TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

No. 261

LIGHT AIRPLANES

Which Participated in Contest at Lympne, England, October, 1923.

Taken from "Flight," September 20, 27, October 4, 11, 18, 1923, and "The Aeroplane," April 4, September 19, October 17, 1923.

Compiled by the National Advisory Committee for Aeronautics.

May, 1924.

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The purpose of this memorandum is to present in a concise form a description, with drawings, of the most practical light airplanes participating in the meet at Lympne, England, in October, 1923.

Features, which are particularly suitable for this type of aircraft, are described and a special reference is made to achievements which indicate progress and possibilities both from a commercial and a military point of view. The order of presentation has been arranged according to efficiency in mileage attained on a gallon of gasoline and also in the order of other attainments by airplanes not entered for the economy test.

A tabulation is given in the individual drawings and inserts are added showing the rank in velocity and altitude flights. The diagram (Figure 12) gives the relative sizes in plan outline.

Appendix I of this memorandum refers to another light airplane which did not participate in the flights at Lympne.

Appendix II contains a set of drawings of four different propellers suitable for light airplanes.

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* Taken from "Flight," September 20, 27, October 4, 11, 18, 1923, and "The Aeroplane," April 4, September 19, October 17, 1923.

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"A.N.E.C." Monoplane.

The "A.N.E.C." light airplane (monoplane), entered by the Addlestone Aeronautical Association and H. Blundell, and manufactured by the Air Navigation and Engineering Company, attained the greatest mileage (87.5 miles) on a gallon of gasoline and also the greatest altitude (14,400 feet) and still further, finished second in the speed test, having made 74 M.P.H.

The wing contains but one spar which, in cross section, is a box-like triangular structure with plywood sides. This spar has been found to be remarkably efficient in resisting torsional and bending stresses.

A forward portion of the wing has a plywood covering.

Another unusual feature is in the shape of the plywood-covered fuselage. The sides are curved in at the wings, giving the pilot an angular view ahead on both sides, and with the triangular shape of the spar, he is able to see upward and also ahead at a reasonable angle.

In the landing gear the axle is hinged at the center, leaving the wheel ends free to move up or down in the elastic cords attached at the fuselage sides.

The wheels are made of wood with three-ply sides and with a laminated ash rim covered with leather.

The controls consist of the usual stick and foot bar and were found very satisfactory, except for an undue sensitiveness caused by a too highly-geared elevator.

A sooted plug of the engine was responsible for the forced landing of this airplane. This engine performed well in other airplanes and whether or not the trouble was due to the inverted position of the engine is difficult to determine at this time. Figure 1 contains outline drawings and a tabulation of dimensions, areas, etc.

"Wren" Monoplane.

The "Wren" light airplane (monoplane), entered and built by the English Electric Company, two in number, competed in the mileage per gallon of gasoline contest, one tying with the A.N.E.C. making 87.5 miles, and the other finishing second with 82.5 miles. These airplanes did not take part in the competition for altitude or speed.

All parts were designed to meet the standard safety factors of the Air Ministry.

The fuselage is of the orthodox construction reinforced at points where attachment for wings, landing gear, etc., are made.

The main spars, of substantial box section, are of spruce with a special form of internal bracing which gives great torsional stiffness. The upper surface of the leading edge of the wings is covered with three-ply while the entire covering is of a special light fabric doped with Titanine glider dope and finished in aluminum.

The tailplane, elevator fin and rudder are of substantial build, following standard constructional methods. The controls,

which are very efficient, also follow the approved standard practice.

The power is quite adequate for cross-country flying, except in very strong opposing winds, and is sufficient for a quick take-off from a reasonably level field. The inward position of the wheels not only reduces head resistance but enables a landing on rough or plowed fields without risk of turning over which would be almost inevitable with the usual type of landing gear.

The forward portion of the fuselage bottom is protected by a three-ply covering. This feature also serves as a braking surface and preceded by a low land speed of 25 M.P.H. brings the airplane to a standstill within a few yards.

The controllability is perfect even at speeds probably near 20 M.P.H. as shown in the splendid performance exhibited in the so-called "crazy-flying." This airplane was not entered as a racer, the high speed being probably not over 50 M.P.H. The engine is operated at a comparatively low speed thus insuring reliability and durability.

Figure 2 contains the outline drawings and tabulations.

"Handasyde" Monoplane.

The "Handasyde" (monoplane) entered by F. P. Raynham and manufactured by the Air Navigation and Engineering Company, Ltd., ranked third in mileage (65.7 miles) per gallon of gasoline. It did not take part in the speed contest and did not attain a

noteworthy height in the altitude competition.

The large spar is a plywood-covered box which gives good rigidity and especially efficient resistance to torsion.

The fuselage is covered entirely with plywood and the wing and tail unit with fabric.

A very satisfactory gravity feed is provided in the relative location of the gasoline tank to the carburetor.

Controls, of the usual type, are employed.

Figure 3 gives tabulations and the outline drawings.

"Avro" Monoplane.

The "Avro" type 560 (monoplane) is a product of A. V. Roe & Company. This airplane finished fourth in mileage per gallon of gasoline making 63.3 miles. It also won the prize offered for the greatest total mileage covered during the meeting, having flown 80 laps of the course reaching a total distance of 1000 miles. It also made a non-stop flight of 125 miles.

The fuselage construction is similar to that employed in the usual biplane, the covering being of fabric. In form it is very well streamlined.

The wings are biconvex in section somewhat similar to the N.A.C.A. Nos. 73 and 81 with a special light linen fabric covering doped with Titanine glider dope.

Two spars are used and are of built-up box-section with flanges of solid spruce and walls of double diagonal spruce skins. This, it was found, provided an extremely rigid structure.

In the rib construction the T-section spruce flanges are secured together by means of corrugated duralumin struts and stays. The drag bracing is constructed of spruce arranged in the form of a Warren girder. Long push-and-pull rods are employed in the operation of the elevators. Rudder operation is accomplished by means of pedals instead of the usual foot-bar.

An interesting feature in this airplane is in the position of the airspeed indicator which is mounted at the junction of the left wing to the fuselage, remaining there without being disturbed in any way when the airplane is disassembled. A tabulation and drawings in outline of this airplane are given in Figure 4.

"DH-53" Monoplane.

The "DH-53" light airplane, a product of the DeHavilland Aircraft Company, Ltd., is the first light airplane, on record, to have completed a loop. It also performed a series of Immelmann turns and some general stunt flying, receiving generous applause from the spectators upon landing. In the mileage per gallon of gasoline competition it ranked fifth, having attained 59.3 miles. In the speed contest it finished sixth with 57.5 miles per hour.

From the viewpoint of durability and maneuverability this airplane demonstrated that a light airplane can be a very dependable and satisfactory training airplane.

In the construction of the fuselage a three-ply covering is

used which is secured in such a way that the usual wire bracing is not required.

Buckling due to moisture, resulting from rain during the meet, was scarcely perceptible in this structure.

Steel tubing is used instead of the spruce cross struts where the wing bracing struts are attached to the fuselage.

The two wing spars are box-shape with spruce flanges and three-ply walls. The R.A.F. 15 airfoil section is used approximately at the junction of the straight leading edge to the curved tip, the ordinates then being increased as the wing becomes thicker.

The ribs are of the usual design and are made of spruce, while the compression struts are I shape in cross section.

A differential control is used for the ailerons, giving the upward travel a greater angle than the downward. A very effective silencing of the engine is accomplished in the use of a Y shape exhaust with a long curved collector pipe extending well back under the fuselage. Figure 5 contains outline drawings and tabulations.

"Hurricane" Monoplane.

The "Hurricane" (monoplane), a product of the R.A.E. Aero Club, did not participate in the mileage per gallon or the altitude contest.

It was apparently entered for speed only and finished third in that event, making 58.5 miles per hour. A broken rocker arm

of the engine was responsible for the forced landing of this airplane.

The landing gear consists simply of a steel leaf spring placed across the bottom of the fuselage with the wheels attached to its ends.

The control stick construction is quite unusual in this airplane, due no doubt to the very unusual shape of the fuselage.

Tabulations and outline drawings are given in Figure 6.

"Viget" Biplane.

The "Viget" (biplane) designed by the chief engineer of Vickers Limited and built by them, was characterized as an exceptionally fine piece of work.

This light airplane, a perfect orthodox biplane, finished fourth in the speed contest making 58.1 miles per hour.

It was the first airplane to take the air at the meet and it climbed with remarkable speed.

The fuselage is fabric covered and the framework consists of wire-braced girders with spruce longerons and struts. The longerons are of small square section while the struts are routed out to a cruciform section.

Specialfittings of duralumin straddle the longerons, avoiding the usual drillings for bolts, and are held in place by small wood screws.

A fireproof bulkhead is installed immediately back of the

engine housing. The engine is supported by longerons of steel tubing and is mounted sufficiently low to give a gravity feed from the gasoline tank mounted in the deck fairing behind the bulkhead.

The controls are of the usual type for biplanes. The control stick is of duralumin tubing.

A complete set of instruments is carried.

The propeller is chain driven with a $2\frac{1}{2}$ to 1 reduction. Ball thrust bearings are used.

Constructionally the wings are of the standard design, wood and fabric, with the R.A.F. 15 airfoil section. The only unusual feature is in the wing-length ailerons and their hinging, the upper ailerons being hinged at the top corner and the lower ailerons at the bottom corner of their respective spars.

Provision is made for adjustment of the tailplane while the airplane is on the ground.

The struts of the landing gear are made of streamline steel tubing. Figure 7 will give the usual outline drawings and tabulations.

"Avro 558" Biplane.

The "Avro type 558" (light biplane) entered and built by A. V. Roe & Company, is of special interest in that this firm is not new in the design and construction of low-powered airplanes.

This biplane finished second in the altitude contest, having reached 13,850 feet.

The main features are perhaps in the high aspect ratio, the pronounced stagger and the construction of the I struts. The struts are of solid spruce with slotted ends into which are inserted and riveted the V shape duralumin plates.

The internal construction of the wings is of the standard type, the spars being box-shaped of spruce, and the ribs of spruce with three-ply webs. The leading and trailing edges are formed by steel tubing of small diameter.

The fuselage is of a somewhat unusual construction in that it consists of four longerons braced with diagonal struts forming a Warren girder, the struts being attached to the longerons by three-ply plates. The top longerons form a straight horizontal line, and the main structure of the fuselage is fairly shallow. The required depth for the fuselage is obtained in the use of an additional false top or deck of spruce stringers supported on three-ply formers. Fabric is used entirely as the covering.

The propeller shaft, which is above the crankcase and magneto, revolves in ball bearings driven by chain at a reduction of $2\frac{1}{2}$ to 1.

Fuel and oil are carried in a twin tank mounted on top of the longerons, immediately behind the engine, affording sufficient head for a gravity feed.

Rudder operation is accomplished by means of pedals instead of a foot bar.

In flight it was shown that the inherent stability of this airplane was especially good. The outline drawings and tabulation are given in Fig. 8.

"Gannett" Biplane.

The "Gannet" (light airplane) manufactured and entered by the Gloucestershire Aircraft Company, Ltd., failed to take part in the contest at all, on account of a refractory engine. A very complete description of this airplane is available and is given with this memorandum, believing it will be of value to designers who may be interested in this type of aircraft.

The general design, it will be seen, follows that of the orthodox biplane.

In order to meet the stipulations of the meeting the wings are made to fold back along the fuselage, the trailing portion of the central section having first been folded toward the leading edge.

The fuselage has flat sides and is covered with three-ply wood. The deck, which is fairly deep, is made of spruce stringers mounted on light formers with a fabric covering. A shallower fairing is used under the bottom of the fuselage.

A relatively deep profile is used and the wing structure conforms to standard design. The spars are of spruce with an I shape cross section. The ribs have spruce flanges and the compression struts have three-ply cut out webs. Streamline steel tubing is used as struts between the upper and lower wings with bracing of streamline wires run in the usual direction.

Access to the cockpit is had by the raising of the trailing portion of the central section, which is afterward lowered to its

original position and locked.

A fireproof bulkhead is provided between the engine and cockpit. The engine is not operated at extremely high speeds making the use of a reduction drive unnecessary. The engine is a two-cylinder vertical two-stroke type. As seen from the drawings, the cowling over the nose is well formed and should hold the resulting drag to a minimum.

The position of the gasoline tank in the upper central section affords a good head for the gravity feed. Figure 9 contains the outline drawings and tabulations.

"Peyret" Monoplane.

The "Peyret" (monoplane) constructed by L. Peyret proved to be an excellent climber having reached 9400 feet, third in the altitude competition. Structurally, however, it met with serious misfortune when returning from a second flight - an effort to surpass other records. At a height of but 100 feet the wings collapsed completely, causing the structure to fall rapidly to the ground, killing Mr. Maneyrol, the pilot, instantly.

The designer who witnessed the accident was of the opinion that a down load on the front spar had created an extraordinary compression load on the brace struts, which had been designed principally to work in tension, causing the structure to fail.

Drawings in outline and tabulations are given in Figure 10.

Sayers-Handley Page Monoplane.

The Sayers-Handley Page (monoplane) entered by Major Bradshaw and built by the Handley Page Ltd., also experienced engine trouble and was compelled, as a result, to withdraw from the contest for distance - determined by the number of laps around the course. The cowling over the cockpit, containing but two look-out openings, was not received favorably, according to accounts, as it interfered seriously with the pilot's view.

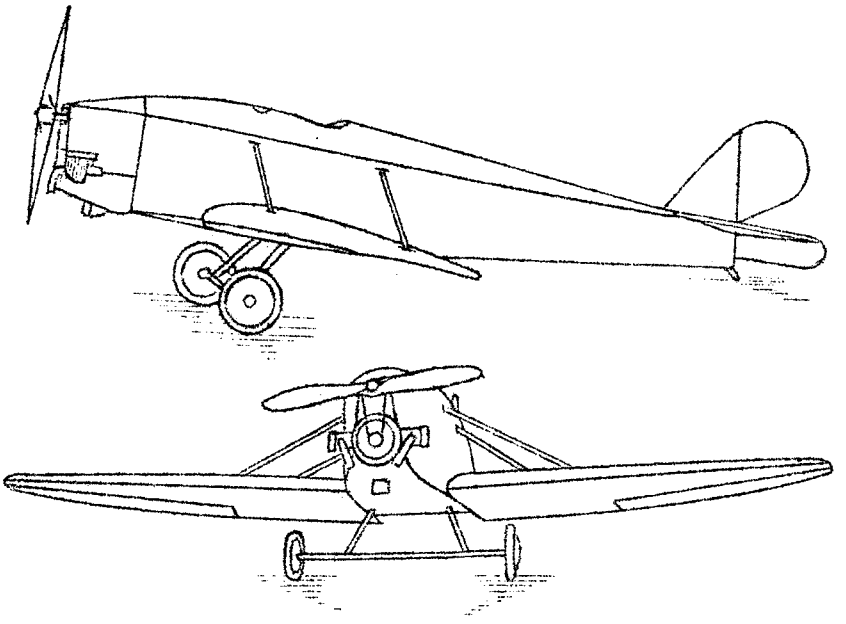
This airplane made some very successful flights after the meeting and an effort has been made to obtain information regarding its construction, aside from the plan and elevation drawings with tabulations in Figure 11, but without success. It appears, however, to be faster than some of the more successful airplanes. It lands at about the same speed and has probably at least as much reserve power.

The rudder control is not quite as good as might be wished but the elevator and ailerons are extremely effective.

Pixie II.

The Pixie II, a Geo. Parnall & Company product, attained the greatest speed during the meeting, having made 76.1 miles per hour. It is regrettable that there is very little information forthcoming either in descriptive matter, drawings, or tabulations, regarding this remarkable light airplane.

Two views, however, taken from halftone cuts, are given below.



The resemblance to the DH-53 light airplane is at once apparent. The span, it will be seen, is shorter, and the diagonal struts are parallel instead of converging.

The landing gear axle is also longer and with the shorter span of the wings the skids for the latter are not necessary.

The rear spar is built with a bend at the elevator from which point it extends to and joins the front spar at the wing tip.

The ailerons have a differential action.

A very neat adjustment is provided at the strut ends adjoining the fuselage. The tailplane is adjustable on the ground.

Belgian "Poncelet" Monoplane.

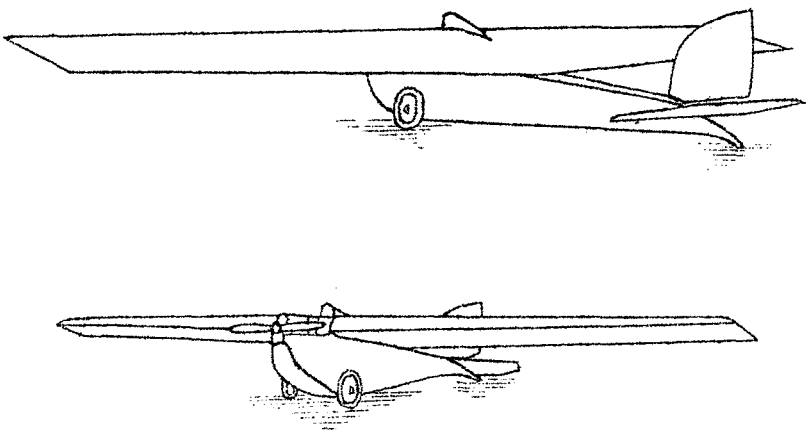
The Belgian "Poncelet" light airplane (monoplane) "Castar" and "Vivette" were entered by J. B. Rickard and G. A. de Ro, for the altitude contest. The "Castar" made an excellent start but there is no record as to the result of the altitude flight. In the matter of speed, however, it was found to have made 58 M.P.H., ranking fifth in this respect.

The "Vivette" was less fortunate. When it began to rise the pilot banked slightly to the left, at which time a gust of wind lifted the right wing. This produced a very sudden side-slip causing the airplane to drop violently upon and buckling the left wheel. Another gust of wind lifted the tail, landing the airplane on its back. The pilot happily escaped without injury.

An unusual feature in these airplanes is the position of the gasoline tank, which is located directly back of the pilot's head, forming the usual fairing at that point. In the accident this tank fairing provided the desired protection for the pilot's head, but had the gasoline leaked out and become ignited the pilot would have been in a very precarious position.

The usual outline drawings are not obtainable but the principal dimensions are: Length overall 21 ft. 6 in.; span 36 ft. 6 in.; wing area 215 sq.ft.

The sketch below was taken from halftone cuts



A 750 cm³ (45.77 cu.in.) Sergant 4-cylinder vertical air-cooled engine is used. Internal reduction gears are provided in this engine.

Fig.1.

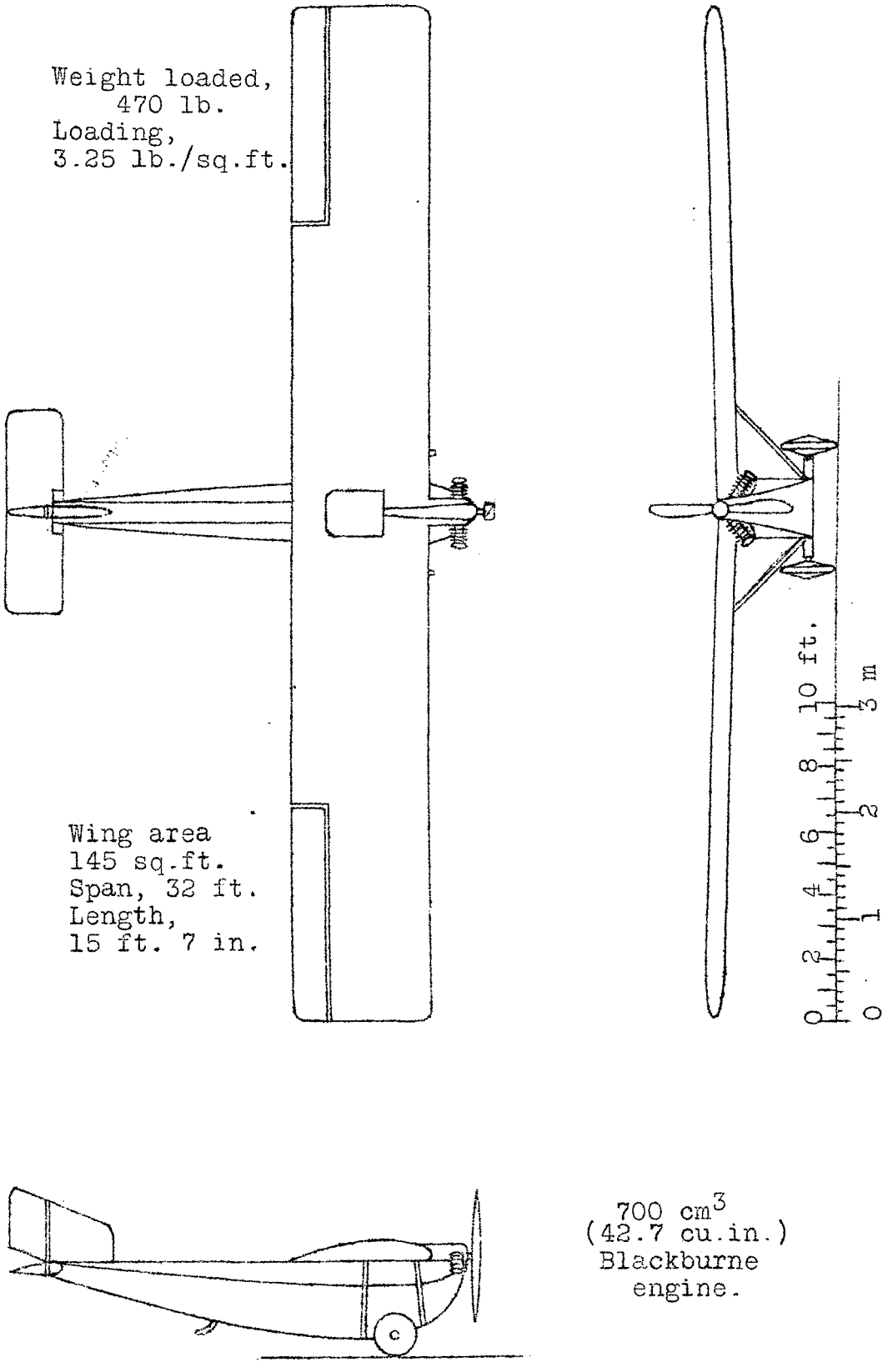


Fig.1, "A.N.E.C." light airplane.

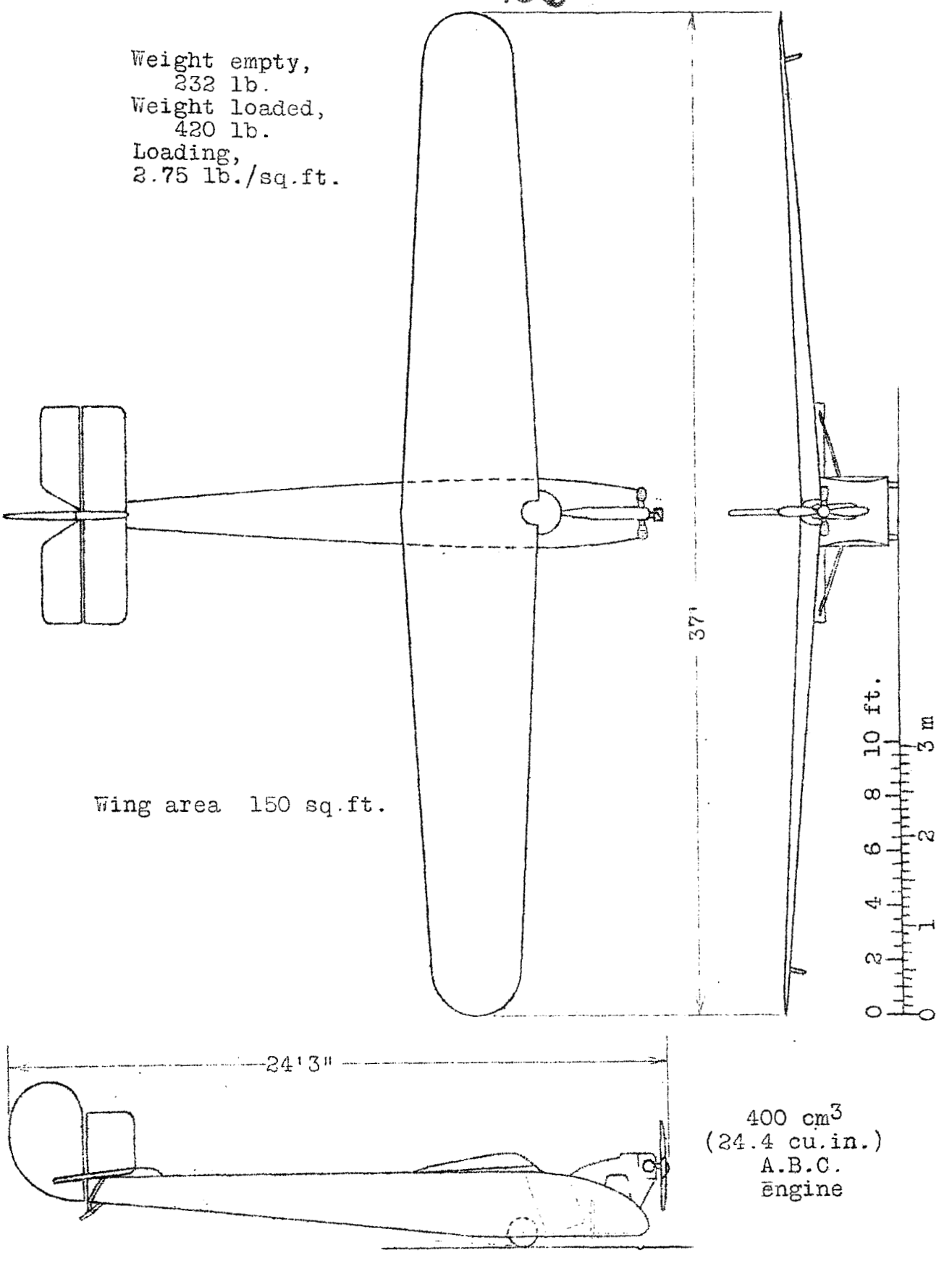


Fig. 2 The "Wren" light airplane.

Fig.3

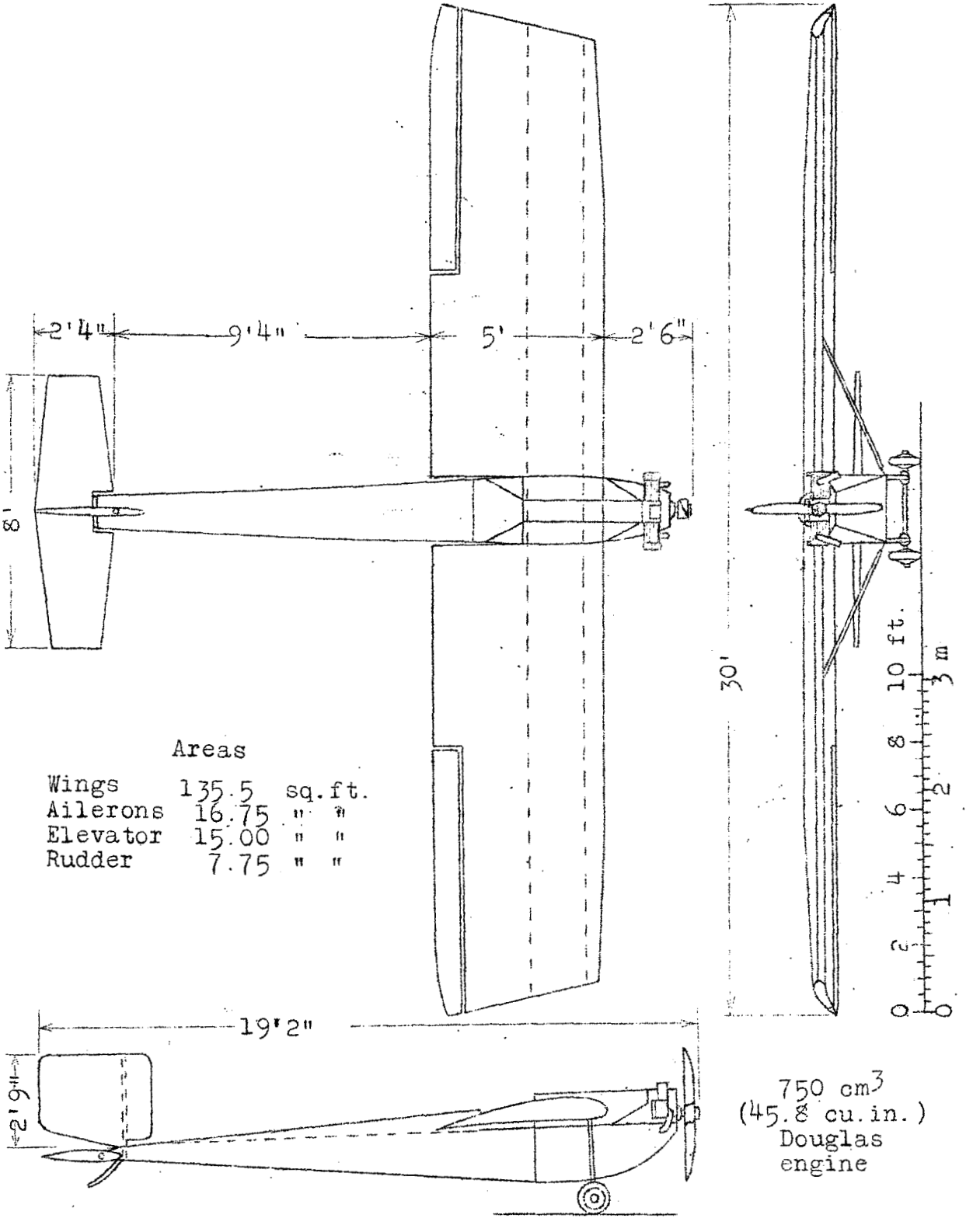


Fig.3 The "Handasyde" light airplane.

Fig. 4

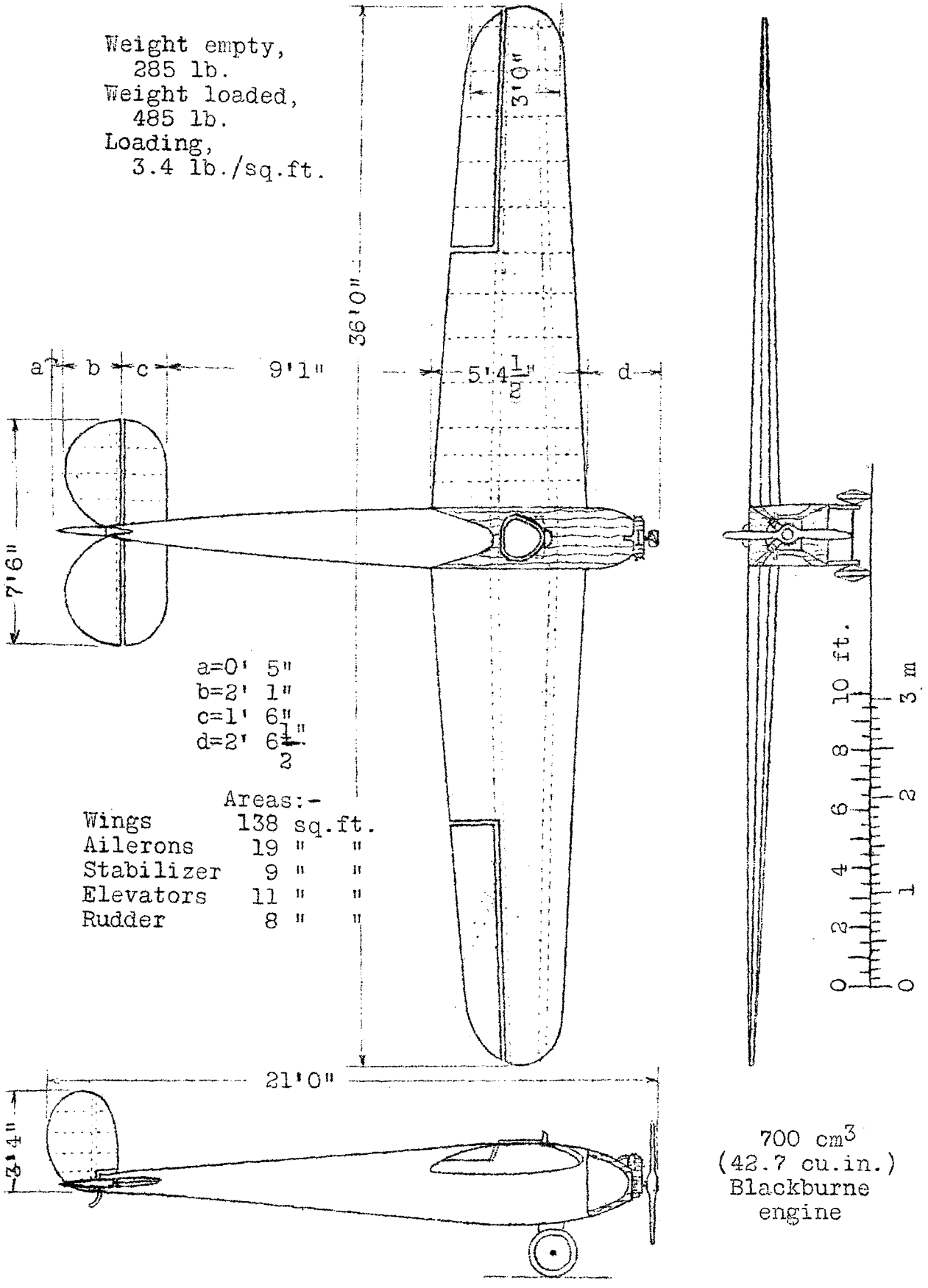
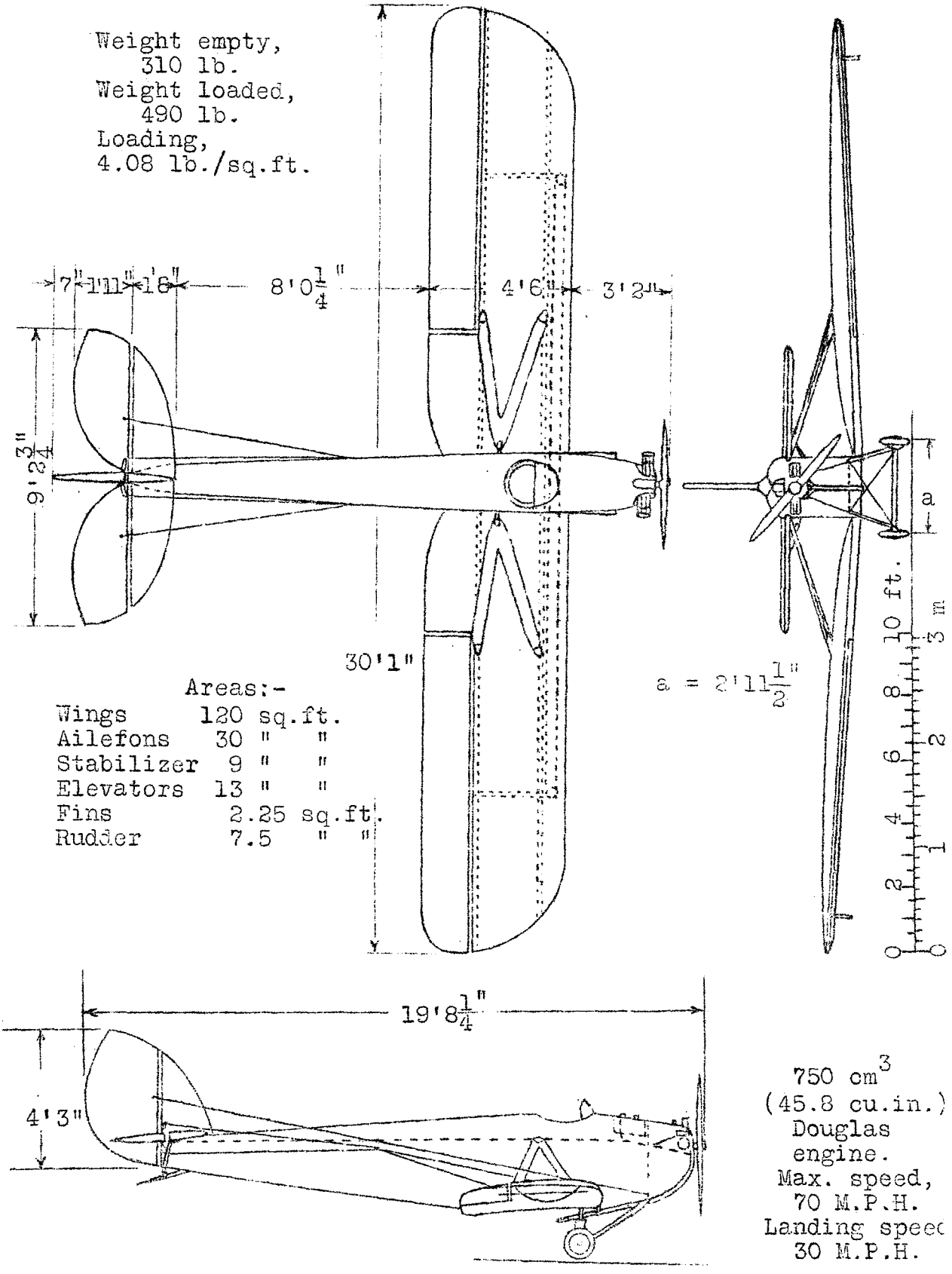


Fig. 4 The "Avro type 560" light airplane.

Fig.5.



Areas:-

Wings	120	sq.ft.
Ailefons	30	" "
Stabilizer	9	" "
Elevators	13	" "
Fins	2.25	sq.ft.
Rudder	7.5	" "

Fig.5. The "DH-53" light airplane.

Fig. 6

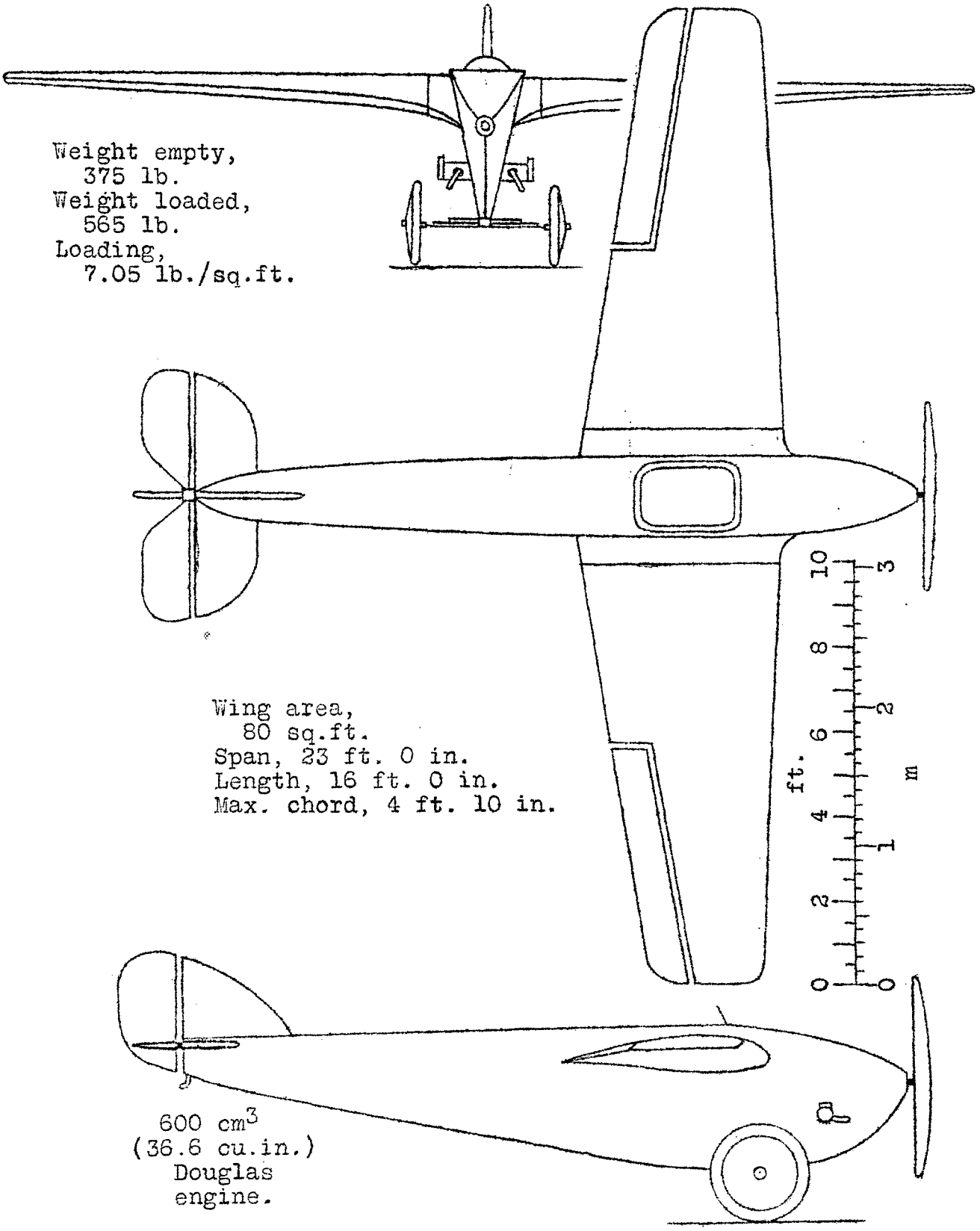


Fig. 6 The "Hurricane" light airplane.

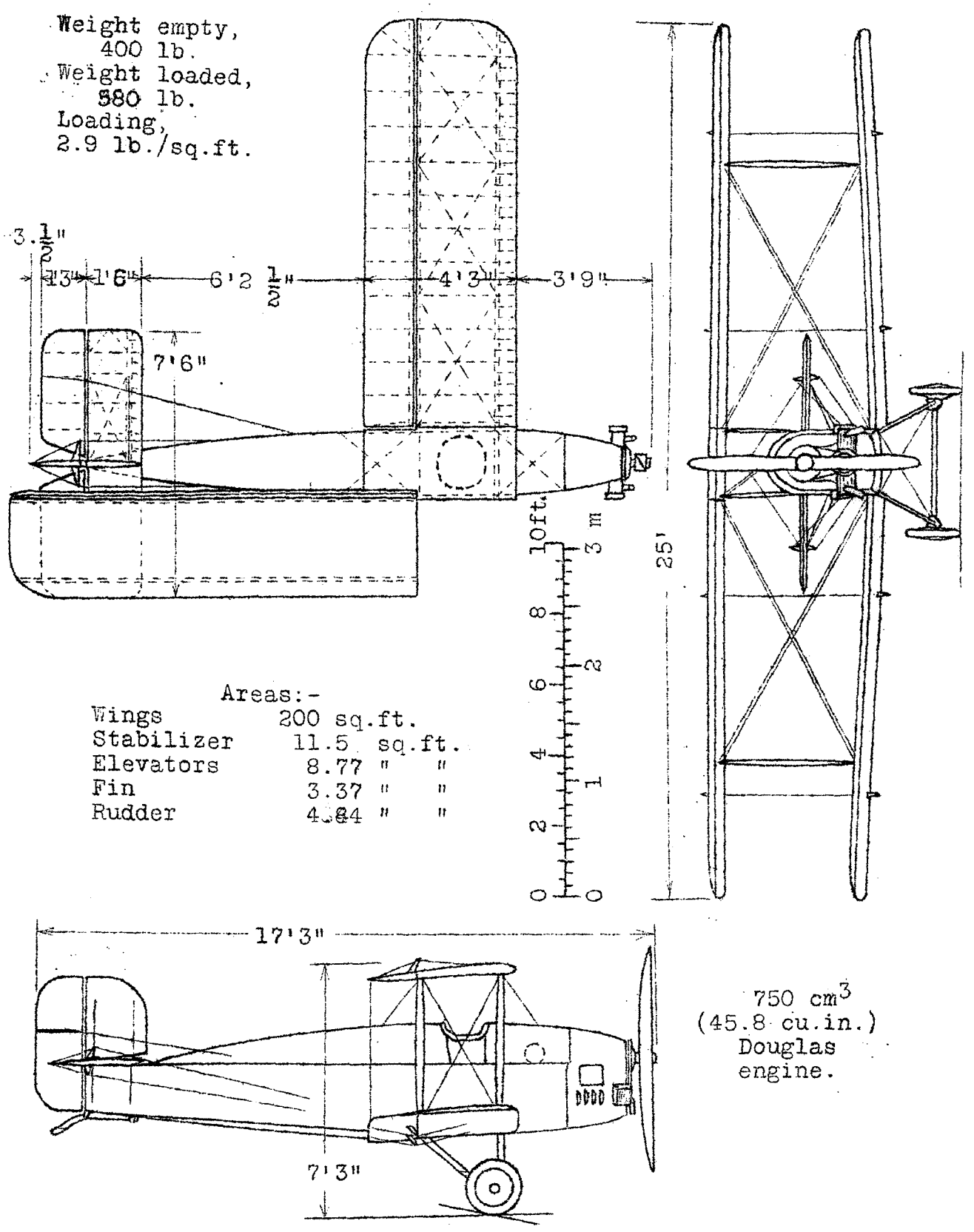


Fig.7 The "Viget" light airplane.

Fig. 8

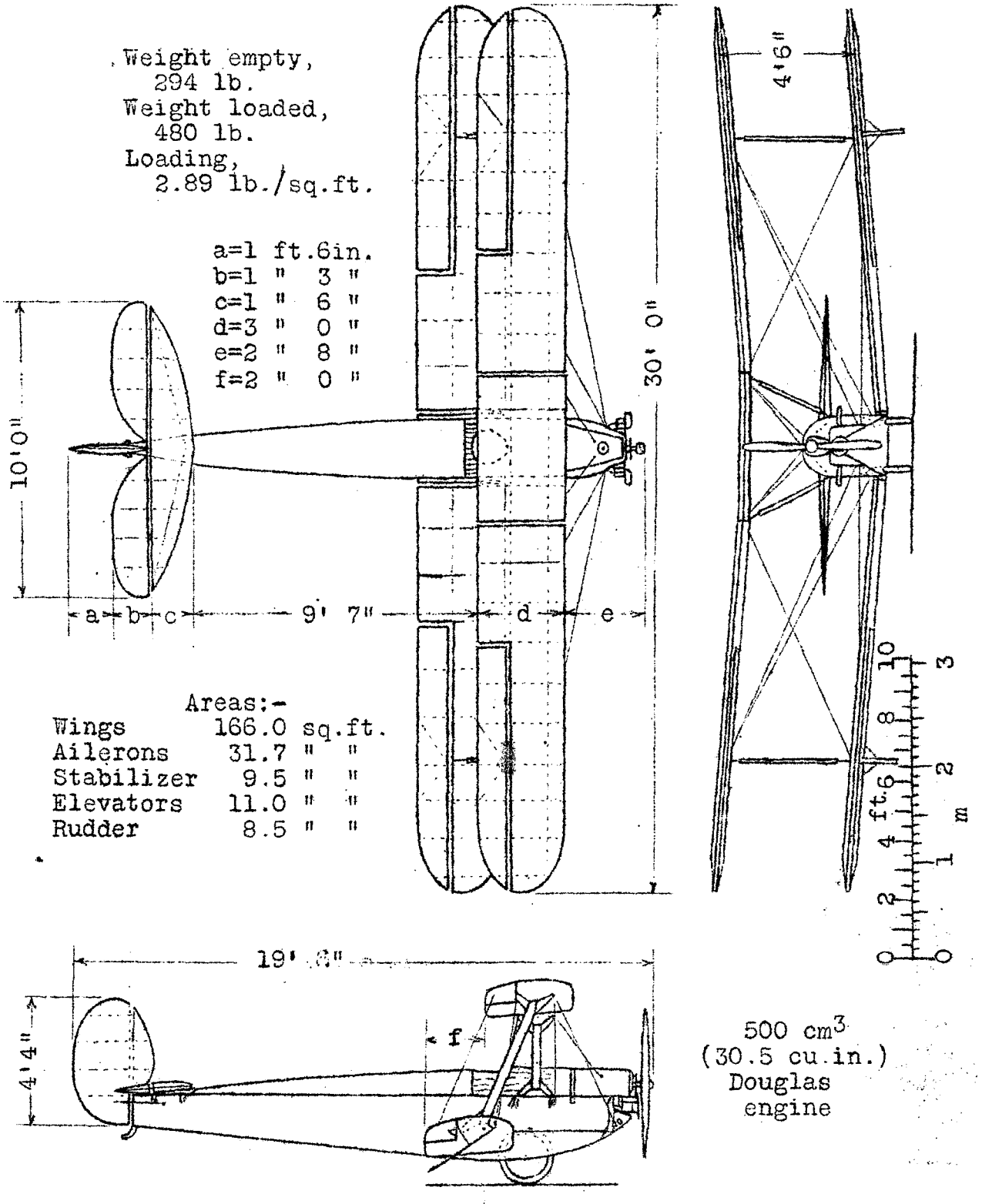
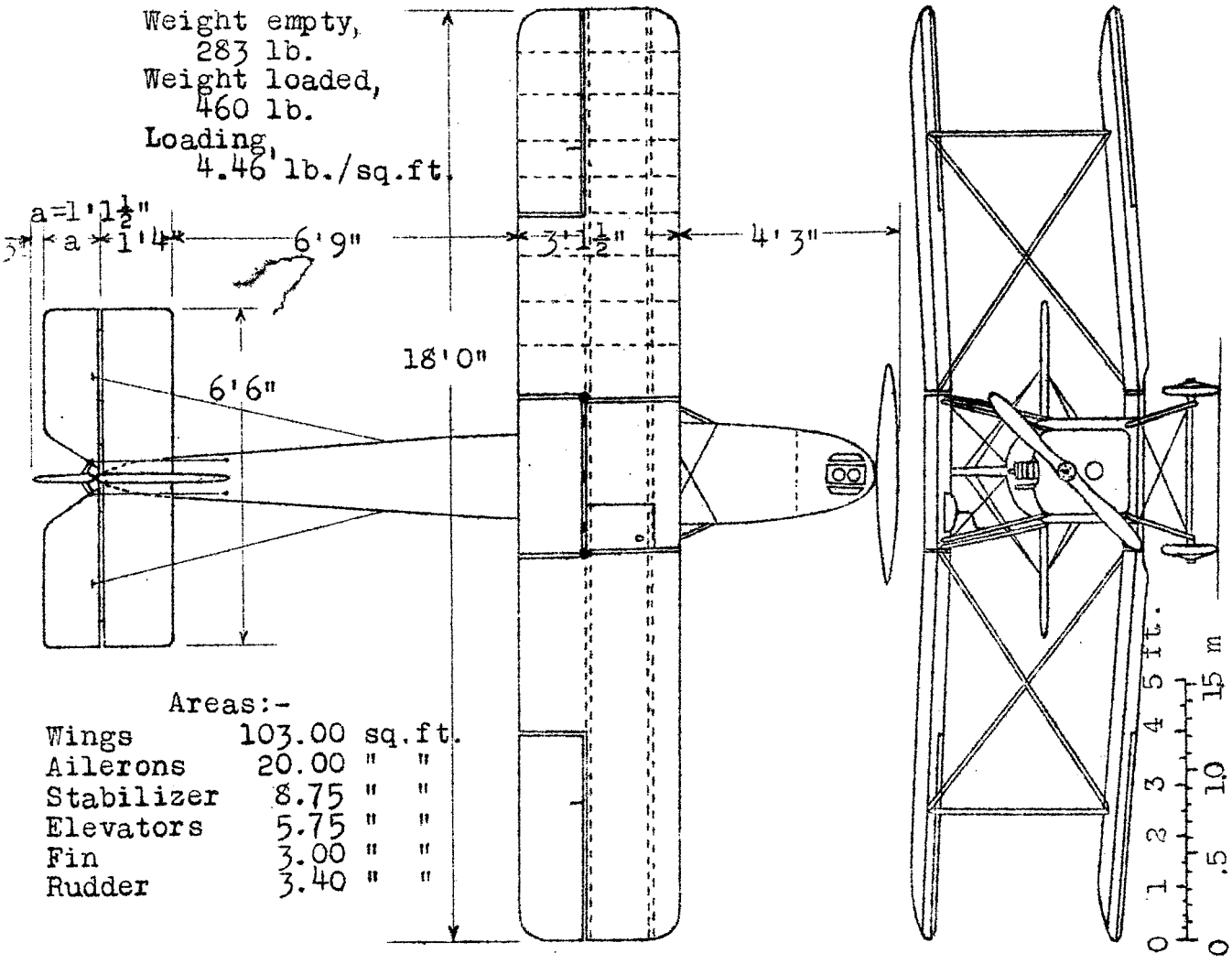
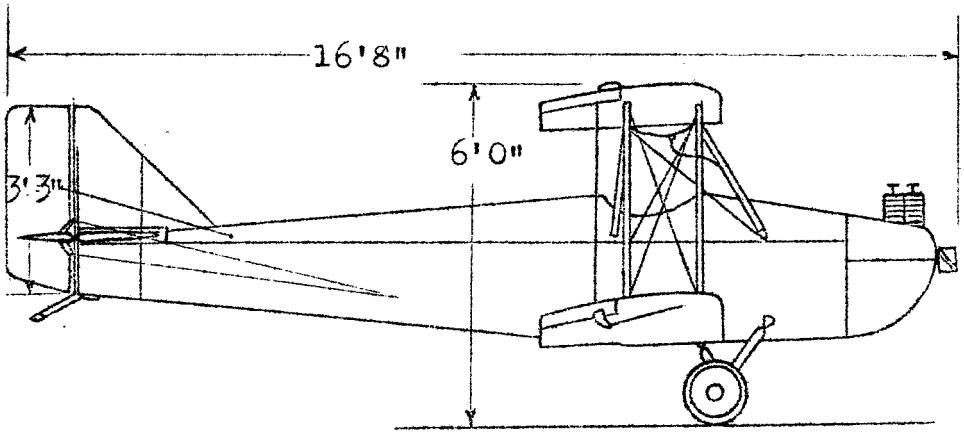


Fig. 8 The "Avro type 558" light airplane.

Fig.9.





750 cm³
(45.8 cu.in.)
Two stroke,
low speed,
Carden
engine.

Fig.9. The "Gannet" light airplane.

16 J

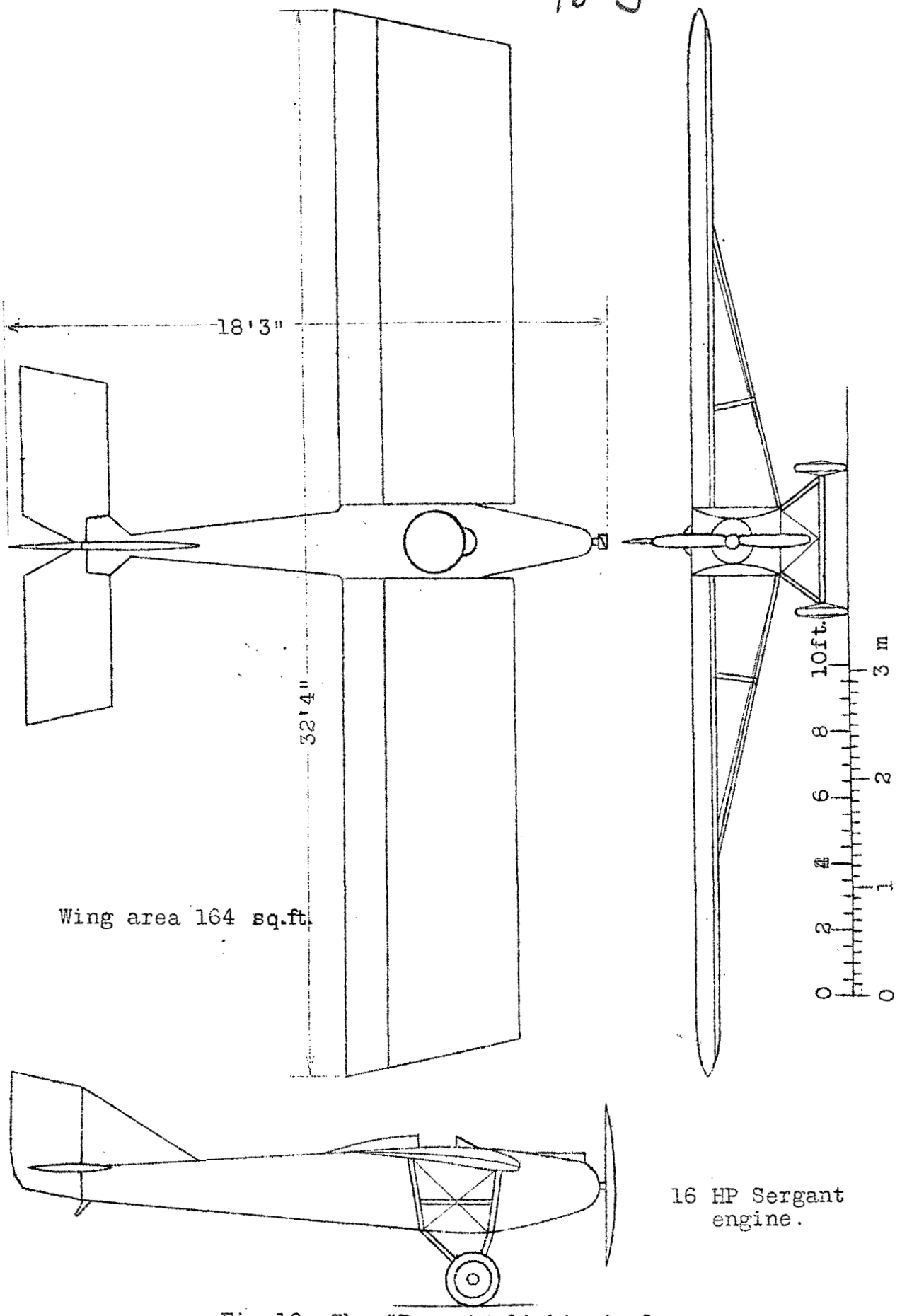


Fig.10 The "Peyret" light airplane.

16 K

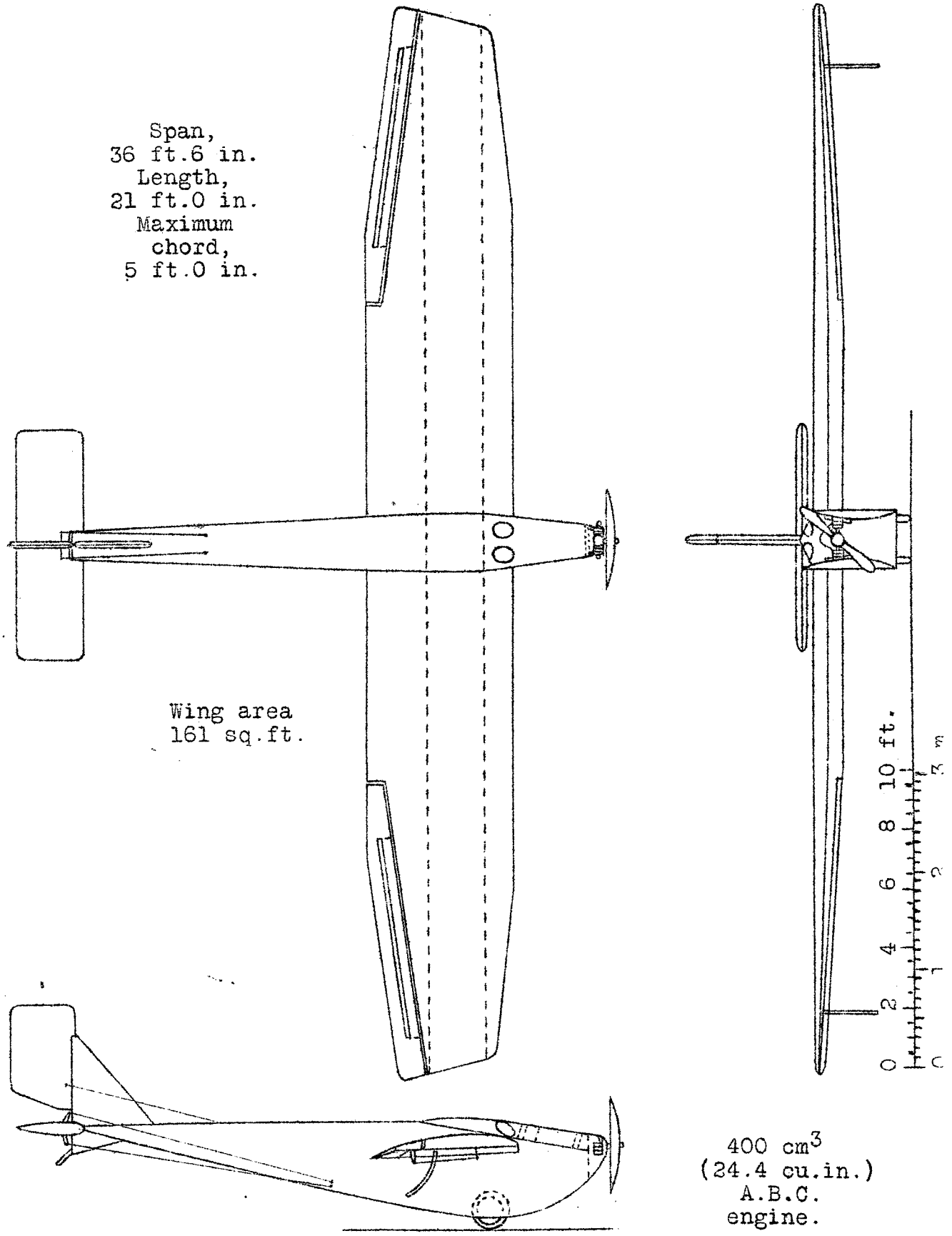


Fig.11. The Sayers - Handley Page light airplane.

Fig.12.
The "Pixie II","Castar",and "Vivette" are omitted as there are no plan drawings available.

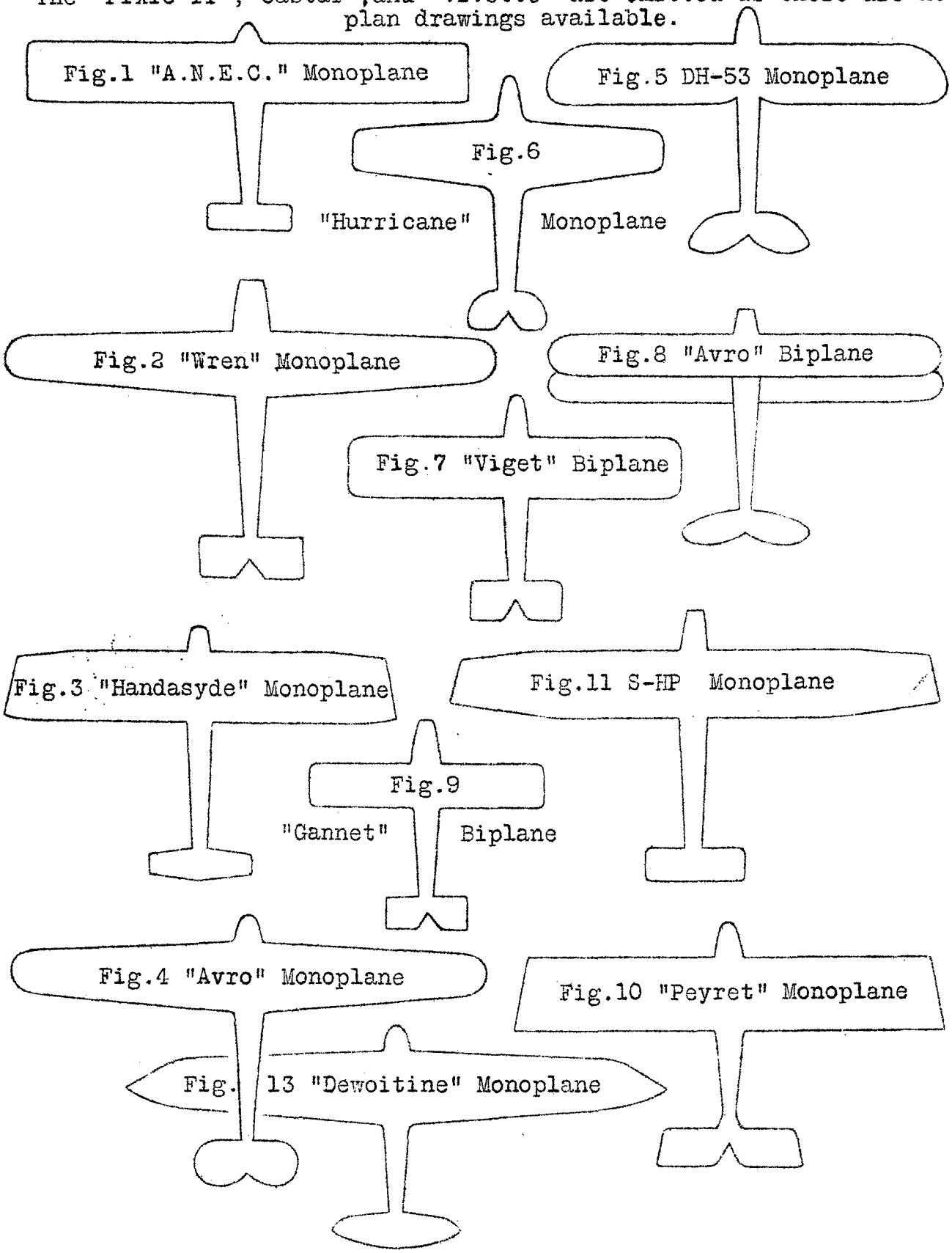


Fig.12. Plan outline of Light airplanes participating in contest at Lympne. The Dewoitine did not take part and is included as a matter of comparison.

Appendix I.

The "Dewoitine" light airplane (monoplane) constructed by Dewoitine, has attracted a great deal of attention both in Europe and the United States, and is considered an exceptional light airplane. A description with drawings is given in this appendix to show, upon comparison, that excellent results were attained at Lympne.

It is rated as having a maximum speed of 68.35 miles per hour and a landing speed of 18.6 miles per hour. A theoretical ceiling of approximately 10,000 feet is claimed. The approximate weight per HP is 55 lb. A continuous box spar is used in the wings, the leading edge of which is strengthened with plywood. Plywood is also used in the construction of the fuselage.

The landing gear is made of duralumin.

The cockpit is immediately behind the wing spar, which passes through the fuselage.

This airplane is balanced at 33% of the wing chord.

Three different types of engines are used: the Vaslin 4-cylinder, horizontally opposed, air-cooled; the Salmson 3-cylinder Y, air-cooled; and the Clerget 2-cylinder, horizontally opposed, air-cooled.

The results given in this appendix are those obtained with the Clerget engine making the basis of comparison, with the afore-described airplanes, very nearly the same.

Figure 13 contains the tabulation and outline drawings.

* Taken from "L'Aeronautique," July, 1923.

Fig. 13

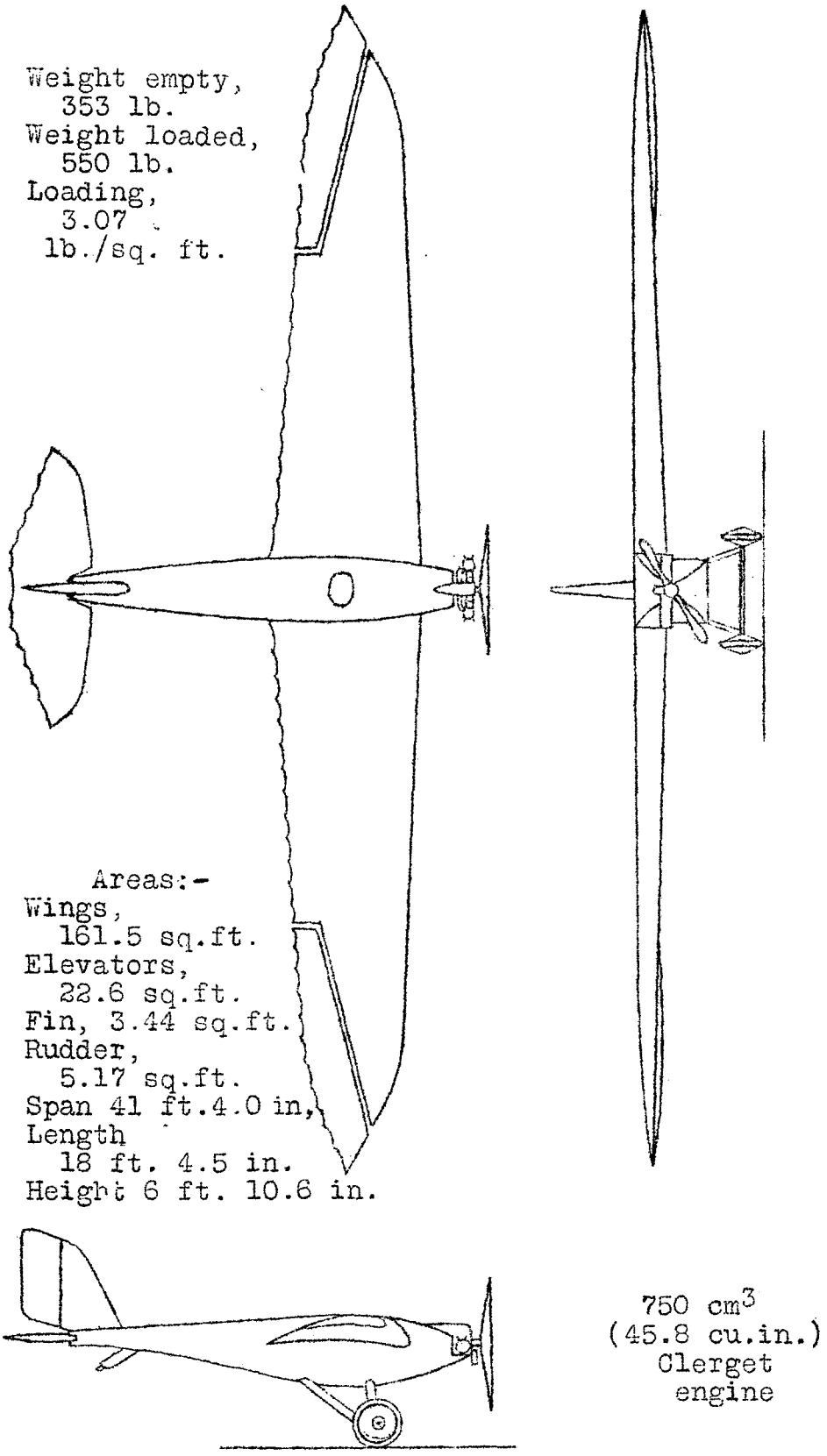


Fig. 13 The "Dewoitine" light airplane

Appendix II.

LIGHT AIRPLANE PROPELLERS

Based on Optimum Efficiency at 60 M.P.H.*

This section of the Technical Memorandum regarding light airplanes contains four diagrammatic drawings of examples of propellers for this type of aircraft. Tables of ordinates for the several airfoil sections occurring at the different radii are included immediately following the individual drawings. In the manufacture of these propellers, the drawings should first be made full size, adhering closely to dimensions and contour lines as given on the accompanying diagrams. The hub diameter, as will be seen, is approximately 1/12 of the propeller diameter.

The material could be of walnut or mahogany or, if a lower R.P.M. is used, spruce would answer the purpose fairly well. All laminations should be of uniform thickness except the outer layers which may be as thin as necessary to conform to the contour in the elevation. As the laminations approach the tip great care must be exercised to avoid the use of short lengths or narrower strips. A uniformity of thickness is especially necessary in this portion in order to make possible the carving of a perfectly smooth and continuous surface.

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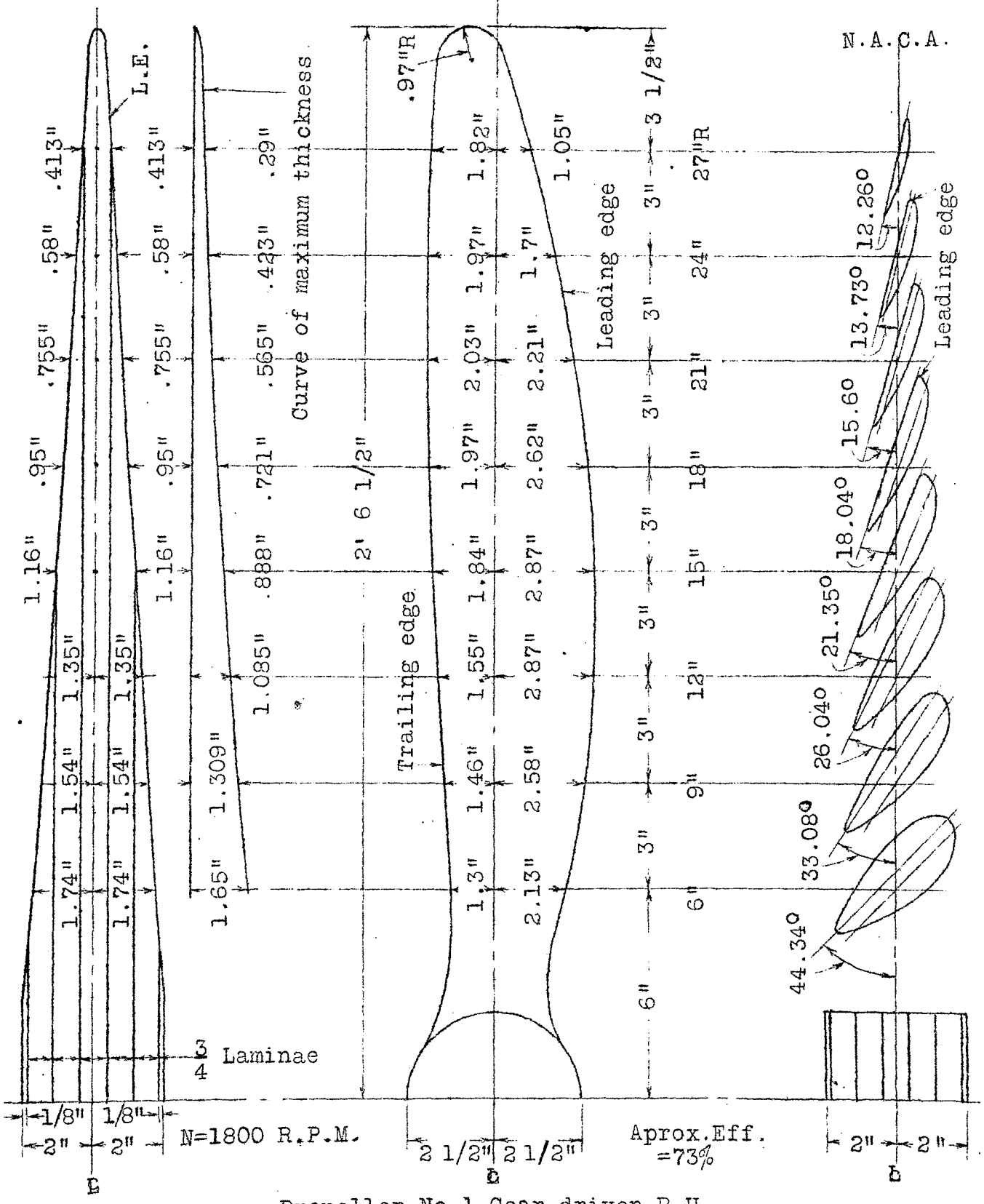
* Designed by Bureau of Aeronautics, Navy Department, Washington, D. C.



Propeller No.1 Gear driven.R.H.

Dia.=5'1" Pitch=3.07' Aspect ratio=6 Speed=60 M.P.H. HP.=15

Dimensions for Propeller No. 1.

Radius	6"		9"		12"	
Blade width	4.56"		4.78"		5.04"	
Camber	U	L	U	L	U	L
Max. ordinate	.975	-.675	.984	-.325	.973	-.112
Rad.L.E.	.098	.068	.098	.033	.097	.011
2.5	.400	-.277	.403	-.133	.399	-.046
5	.575	-.398	.581	-.192	.574	.066
10	.770	-.533	.777	-.257	.769	-.089
20	.926	-.641	.935	-.309	.924	-.106
30	.973	-.674	.982	-.324	.971	-.112
40	.965	-.668	.974	-.322	.963	-.111
50	.926	-.641	.935	-.309	.924	-.106
60	.848	-.587	.856	-.283	.847	-.097
70	.722	-.500	.728	-.241	.720	-.083
80	.546	-.378	.551	-.182	.545	-.063
90	.341	-.236	.344	-.114	.341	-.039
Rad.T.E.	.075	.052	.076	.025	.075	.009
Max. thickness	1.650"		1.309"		1.085"	

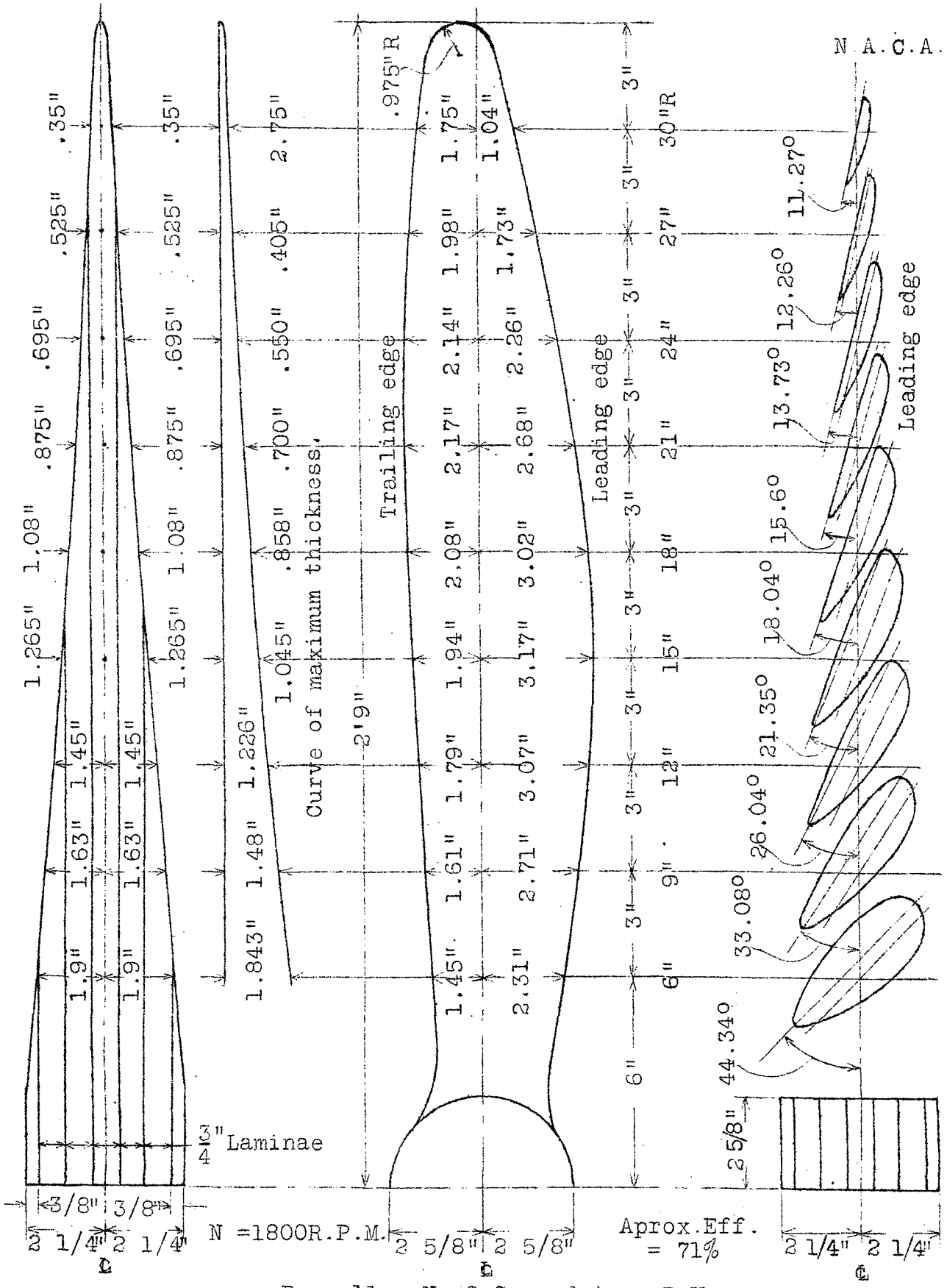
All ordinates are in inches.

Dimensions for Propeller No. 1 (Cont.)

Radius	15"	18"	21"	24"	27"
Blade width	5.05"	4.83"	4.40"	3.77"	2.92"
Camber	U	U	U	U	U
Max. ordinate	.888	.721	.565	.423	.290
Rad.L.E.	.089	.072	.057	.042	.029
2.5	.364	.296	.232	.173	.119
5	.524	.425	.333	.250	.171
10	.702	.570	.446	.334	.229
20	.844	.685	.537	.402	.276
30	.886	.720	.564	.422	.289
40	.879	.714	.559	.419	.287
50	.844	.685	.537	.402	.276
60	.773	.627	.492	.369	.252
70	.657	.534	.418	.313	.215
80	.497	.404	.316	.237	.162
90	.311	.252	.198	.148	.102
Rad.T.E.	.068	.056	.044	.033	.022
Max. thickness	.888"	.721"	.565"	.423"	.290"

All ordinates are in inches.

20a



N =1800R.P.M.

Aprox.Eff. = 71%

Propeller No.2 Gear driven.R.H.

Dia.=5'6" Pitch=3.07' Aspect ratio=6 Speed=60M.P.H. HP =20

Dimensions for Propeller No. 2.

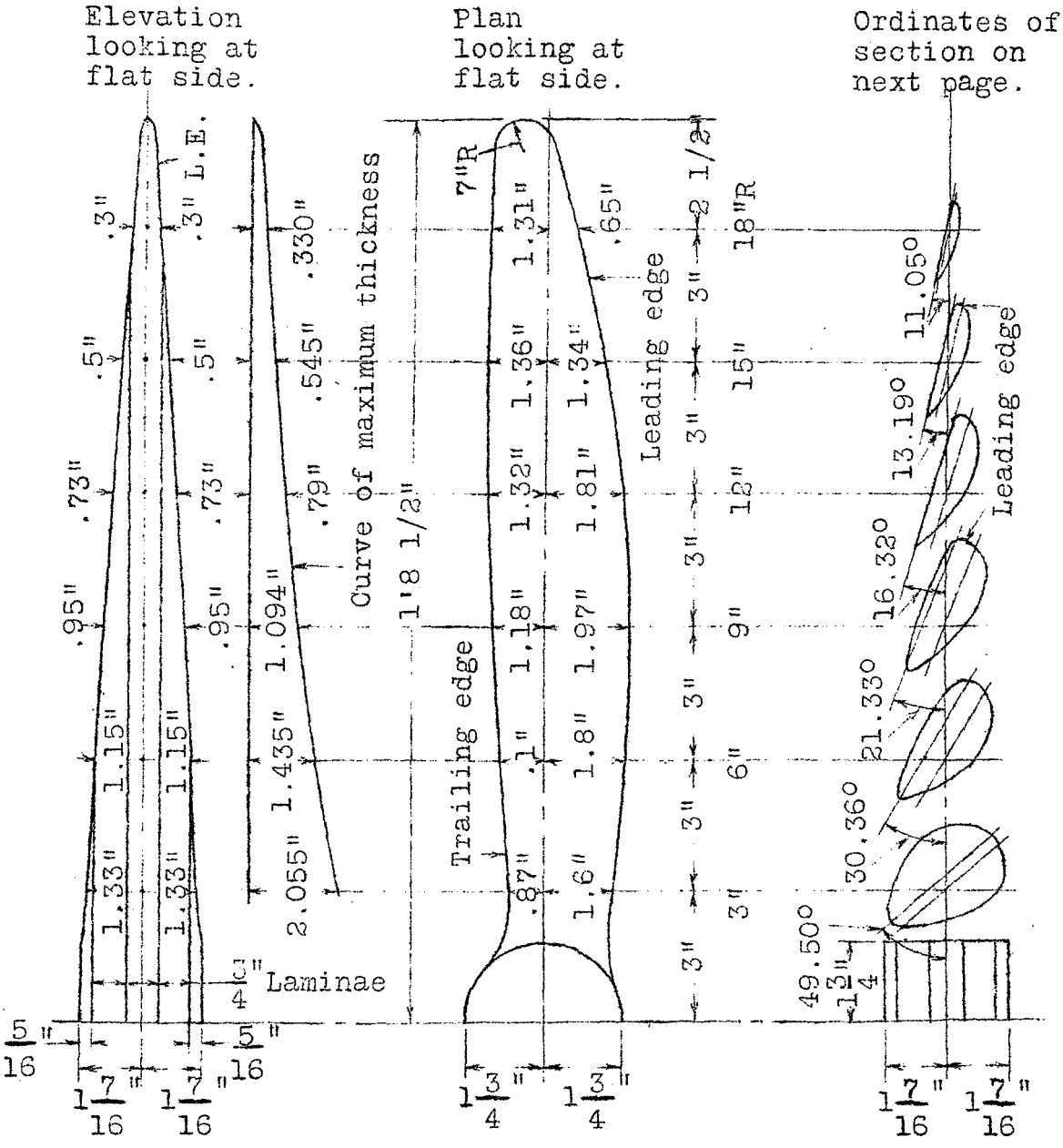
Radius	6"		9"		12"	
Blade width	4.97"		5.12"		5.40"	
Camber	U	L	U	L	U	L
Max. ordinate	1.048	-.795	1.060	-.420	1.056	-.170
Rad.L.E.	.105	.080	.106	.042	.106	.017
2.5	.430	-.326	.435	-.172	.433	-.070
5	.618	-.469	.625	-.248	.623	-.100
10	.828	-.628	.837	-.332	.834	-.134
20	.996	-.755	1.007	-.399	1.003	-.162
30	1.046	-.793	1.058	-.419	1.054	-.170
40	1.038	-.787	1.049	-.416	1.045	-.168
50	.996	-.755	1.007	-.399	1.003	-.162
60	.912	-.692	.922	-.365	.919	-.148
70	.776	-.588	.784	-.311	.781	-.126
80	.587	-.445	.594	-.235	.591	-.095
90	.367	-.278	.371	-.147	.370	-.060
Rad.T.E.	.081	.061	.082	.032	.081	.013
Max. thickness	1.843"		1.480"		1.226"	

All ordinates are in inches.

Dimensions for Propeller No. 2 (Cont.)

Radius	15"		18"	21"	24"	27"	30"
Blade width	5.50"		5.37"	5.04"	4.52"	3.81"	2.82"
Camber	U	L	U	U	U	U	U
Max. ordinate	1.010	-.035	.858	.700	.550	.405	.275
Rad.L.E.	.101	.004	.086	.070	.055	.041	.028
2.5	.414	-.014	.352	.287	.226	.166	.113
5	.596	-.021	.506	.413	.325	.239	.162
10	.798	-.028	.678	.553	.435	.320	.217
20	.960	-.033	.815	.665	.523	.385	.261
30	1.008	-.035	.856	.699	.549	.404	.275
40	1.000	-.035	.849	.693	.545	.401	.272
50	.960	-.033	.815	.665	.523	.385	.261
60	.879	-.031	.747	.609	.479	.352	.239
70	.747	-.026	.635	.518	.407	.300	.204
80	.566	-.020	.481	.392	.308	.227	.154
90	.354	-.012	.300	.245	.193	.142	.096
Rad.T.E.	.078	.003	.066	.054	.042	.031	.021
Max. thickness	1.045"		.858"	.700"	.550"	.405"	.275"

All ordinates are in inches.



Propeller No.3 Direct driven R.H.

Dia.=3'5" Pitch=1.84' Aspect ratio=6

Speed=60 M.P.H. N=3000 R.P.M. HP.=15

Approx. Eff.=61%

N.A.C.A.

Dimensions for Propeller No. 3.

Radius	3"		6"	
Blade width	3.08"		3.21"	
Camber	U	L	U	L
Max. ordinate	1.055	-1.000	1.082	-.353
Rad.L.E.	.106	.100	.108	.035
2.5	.433	-.410	.444	-.145
5	.623	-.590	.638	-.208
10	.834	-.790	.855	-.279
20	1.002	-.950	1.028	-.335
30	1.053	-.998	1.080	-.352
40	1.044	-.990	1.071	-.350
50	1.002	-.950	1.028	-.335
60	.918	-.870	.941	-.317
70	.781	-.740	.801	-.261
80	.591	-.560	.606	-.198
90	.369	-.350	.379	-.124
Rad.T.E.	.081	.007	.083	.027
Max. thickness	2.055"		1.435"	

All ordinates are in inches.

Dimensions for Propeller No. 3 (Cont.)

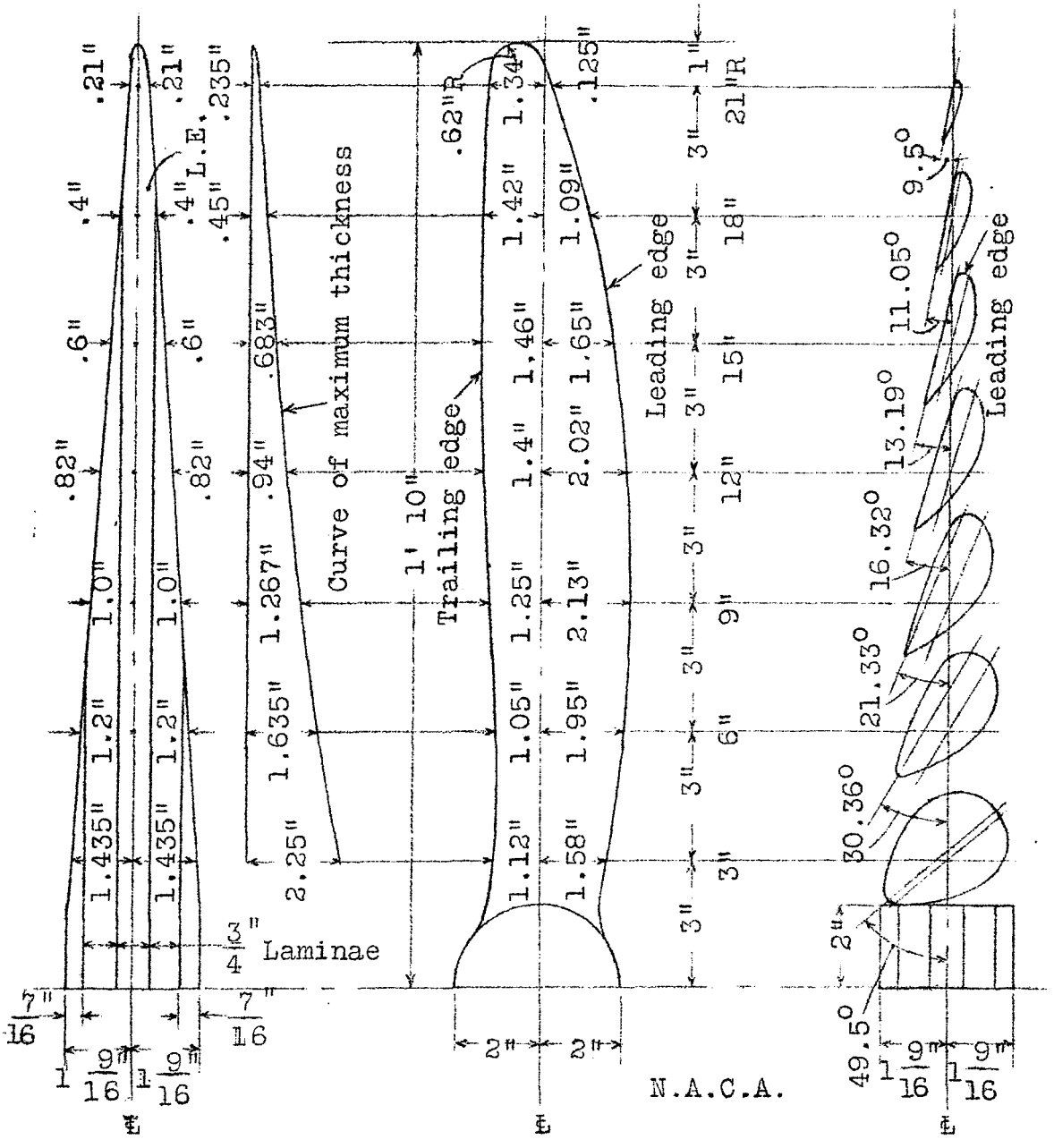
Radius	9"		12"	15"	18"
Blade width	3.41"		3.27"	2.78"	2.00"
Camber	U	L	U	U	U
Max. ordinate	1.040	-.054	.790	.545	.330
Rad.L.E.	.104	.005	.079	.055	.033
2.5	.426	-.022	.324	.224	.135
5	.614	-.032	.466	.322	.195
10	.822	-.043	.624	.431	.261
20	.988	-.051	.751	.518	.314
30	1.038	-.054	.788	.544	.329
40	1.030	-.054	.782	.540	.327
50	.988	-.051	.751	.518	.314
60	.905	-.047	.687	.474	.287
70	.770	-.040	.585	.403	.244
80	.582	-.030	.442	.305	.185
90	.364	-.019	.277	.191	.116
Rad.T.E.	.080	.004	.061	.042	.025
Max. thickness	1.094"		.790"	.545"	.330"

All ordinates in inches.

Elevation looking at flat side.

Plan looking at flat side.

Ordinates of sections given on next page.



Propeller No.4 Direct drive R.H.

Dia.= 3'8" Pitch = 1.84 ft. Aspect ratio = 6

Speed = 60 M.P.H. N = 3000 R.P.M. HP. = 20

Approx. Eff. = 60%

Dimensions for Propeller No. 4.

Radius	3"		6"	
Blade width	3.30"		3.41"	
Camber	U	L	U	L
Max. ordinate	1.125	-1.125	1.160	-.475
Rad.L.E.	.113	.113	.116	.048
2.5	.461	-.461	.476	-.195
5	.664	-.664	.684	-.280
10	.889	-.889	.916	-.375
20	1.069	-1.069	1.102	-.451
30	1.123	-1.123	1.158	-.474
40	1.114	-1.114	1.148	-.470
50	1.069	-1.069	1.102	-.451
60	.979	-.979	1.009	-.413
70	.833	-.833	.858	-.352
80	.630	-.630	.650	-.266
90	.394	-.394	.406	-.166
Rad.T.E.	.087	.087	.089	.037
Max. thickness	2.25"		1.635"	

All ordinates are in inches.

Dimensions for Propeller No. 4 (Cont.)

Radius	9"		12"	15"	18"	21"
Blade width	3.65"		3.58"	3.21"	2.55"	1.48"
Camber	U	L	U	U	U	U
Max. ordinate	1.167	-.100	.940	.683	.450	.235
Rad.L.E.	.117	.010	.094	.068	.045	.024
2.5	.479	-.041	.385	.280	.185	.096
5	.689	-.059	.555	.403	.266	.139
10	.922	-.079	.743	.540	.356	.186
20	1.109	-.095	.893	.649	.428	.223
30	1.165	-.099	.938	.682	.449	.235
40	1.155	-.099	.931	.676	.446	.233
50	1.109	-.095	.893	.649	.428	.223
60	1.015	-.087	.818	.594	.392	.205
70	.864	-.075	.696	.505	.333	.174
80	.654	-.056	.526	.382	.252	.132
90	.409	-.035	.329	.239	.158	.082
Rad.T.E.	.090	.008	.072	.053	.035	.018
Max. thickness	1.267"		.940"	.683"	.450"	.235"

All ordinates are in inches.

Appendix III.

LIGHT AIRPLANE PROPELLERS

Based on Optimum Efficiency at 60 M.P.H.*

Since issuing the Technical Memorandum No. 361 with appendices I and II, regarding light airplanes, two lighter and more efficient propellers of small diameter have been designed.

These propellers, Nos. 3A and 4A, are described in this appendix. Their weight is the minimum for the required strength, and their efficiency is very similar to that of propellers Nos. 1 and 2.

The usual diagramatic drawings and tables of ordinates are given, followed by curves which show the relative approximate efficiency of the six propellers.

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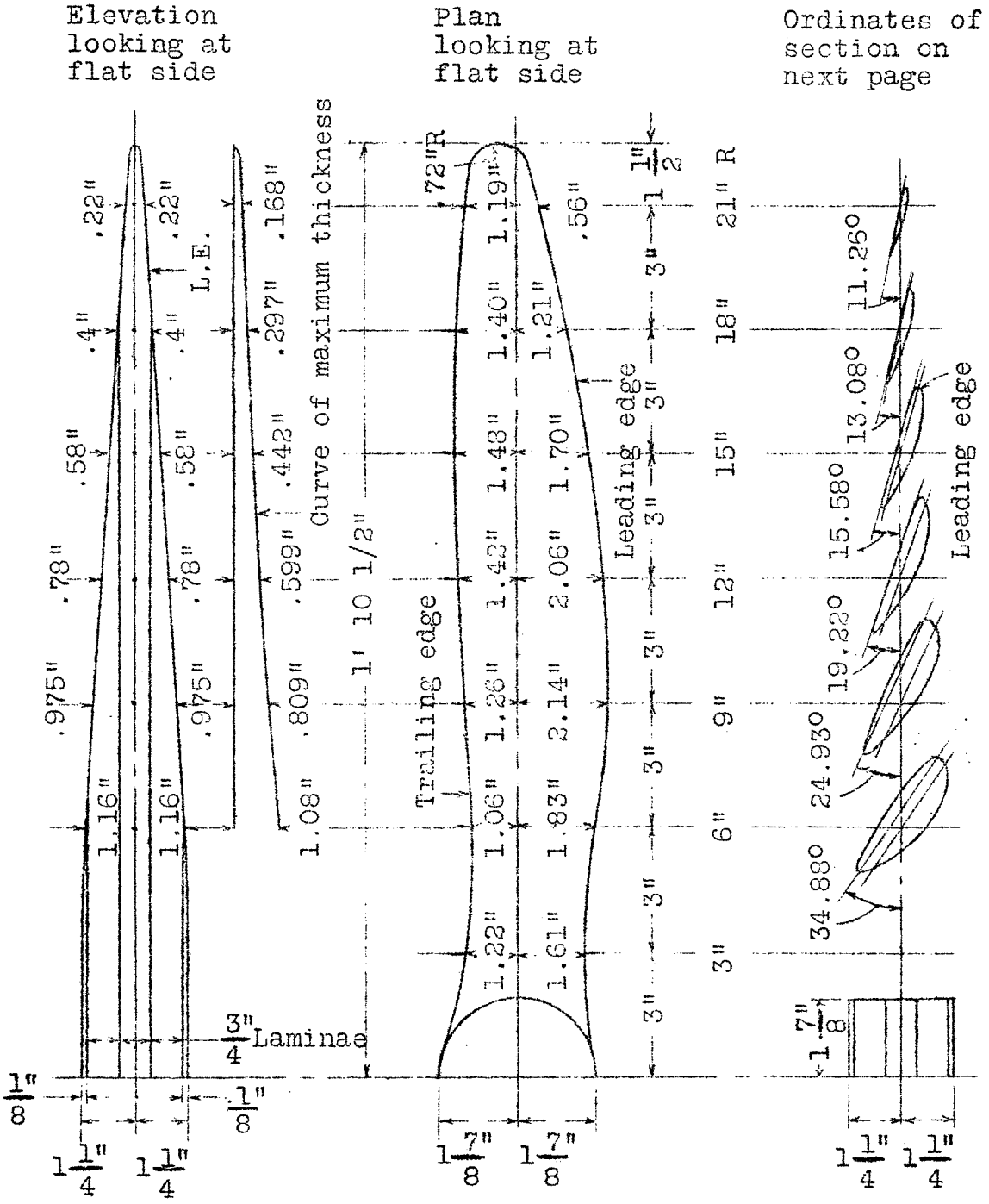
*Designed by Bureau of Aeronautics, Navy Department, Washington, D. C., July 1924.



Propeller No.3A. Direct driven. R.H.

Dia.=3'9" Pitch=2.19' Aspect ratio=6

Speed=60 M.P.H. N=3000 R.P.M. HP.=15

Approx. Eff.=70%

Dimensions of Propeller No. 3A

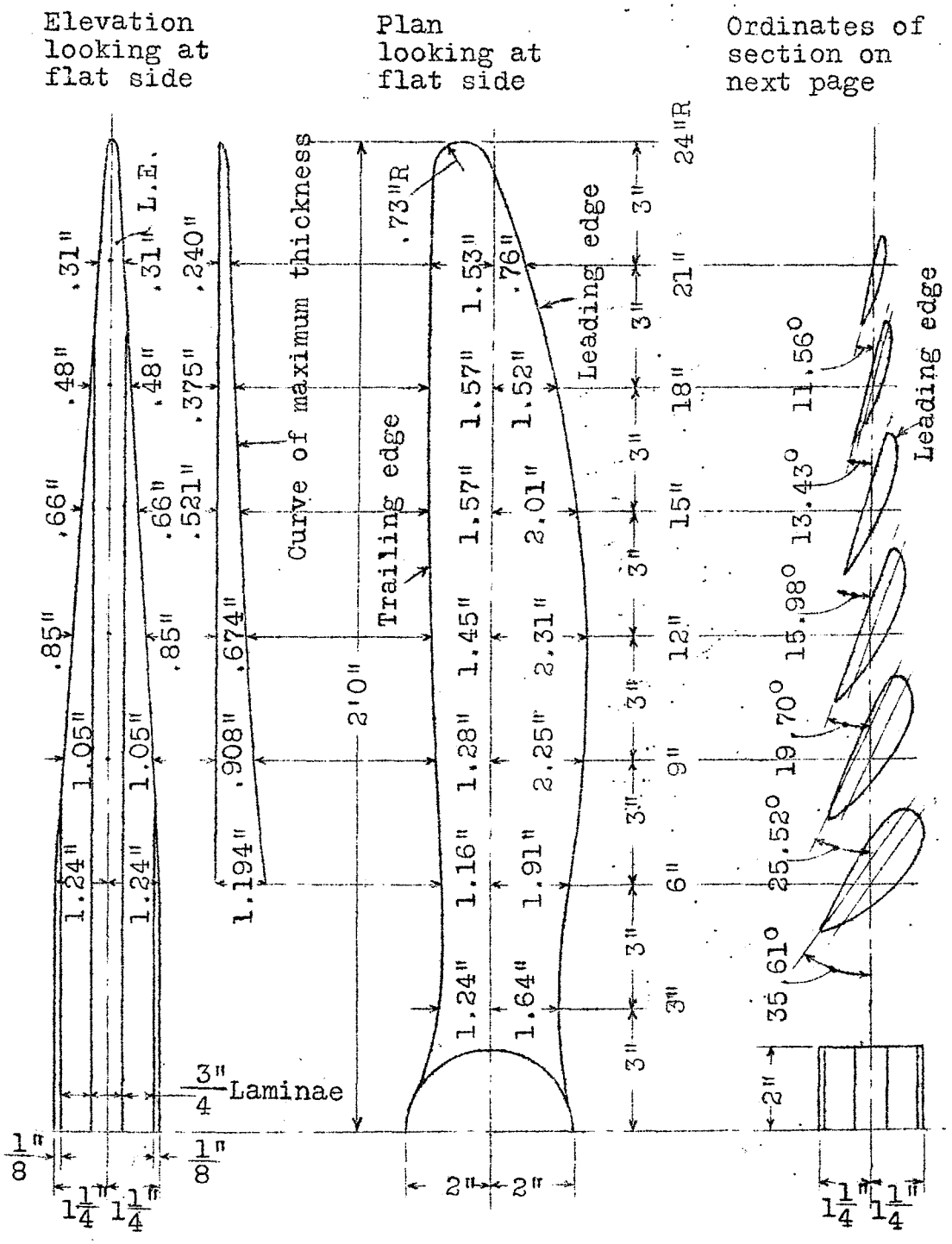
Radius	6"		9"		12"	15"	18"	21"
Blade width	3.51"		3.71"		3.68"	3.33"	2.68"	1.75"
Camber	U	L	U	L	U	U	U	U
Max. ordinate	.774	.306	.736	.073	.599	.442	.297	.168
Rad. L.E.	.077	.031	.074	.007	.060	.044	.030	.017
2.5	.317	-.125	.302	-.030	.246	.181	.122	.069
5	.457	-.181	.434	-.043	.353	.261	.175	.099
10	.611	-.242	.581	-.058	.473	.349	.235	.133
20	.735	-.291	.699	-.069	.569	.420	.282	.160
30	.772	-.305	.735	-.073	.598	.441	.296	.168
40	.766	-.303	.729	-.072	.593	.438	.294	.166
50	.735	-.291	.699	-.069	.569	.420	.282	.160
60	.673	-.266	.640	-.064	.521	.385	.258	.146
70	.573	-.226	.545	-.054	.443	.327	.220	.124
80	.433	-.171	.412	-.041	.335	.248	.166	.094
90	.271	-.107	.258	-.026	.210	.155	.104	.059
Rad. T.E.	.060	.024	.057	.006	.046	.034	.023	.013
Max thickness	1.08"		.809"		.599"	.442"	.297"	.168"

(Per cent of chord)

All ordinates in inches

U = upper camber. L = lower camber

There is no lower camber at 12", 15", 18" and 21" radii.



Propeller No.4A. Direct driven..R.H.

Dia.=4'0" Pitch=2.25' Aspect ratio=6

Speed=60 M.P.H. N= 3000 R.P.M. HP.= 20

Approx. Eff.= 68.5%

Dimensions of Propeller No. 4A

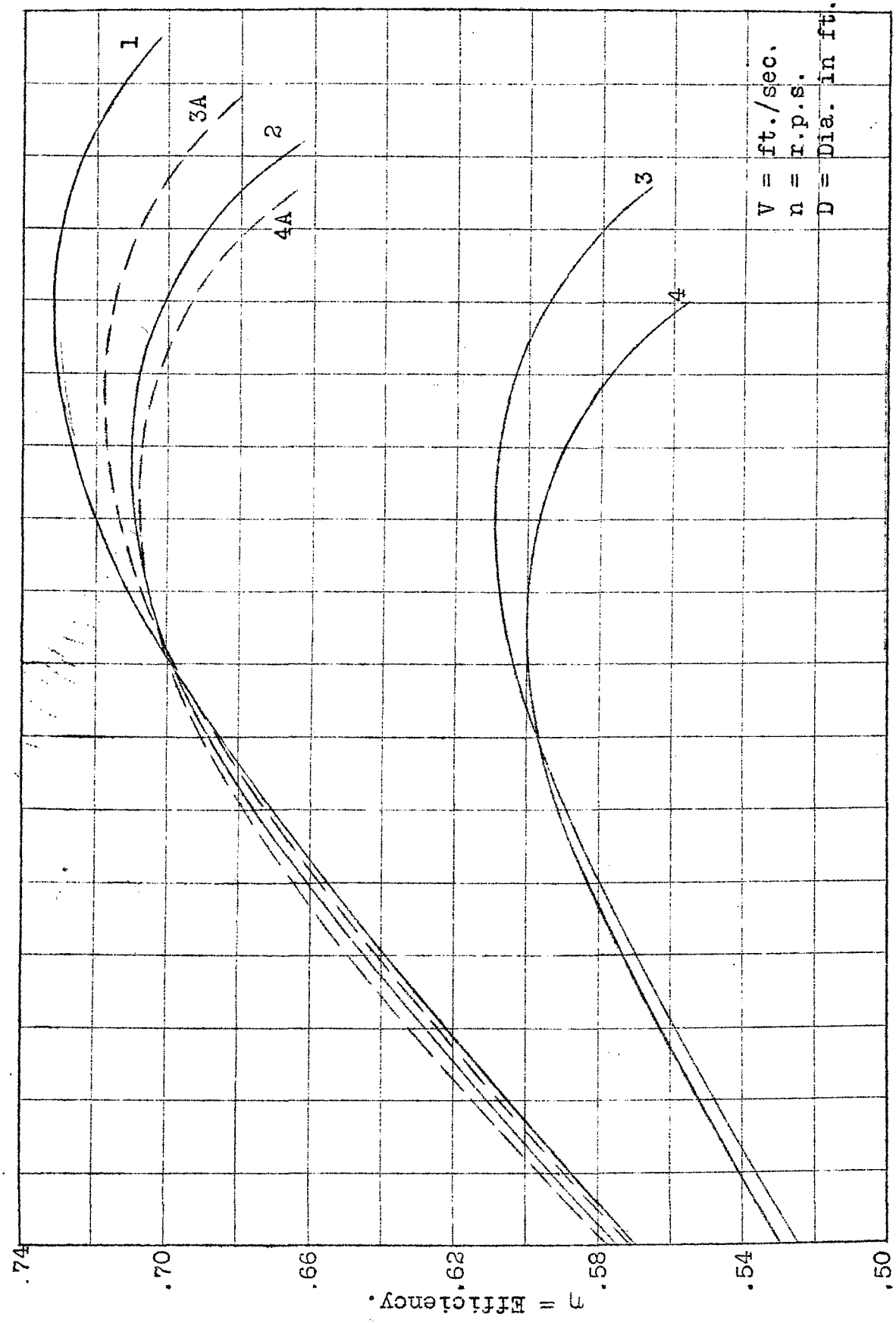
Radius	6"		9"		12"	15"	18"	21"
Blade width	3.71"		3.91"		3.98"	3.69"	3.17"	2.34"
Camber	U	L	U	L	U	U	U	U
Max. ordinate	.819	.375	.804	.104	.674	.521	.375	.240
Rad. L.E.	.082	.038	.080	.010	.067	.052	.038	.024
2.5	.336	-.154	.330	-.043	.276	.214	.154	.098
5	.483	-.221	.474	-.061	.398	.307	.221	.142
10	.647	-.296	.635	-.082	.532	.412	.296	.190
20	.778	-.356	.764	-.099	.640	.495	.356	.228
30	.817	-.374	.802	-.104	.673	.520	.374	.240
40	.811	-.371	.796	-.103	.667	.516	.371	.238
50	.778	-.356	.764	-.099	.640	.495	.356	.228
60	.713	-.326	.699	-.090	.586	.453	.326	.209
70	.606	-.278	.595	-.077	.499	.386	.278	.178
80	.459	-.210	.450	-.058	.377	.292	.210	.134
90	.287	-.131	.281	-.036	.236	.182	.131	.084
Rad. T.E.	.063	.029	.062	.008	.052	.040	.029	.018
Max. thickness	1.194"		.908"		.674"	.521"	.375"	.240"

Per cent of chord

All ordinates in inches

U = upper camber. L = lower camber

There is no lower camber at 15", 18", and 21" radii.



Approximate efficiency curves for light airplane propellers.