gave a reliable indication of the depth of detonation.

Four different snow conditions were investigated. On very loose, light, dry, new snow the projectiles detonated when reaching firm ground. The snow depth was 30 cm. At the second firings the snow was very hard and it was quite obvious that the projectiles detonated on the snow surface. At the third firings the snow was loose, wet and rather heavy and granulous. The snow depth was only 20 cm, and the estimation of the bursting depth was therefore rather uncertain. However, it was obvious that the projectiles detonated before reaching firm ground, probably after a penetration of about 10 cm. At the fourth firings the snow was very like that of the third firings, but heavier, slightly firmer and with coarser granules. The snow was much deeper and it was quite obvious that the projectiles detonated on the snow surface or after a very slight (max 5 cm) penetration.

The fragmentation tests were carried out in order to examine the fragment damage with the projectile detonating above, on and below the snow surface. Unfortunately it was not possible to carry out the trials with such snow which was certainly known to give detonation below the snow surface (dry, new snow). As it is unknown how the quenching effect on the fragments varies with the snow consistency, the reliability of the results for other types of snow is questionable.

The actual snow was rather loose, wet, granulous and heavy. The depth varied from 50 to 70 cm.

The trials were carried out as static bursts without actually firing the shells. The effect field consisted of 60 vertical 1.8 x 0.4 m boards, 1.3 cm thick, spaced 5 m apart in a square array.

Five projectiles were detonated at each of the following heights above the snow surface: + 4 m, + 2 m, 0 m, - 0.15 m, - 0.3 m, and - 0.6 m (three trials). The angle between the shell axis and the horizontal plane was 60 - 70°.

Fragments which perforated the boards were counted and marked out after each burst. Every fragment which caused a visible mark on the rear side of the board was taken as a perforation, those with a distinct aperture being classified as vigorous perforations, the others as weak ones. These perforations were supposed to represent respectively 75 and 25 % probability of incapacitation. If more than one fragment perforated the same board, it was assumed that the casualities were independent of each other.

With shells detonating at 30 and 60 cm depth it was also necessary to make allowance for damage caused by the blast effect. It was assumed that a shell detonating within a distance of 1 m from a board will cause incapacitation by the blast from the shock wave.

For the depths of 30 and 60 cm consideration was also given to the probability of direct hit which will not only cause incapacitation of the board hit, but also of several others being struck by the fragments from the bursted shell.

On this basis the total damage has been calculated for the various bursting heights. The results are given in Figure 3.3.

A nominal advantage ratio may be calculated for projectiles with proximity fuzes under the assumption that all these will detonate at a constant height of 4 m above the snow surface. Values for the advantage ratio corresponding to various depths of detonation below the snow surface are given below:

Depth	Advantage ratio
15 cm	2,7
30 "	29
60 "	55
100 "	86

The following conclusions as to snow functioning may be drawn:

The firing tests have shown that only on very loose snow such as dry new snow, will the fuze function at a considerable depth below the snow surface. At low temperatures, however, such snow may preserve its consistency and loose structure for a considerable time, and this type of snow is therefore of great importance. Wet new snow was not investigated, but it seems likely that the projectile will penetrate some distance into the snow before detonating. Most other types of snow seem to give detonation on or just below the snow surface.

During the snow conditions existing at the fragmentation trials the efficiency of projectiles penetrating the snow decreases rapidly below 15 cm depth, whereas airbursts are nearly as effective against standing targets as contact bursts. It seems reasonable to suppose that this statement will not be radically changed even with much looser snow. It may therefore be concluded that when the snow is loose and light enough to be penetrated by the projectile without detonation, a considerably increased effectiveness of mortar fire may be obtained by using proximity fuze.

These conclusions are apparently discordant with a Canadian report[x] where it is stated that conclusive evidence is produced that snow does not smother fragmentation, the most reasonable explanation of this fact being that the bombs burst on surface impact.

The Canadian trials, however, were performed on only one type of snow, and the cited conclusion therefore seems to be too extensive. The actual snow was in fact rather heavy (specific gravity 0.48) apart from the uppermost 1 1/4 inches which were very loose, new snow. The experimental results, showing that mortar bombs burst statically on the surface of deep snow produce craters as large as those produced by bombs burst on impact after firing, are therefore completely concordant with our results.

4.0 CONCLUSION

It is obvious, that a construction of the nature of this mortar fuze may be refined and modified eternally. However, we feel that there would be no practical reason for going farther along the laboratory track with this fuze, and will sum up our conclusions at the present time (June 1957).

4.1 The status of the project at the issue of this Supplement

Our laboratory now considers that the development phase of this project has come to an end, the next stage being the pre-production phase. Some 120 VT-fuzes have been built and fired, in addition to all the models not even having passed through our testing procedure.

It may naturally still be said that there are points in the construction which might have been modified, especially in order to render the fuze less expensive. However, as we have stated earlier in FR, the ideal weapon is always too late, so it should be

^{x}Kaye, G.D.: The Reliability of Mortar Bomb Crater Measurements is an Indication of Burst Position. Canadian Army Operational Research Report No. 1. Supplement. - Kingston, Ont. 1951.

born in mind that every effort should be spent to reach production stage as soon as possible, if tactical test firings with pre-production fuzes still show promising results.

4.2 <u>The necessity of and plans for a possible pre-production</u>

In order to evaluate the fuze from a tactical point of view, it is necessary that larger batches than hitherto will be fired. The problems of different landscapes, firing above woods, in shallow valleys and above snow, as well as the problems with the personnel using this new weapon and the other tactical problems which necessarily will arise, have to be investigated.

We have therefore recommended a pre-production series of 1000 fuzes to be produced according to our drawings and descriptions, and tested realistically. We feel that this figure of 1000 is not too large, as mainly statistical data have to be gained. To get the most out of these tactical tests, we would very roughly suggest the following test programme:

40	rounds	on	dry, sandy soil,	range	500 m
40	"	"	" " " "	"	1000 "
40	"	"	" " " "	"	1500 "
40	"	"	swampy land	"	500 "
40	"	"	" "	"	1000 "
40	"	"	" "	"	1500 "
40	"	"	mountain terrain	"	500 "
40	"	"	" "	"	1000 "
40	"	"	" "	"	1500 "
40	"	"	calm, sea water,	"	500 "
40	"	"	" " "	"	1000 "
40	"	"	" " "	"	1500 "
40	"	above medium wood,		"	1000 "
40	"	in drizzle		"	1000 "
40	"	" light rain		"	1000 "
40	"	" heavy rain		"	1000 "
40	"	" dry, falling snow		"	1000 "
40	"	" wet, falling snow		"	1000 "
40	"	during airplane icing conditions		"	1000 "

240 rounds for different purposes, guided
by above experiments

In all 1000 rounds

List of corrections to Final Report (T-141 A)

Page	Line		Old text	New corrected text
7	15	bot.	--- sandy soil	--- sandy soil
"	10-11	"	optimum height height	--- optimum height
"	9	"	The optimum of burst	The optimum height of burst
8	5	top	framentation	fragmentation
13	13	"	$p/po = \frac{2}{\gamma+1}(\frac{V^2}{c^2} - 1)$	$p/po = \frac{2\gamma}{\gamma+1}(\frac{V^2}{c^2} - 1)$
14	12	bot.	--- various refractions	--- various cases
15	17	"	--- shallow trenches	--- medium deep trenches
20	1	"	--- is the reason for	--- is a consequence of
26	5	"	--- against jammin	--- against jamming
28	13	top	approximately 0,7 rms	approximately 0,7 V rms
30	16	"	photophgraphic	photographic
31	5	bot.	procress	process
39	16	top	--- of 1 seconod	--- of 1 second
40	16	bot.	--- must not be capable	--- must be capable
43	6	"	--- firing train	--- explosive train
"	5	"	--- firing train	--- explosive train
44	9	"	--- to 11 g	--- to 12 g
46	16	top	--- firing train	--- explosive train
"	7	bot.	--- from 11 g	--- from 12 g
50	1	"	test queantity	test quantity
54	4	top	33 dummy fuzes	3 dummy fuzes
"	11	bot.	Funtioning tests	Functioning tests
55	14	"	--- were achieded	--- were achieved
59	15	"	2.41 adn 2.42	2,41 and 2,42
64	14	"	Northing	Nothing
65	9	"	--- for V- and	--- for VT- and
67	13	"	--- putside roads	--- outside roads

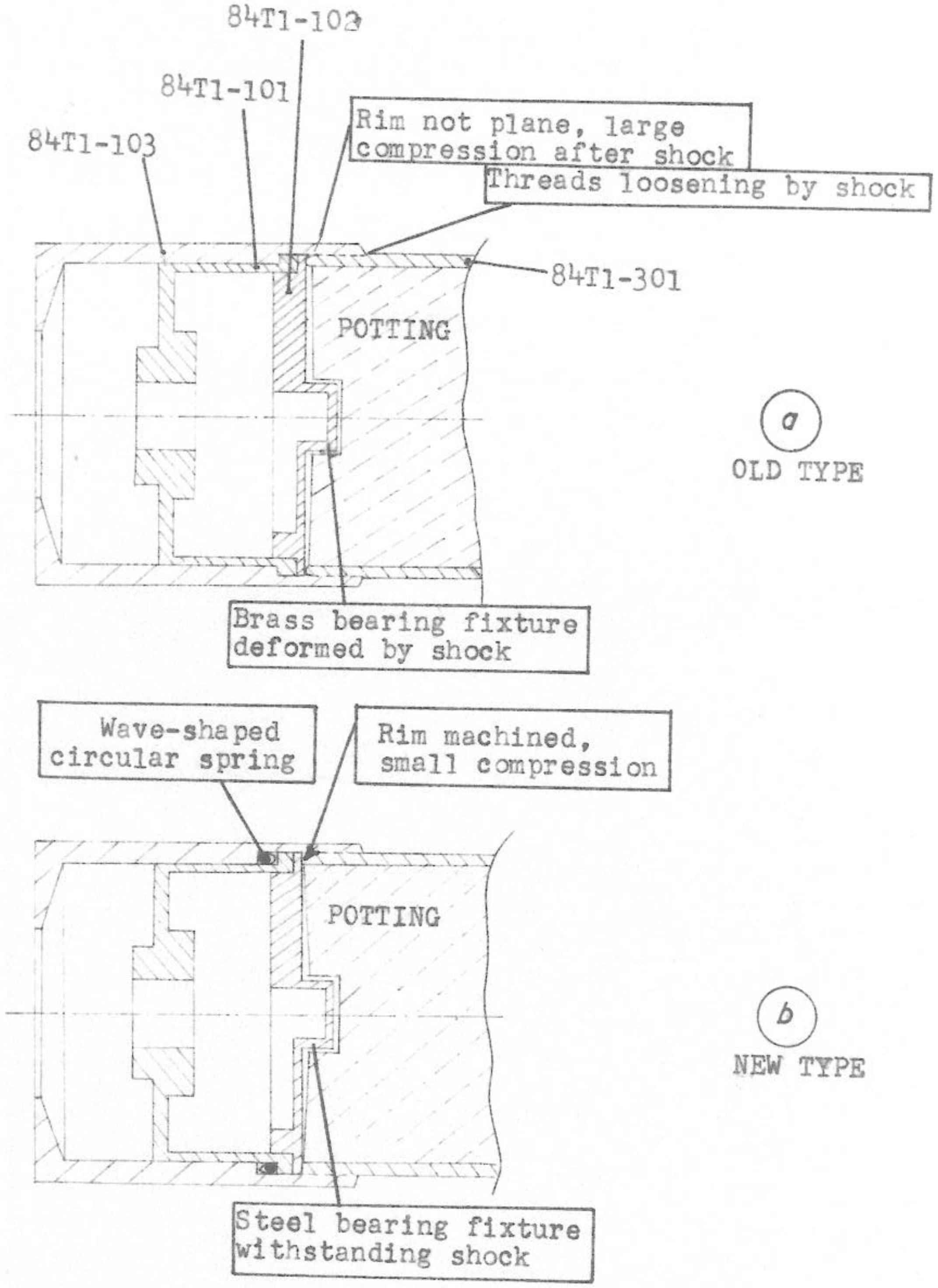


FIGURE 2.1 MODIFICATIONS IN GENERATOR-AMPLIFIER JOINT

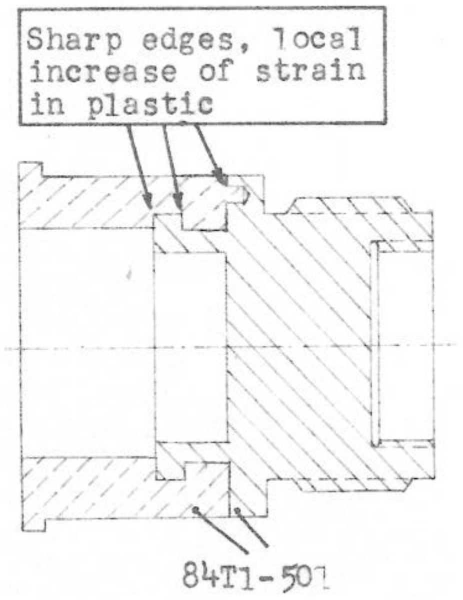


FIGURE 2.3 CRITICAL POINTS IN FUZE BASE CONSTRUCTION

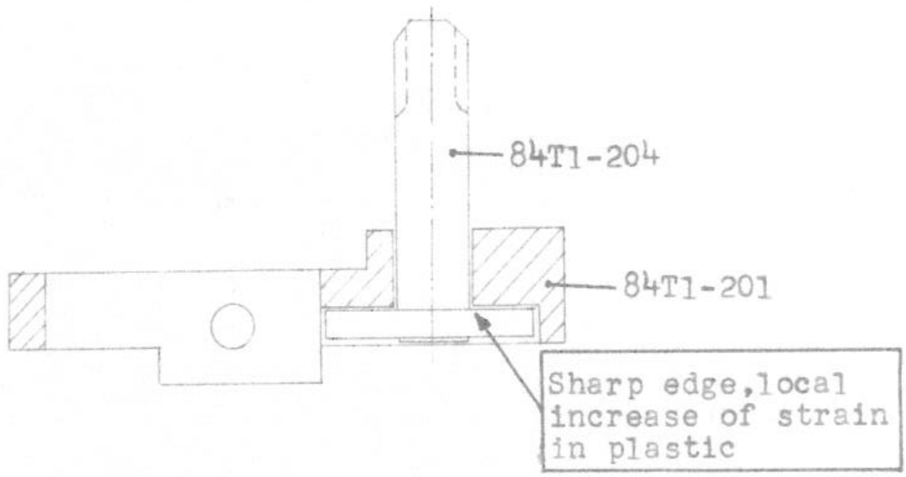


FIGURE 2.4 CRITICAL POINT IN WORM WHEEL CONSTRUCTION

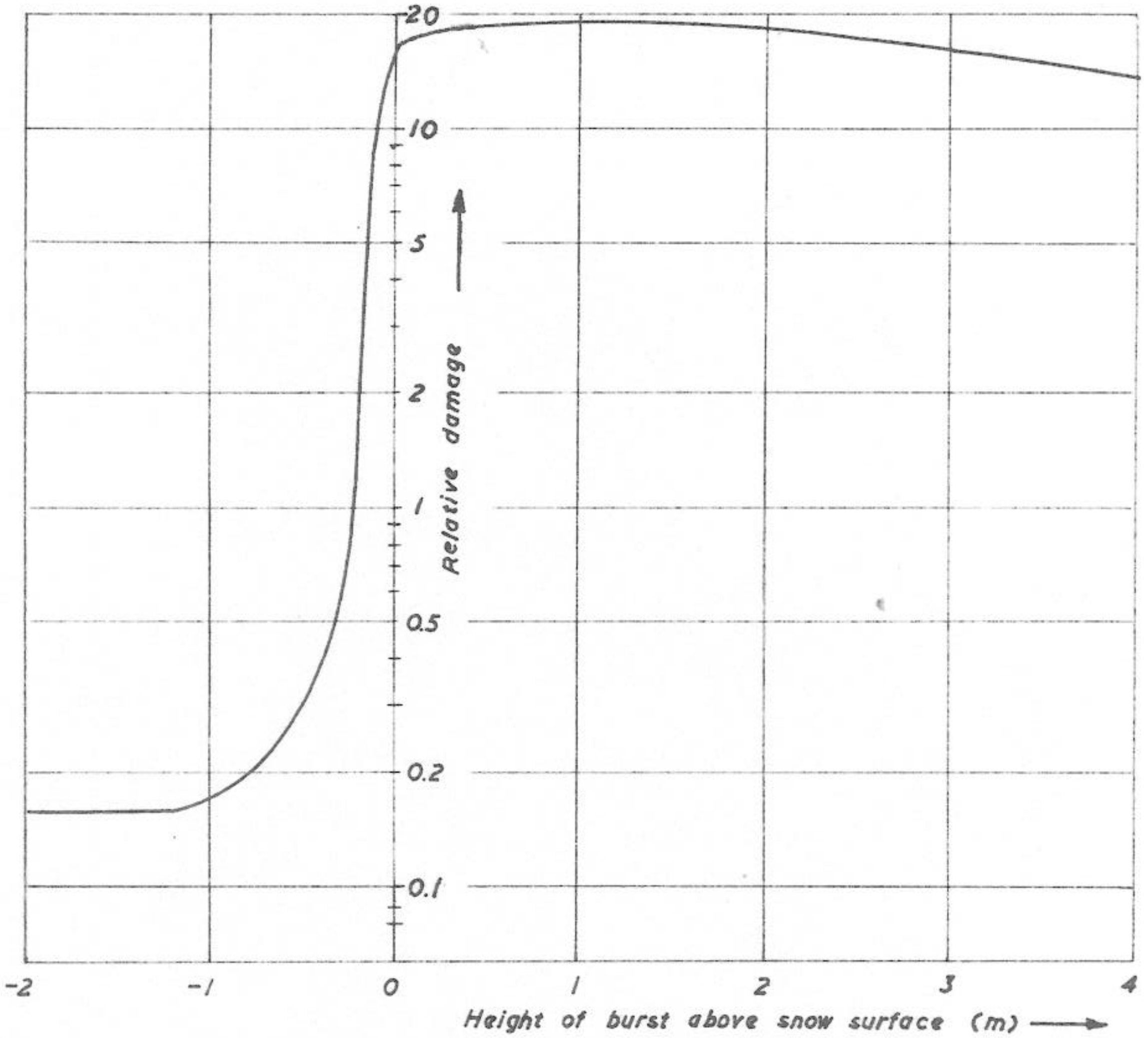
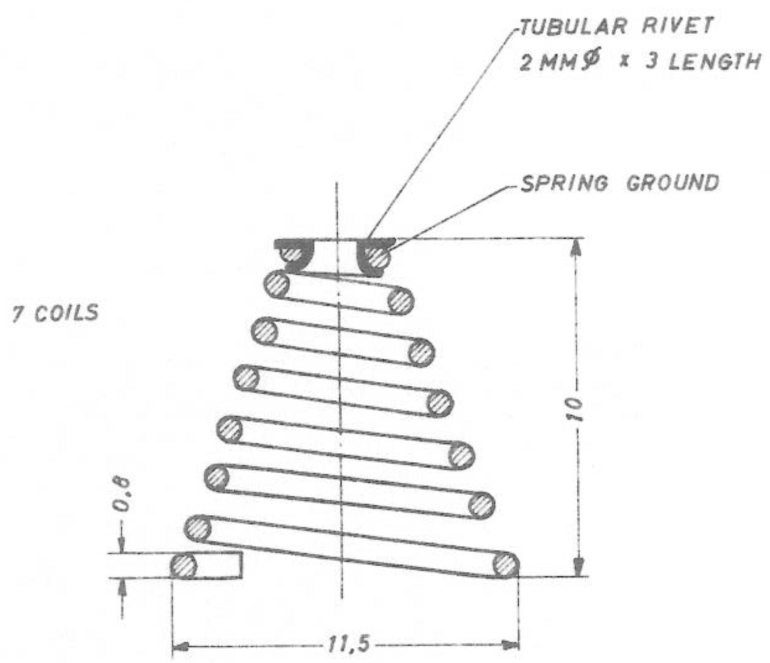
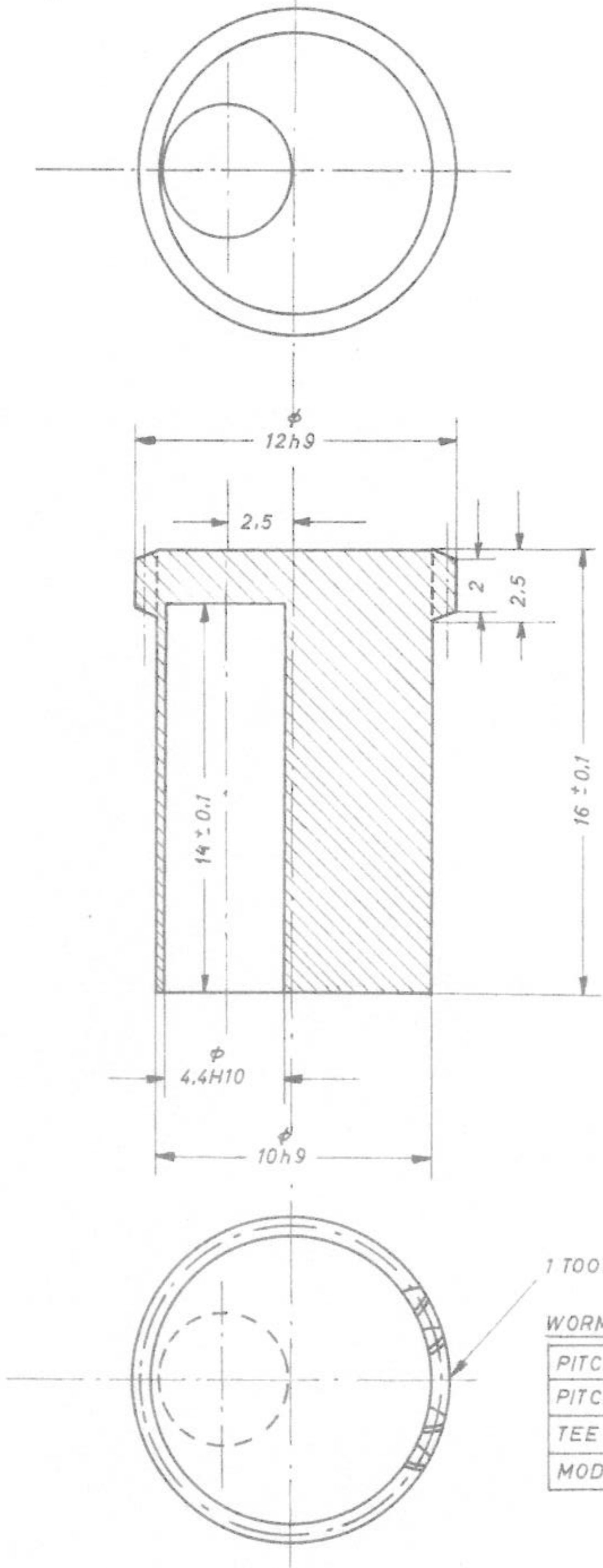


FIG. 3.3 OBSERVED TOTAL DAMAGE AGAINST ERECT TARGETS IN SNOW AS A FUNCTION OF HEIGHT OF BURST.



RELAXED DIMENSION

Material: Piano wire 0,8 mm			
ARMING SPRING	Scale ~4:1	Drawn: C.H.	25.6.57
		Traced: A.M.	
		Ref:	
NORWEGIAN DEFENCE RESEARCH ESTABLISMENT DIVISION T	Supersedes:		
	84T1-504S1		
	Superseded by:		



1 TOOTH ELIMINATED

WORM WHEEL DATA:

PITCH DIAM.	11mm
PITCH ANGLE	5,5°
TEETH NUMBER	22
MODULUS	0,5mm

Material: Duraluminum

ARMING ROTOR	Scale 4:1	Drawn: W.H.	3.10.56
		Traced: Å.S.	
		Ref:	

NORWEGIAN DEFENCE RESEARCH ESTABLISHMENT

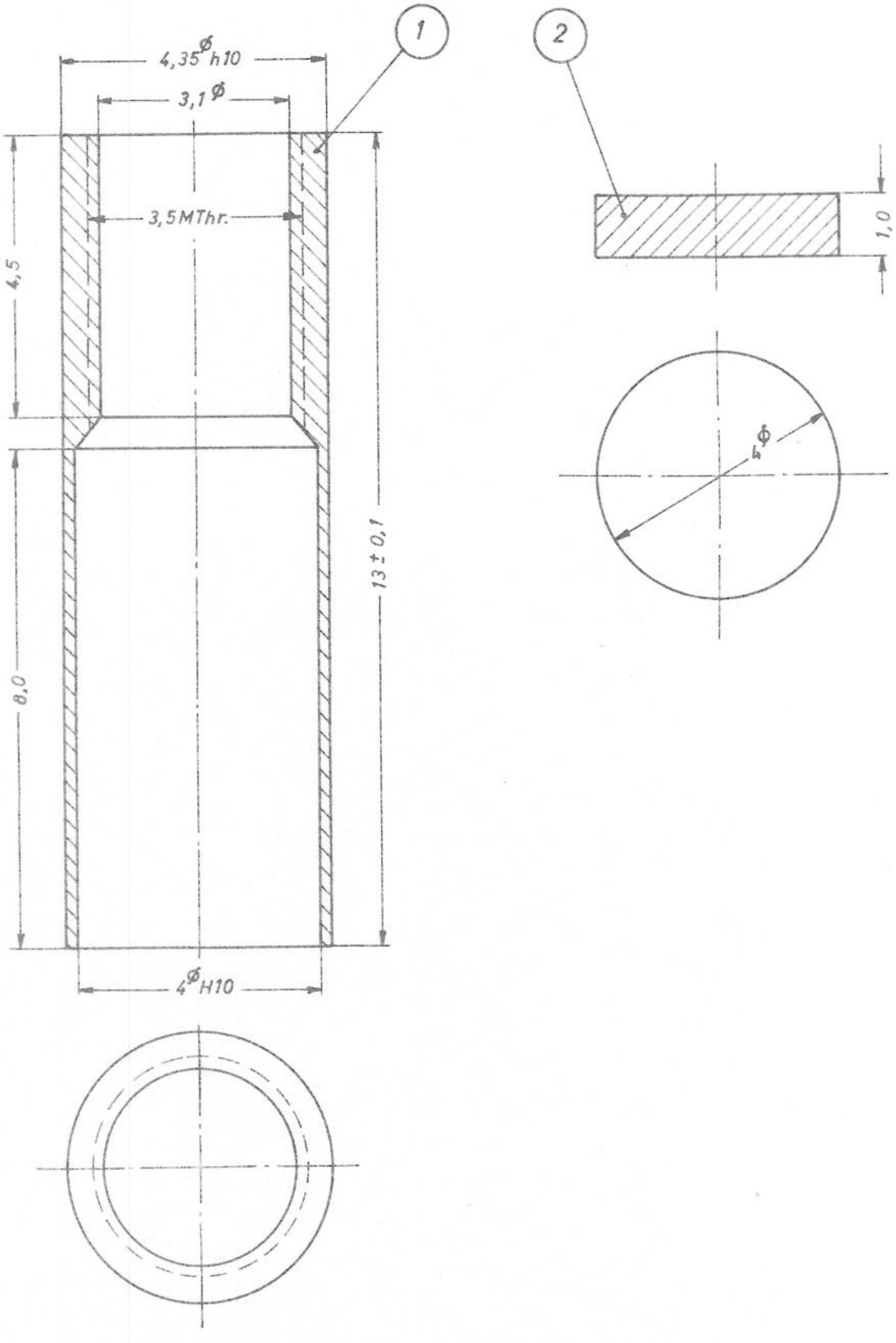
DIVISION T

Supersedes: 84T1-505

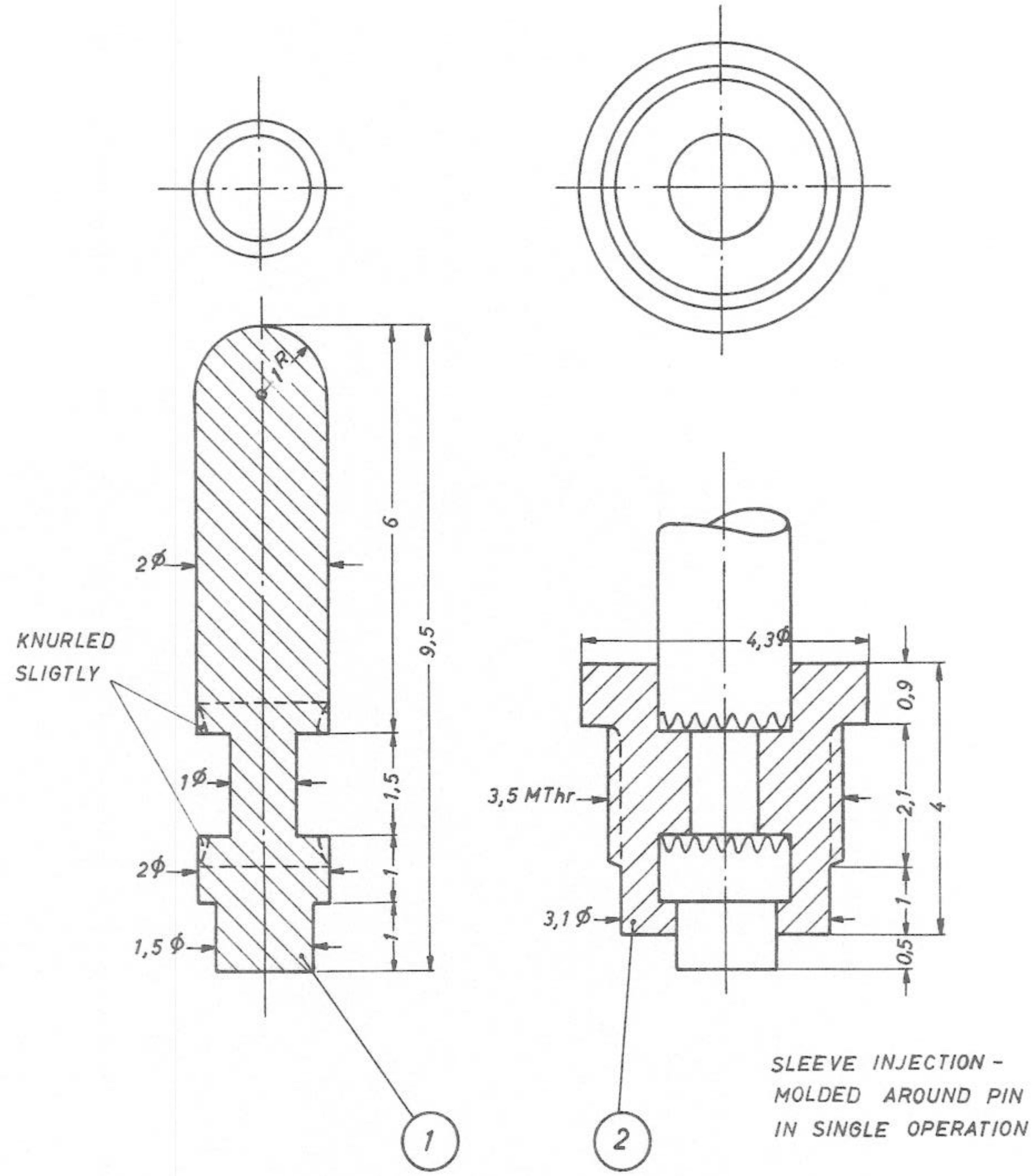
84T1-505S1

6.57

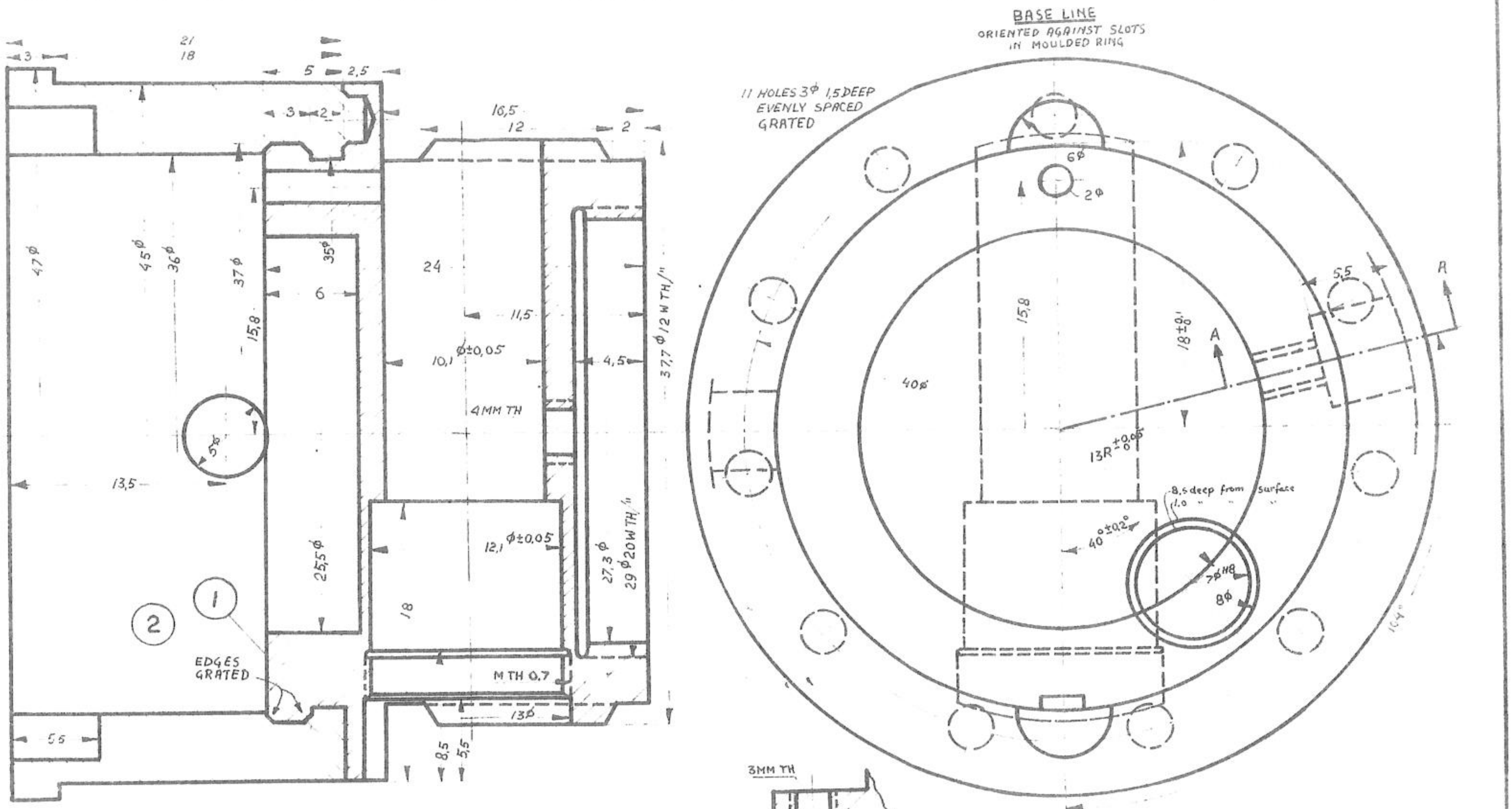
Superseded by:

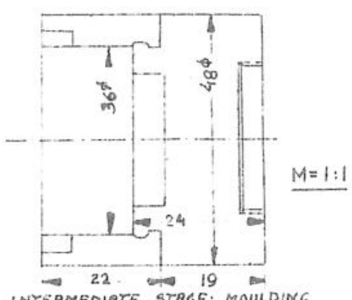


Closing plug	2	Aluminum		
Detonator tube	1	Dural		
Item	No	Material		
DETONATOR CASING		Scale 10:1	Drawn: C.H.	25.6.57
			Traced: A.M.	
			Ref:	
NORWEGIAN DEFENCE RESEARCH ESTABLISHMENT DIVISION T		Supersedes:		
		84T1 - 508S1		
		Superseded by:		

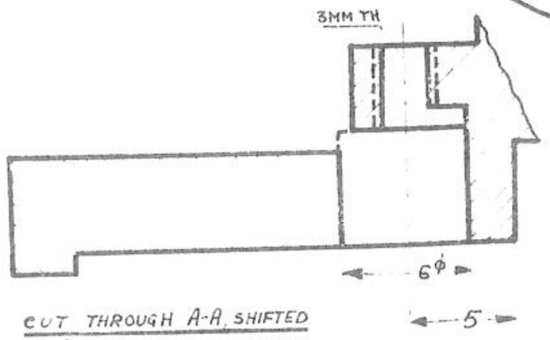


Insulating sleeve	2	Akulon		
Detonator pin	1	Dural		
Item	No	Material		
COMPOSITION MIX ASSEMBLY		Scale	Drawn: C.H.	25.6.57
		10:1	Traced: A.M.	
			Ref:	
NORWEGIAN DEFENCE RESEARCH ESTABLISHMENT		Supersedes:		
DIVISION T		84T1-509S1		
		Superseded by:		





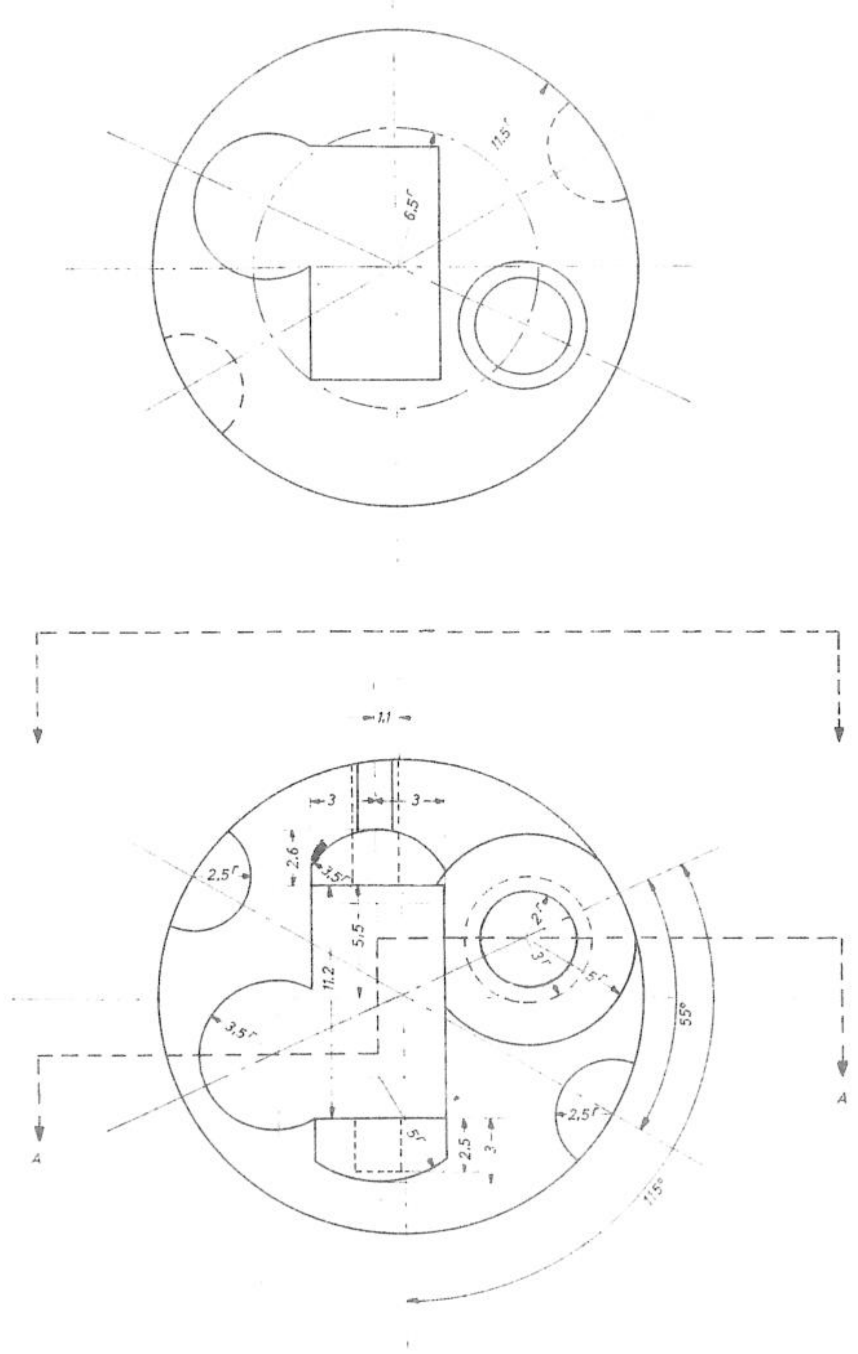
INTERMEDIATE STAGE: MOULDING OF MODULENE RING ON DURAL INSERT

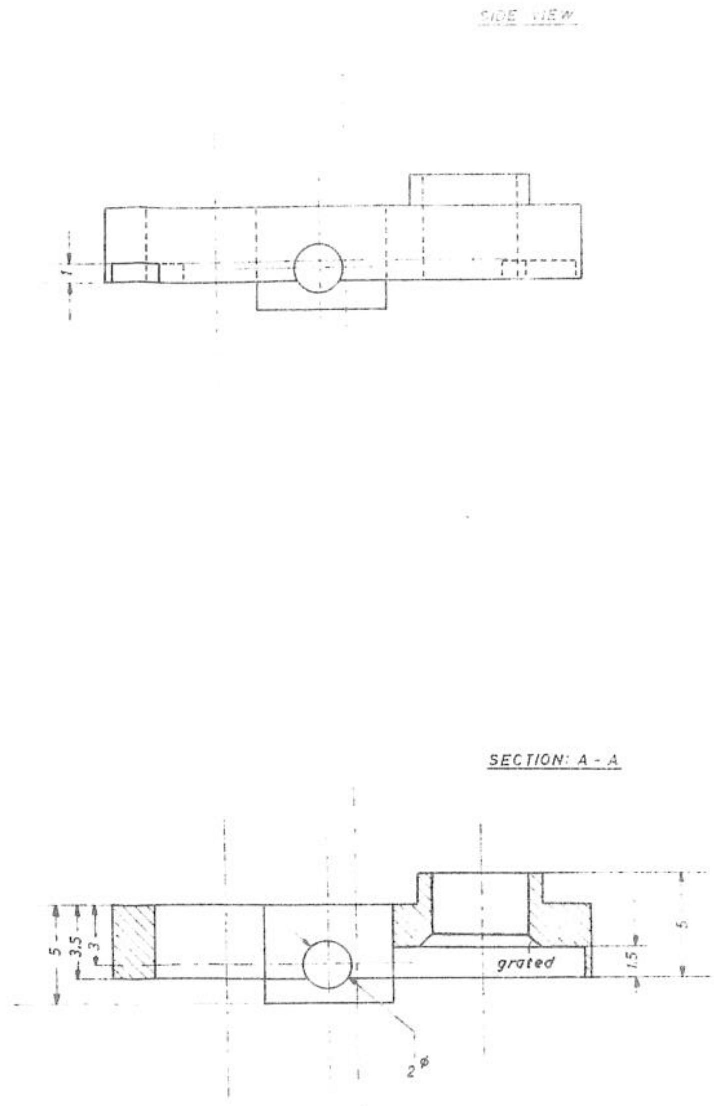


CUT THROUGH A-A, SHIFTED 104° OF PROJECTION PLANE

Antenna ring	2	Super modulene
Screw base	1	Dural
Item	Nº	Material

FUZE BASE	Scale 4:1 (1:1)	Drawn by	
		Traced by	24.12.56
		Ref	
NORWEGIAN DEFENCE RESEARCH ESTABLISHMENT DIVISION T	Supersedes 84T1-501		
	84T1 -501S1		
	Superseded by		





Material: Injection-Moulded Akulon			
GEAR MOUNTING PLATE	Scale 4:1	Drawn A S	19.10.56
		Traced Å S	
		Ref	
NORWEGIAN DEFENCE RESEARCH ESTABLISHMENT DIVISION T	Supersedes 84T1-201		
	84T1-201S1		
	Superseded by		

CONDITIONING:

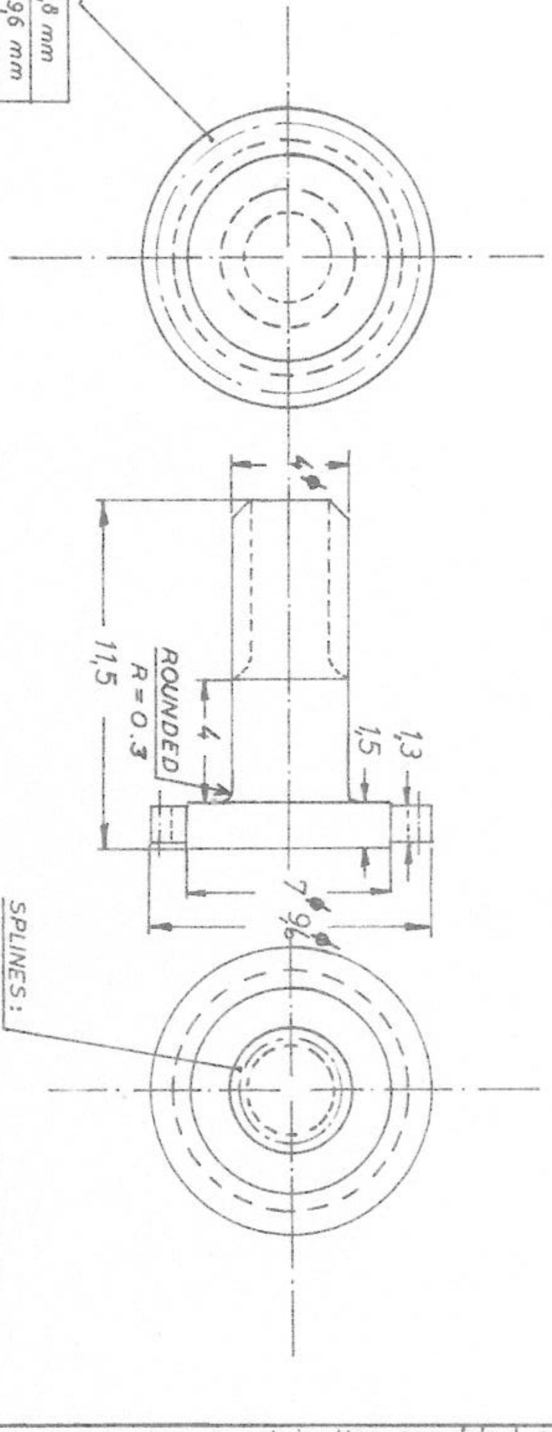
1/2 HOUR IN MINERAL OIL 140°C

1/2 HOUR IN WATER 100°C

ALL DIMENSIONS AFTER CONDITIONING

WORM WHEEL DATA:

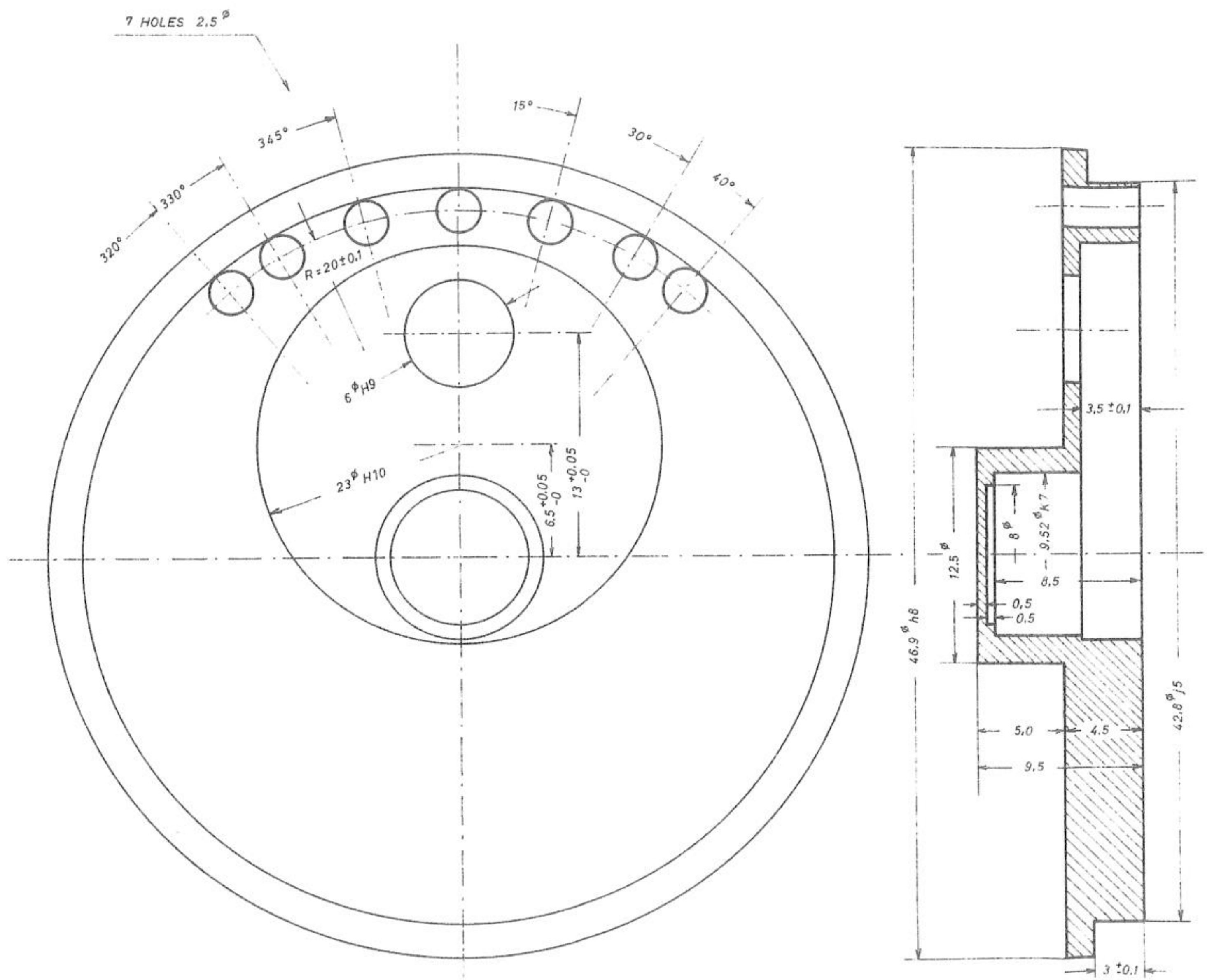
PITCH DIAMETER	8,8 mm
OUTSIDE DIAMETER	9,6 mm
MODULUS	0,4 mm
TEETH NUMBER	22



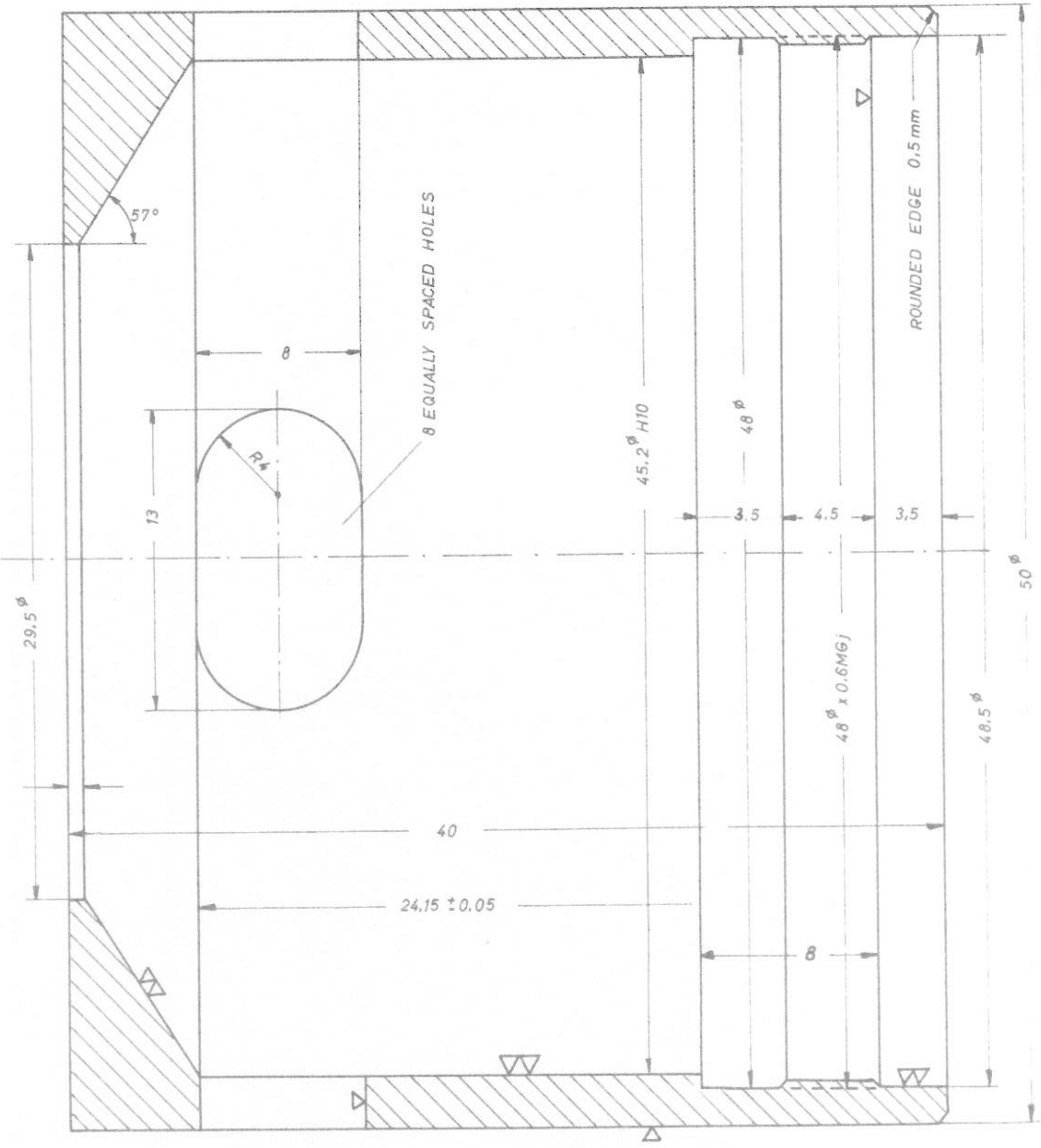
SPLINES:

OUTSIDE DIAMETER	4 mm
INSIDE DIAMETER	2,8 mm
SPLINE NUMBER	10
MODULUS HOB	0,4 mm

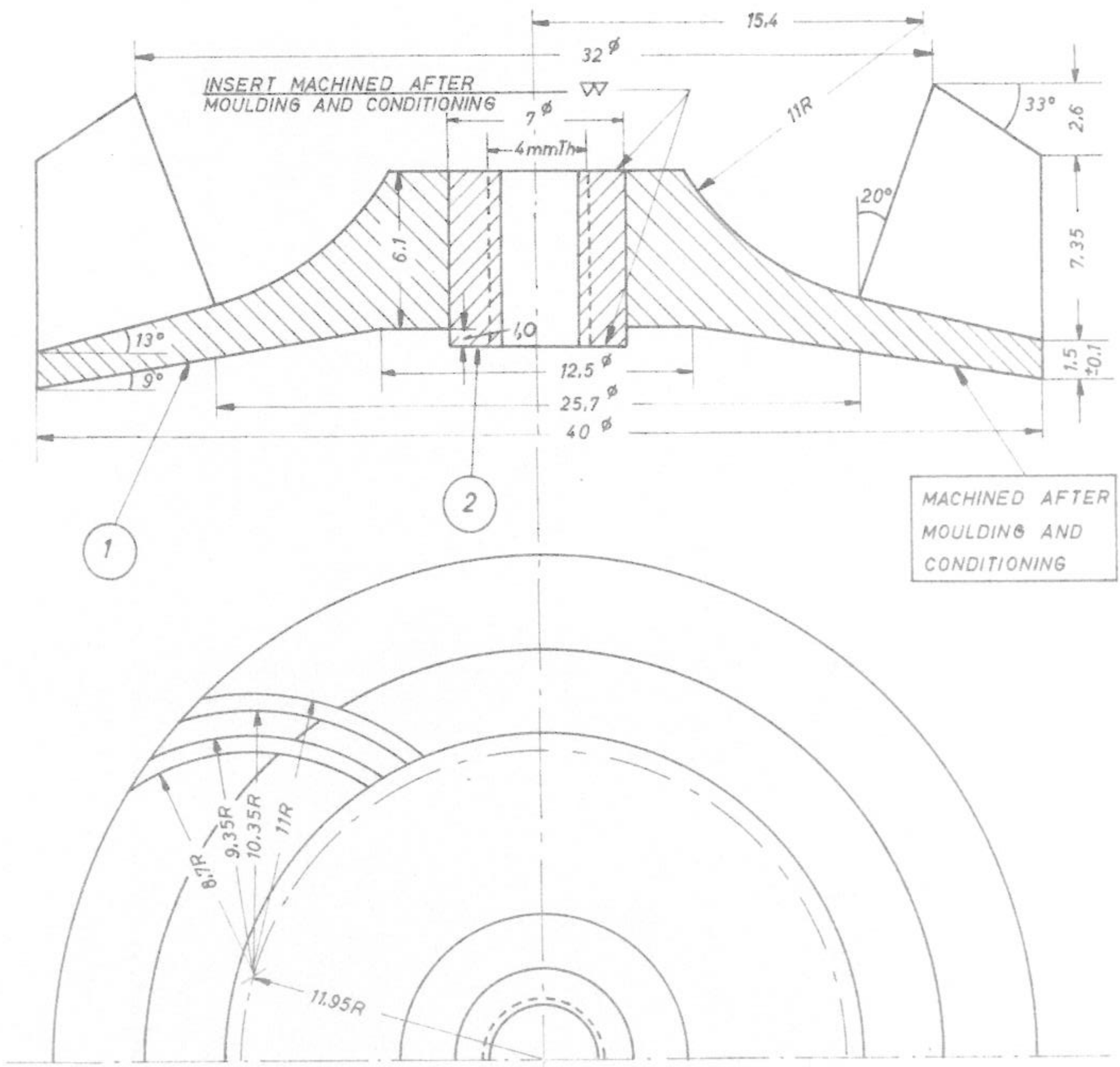
Material: Injection-moulded akulon			
WORM WHEEL	Scale 4:1	Drawn: 18.4.56	KHH+E S
		Traced:	[illegible]
		Ref:	
NORWEGIAN DEFENCE RESEARCH ESTABLISHMENT. DIVISION T	Supersedes: 84TI-204		
	84TI-204S1 6.57		
	Superseded by:		



Material: STEEL			
GENERATOR BEARING FIXTURE	Scale 4:1	Drawn: A S	
		Traced: Å S	
		Ref:	
NORWEGIAN DEFENCE RESEARCH ESTABLISHMENT DIVISION 1	Supersedes: 84T1-102		
	84T1-102 S1 6.57		
	Superseded by		



Material: Brass			
TURBINE HOUSING	Scale 4:1	Drawn: 18.4.56	KHH+ES
		Traced:	Å.S.
		Ref:	
NORWEGIAN DEFENCE RESEARCH ESTABLISHMENT DIVISION T	Supersedes: 84T1-103		
	84T1-103S1 6.57		
	Superseded by:		

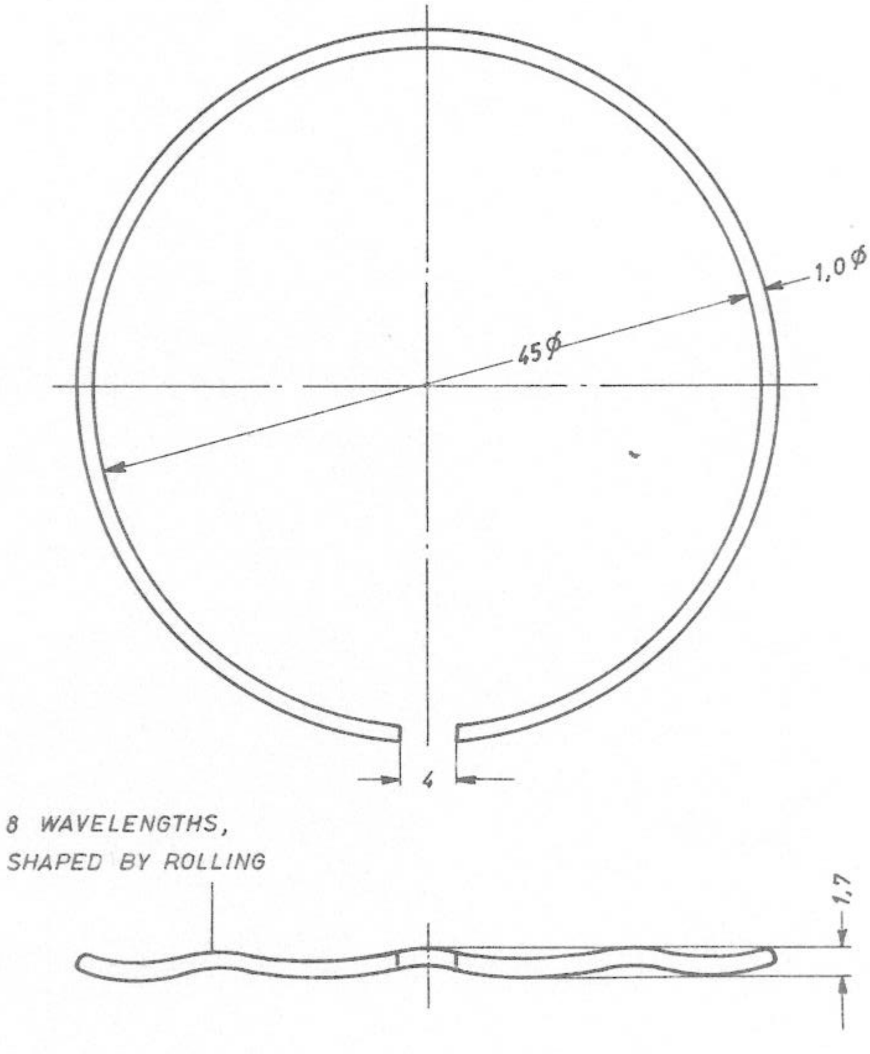


CONDITIONING:

1/2 HOUR IN MINERAL OIL 140° C
1/2 HOUR IN WATER 100° C
ALL DIMENSIONS AFTER CONDITIONING

1	Turbine	Material: Injection Moulded Akulon			
2	Insert	Material: Brass			
TURBINE		Scale 4:1	Drawn: 4.5.56	KHH+ES	
			Traced:	Å.S.	
			Ref:		
NORWEGIAN DEFENCE RESEARCH ESTABLISHMENT DIVISION T		Supersedes: 84T1-110			
		84T1-110S1 6.57			
		Superseded by:			

DIMENSIONS AFTER
ANNEALING PROCESS



Material: Piano wire 1 mm			
WAVY CIRCULAR SPRING	Scale 2:1	Drawn: C.H.	25.6.57
		Traced: A.M.	
		Ref:	
NORWEGIAN DEFENCE RESEARCH ESTABLISHMENT DIVISION T	Supersedes:		
	84T1-115S1		
	Superseded by:		