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RESEARCH MEMORANDUM

SPIN-TUNNEL INVESTIGATION OF THE JETTISONING OF EXTERNAL FUEL TANKS IN SPINS

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NATIONAL ADVISORY COMMITTEE
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SUMMARY

A spin-tunnel investigation has been made to determine the probability of external fuel tanks striking an airplane after being jettisoned in a spin. The investigation showed that for straight-wing fighter-type designs in any case in which jettisoning of tanks in a spin might aid spin recovery the tanks would probably clear all parts of the airplane.

INTRODUCTION

A recent trend in aircraft has been to locate fuel in external tanks mounted on the wings. External fuel tanks are usually jettisonable in order that they may be dropped after the fuel is expended so that the drag will be reduced.

In the course of spin-tunnel investigations, it has been indicated that when external fuel tanks are installed on an airplane, a pilot may encounter difficulty in recovering from a spin by control movement and it may be necessary to jettison the tanks in order to increase rudder effectiveness in obtaining spin recovery by changing from a relative wing-heavy to fuselage-heavy mass-distribution condition (reference 1). The possibility that the jettisoned tanks may collide with the airplane from which they are released has caused some concern. Accordingly, a study was undertaken in the Langley 20-foot free-spinning tunnel to determine the probability of such a collision. The study was made of data previously obtained in the course of routine testing of models typical of straight-wing fighter-type designs but hitherto unpublished.

SYMBOLS

b wing span, feet

ρ air density, slugs per cubic foot

APPARATUS AND METHODS

The models used for the tests were models typical of straight-wing fighter-type airplanes ranging in scale from 1/16 to 1/25 and were prepared for testing by the Langley Aeronautical Laboratory. Three-view sketches of the models tested with full-scale dimensions of the airplanes represented are shown in figure 1. The tanks were built of wood and independently ballasted with lead weights to the appropriate weights and center-of-gravity locations. A remote-control mechanism was installed in the models for jettisoning of the tanks.

Nine of the models were ballasted to obtain dynamic similarity to the respective airplanes at a test altitude of 15,000 feet (ρ = 0.001496 slug/cu ft). For the other two models, a test altitude of 20,000 feet was used.

The tests were performed in the Langley 20-foot free-spinning tunnel, the operation of which is similar to that of the Langley 15-foot free-spinning tunnel described in reference 2, except that the models are launched by hand with spinning rotation into a vertically rising air stream rather than launched by a spindle.

For one of the models (model 1), fully loaded and empty tanks were jettisoned from steep and flat erect spins and from inverted spins for several spanwise locations from the plane of symmetry to the wing tips. The data obtained with the remainder of the models (models 2 to 11) were all for erect spins and included steep and flat spins with fully loaded tanks and some tests with empty tanks. The spanwise location of the tanks was not varied during any one of these tests (models 2 to 11), but the range covered by the collected data is from the plane of symmetry to the wing tips.

During most tests, motion pictures were taken and were subsequently used to check the visual observations of the paths followed by the jettisoned tanks. Tests of each configuration were repeated until it was clearly established whether or not the tanks would strike the model.

RESULTS AND DISCUSSION

The results of the model-tank-jettison tests are presented in tables I and II.

The models tested did not represent some of the most recent jet- and rocket-propelled designs as regards extreme mass distribution along the fuselage which, it has been indicated, are conducive of violent rolling and yawing spinning motions (reference 3). When wing tanks are installed on such a design, however, the loading either would become such as to eliminate this motion and thus the following results would be applicable, or it would remain such as to still give an oscillatory spin, for which present spin-tunnel research indicates that it should not be necessary to jettison tanks for spin recovery.

The results obtained with model 1 (fig. 1(a)) are presented in table I and data obtained with models 2 to 11 (figs. 1(b) to 1(k)) are presented in table II. The data show that fully loaded tanks dropped clear of the model from all spanwise locations for all erect spins. The loaded tanks also went clear of the model when jettisoned in inverted spins for all spanwise locations except the plane of symmetry. As previously mentioned, jettisoning of external fuel tanks in a spin is sometimes necessary in order to increase the effectiveness of the rudder in terminating the spin by changing from a relative wing-heavy to a fuselage-heavy mass-distribution condition. Thus it is unlikely that jettisoning of a fuel tank located at or near the plane of symmetry would be beneficial for spin recovery and therefore it need not be attempted. In all tests with the loaded tanks, the tanks fell away from the model, that is, the tanks had a higher rate of descent than the model. It was also noted that the tanks were always thrown away from the spin axis and that the tanks on the inboard wing (right wing in a right spin) appeared to go forward relative to that wing and the tanks on the outboard wing appeared to go back relative to that wing.

Results of jettison tests with empty tanks are also presented in tables I and II. The data show that the tanks safely cleared the model when released in erect or inverted spins for all spanwise locations except the plane of symmetry. As explained above, jettisoning of tanks at the plane of symmetry cannot be expected to aid in recovery from a spin and therefore need not be attempted. In all tests with empty tanks, the tanks went up with respect to the model, that is, the empty tanks had a rate of descent that was less than the rate of descent of the model. As was the case for loaded tanks, empty tanks were always thrown away from the spin axis and again the tank on the inboard wing appeared to go forward relative to that wing and the tank on the outboard wing appeared to go back relative to that wing.

In all cases, for either the loaded or empty conditions, the tanks cleared the tail of the model.

The rate of descent of the tanks, it was indicated, will vary with the amount of fuel in the tanks. Fully loaded tanks will fall faster than the airplane; whereas empty tanks will fall slower than the airplane. At some intermediate loading the tanks could fall at the same rate of descent as the airplane and the possibility of collision is increased. A study of the films obtained during the investigation with models 1, 6, 9, and 10 indicated that for empty and fully loaded tanks located at $0.50\frac{b}{2}$ or further outboard, the horizontal movement of the tanks would probably be great enough to clear the wing tips or tail of the airplane. If the empty and fully loaded tanks clear the model, it is apparent that for an intermediate loading of the tanks the horizontal movement should also be great enough to carry the tanks clear of the airplane. With the tanks located inboard $0.50\frac{b}{2}$, for some tests the tanks cleared the model horizontally but for others they did not clear. Inasmuch as tanks only partially loaded and located inboard of $0.50\frac{b}{2}$ would not be expected to affect rudder effectiveness very greatly because their effect on mass distribution would be relatively small, it is felt that jettisoning of tanks located inboard of $0.50\frac{b}{2}$ on a spinning airplane should not be attempted unless all other methods of recovery have failed.

CONCLUSIONS

The results of tank-jettison tests for eleven models made in the Langley 20-foot free-spinning tunnel indicate that in any case for which jettisoning of tanks in a spin of a straight-wing fighter-type airplane might aid spin recovery, the jettisoned tanks would probably clear all parts of the airplane.

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REFERENCES

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2. Zimmerman, C. H.: Preliminary Tests in the N.A.C.A. Free-Spinning Wind Tunnel. NACA Rep. 557, 1936.

3. Stone, Ralph W., Jr., and Klinar, Walter J.: The Influence of Very Heavy-Fuselage Mass Loadings and Long Nose Lengths upon Oscillations in the Spin. NACA TN 1510, 1948.

TABLE I.– RESULTS OF TANK-JETTISON TESTS WITH MODEL 1 IN THE LANGLEY 20-FOOT FREE-SPINNING TUNNEL

[Spins to pilot's right]

Tank location	Loaded tanks		Empty tanks		Loaded tanks	Empty tanks
	Flat erect spins	Steep erect spins	Flat erect spins	Steep erect spins	Inverted spins	Inverted spins
Plane of symmetry	Dropped almost straight down away from model	Dropped forward of inboard wing, away from spin axis, and down with respect to model	Away from spin axis, forward of inboard wing, and up with respect to model	Struck the bottom of inboard wing, rolled off the trailing edge of the wing, and up with respect to model	Struck the bottom of outboard wing, then rolled off, and dropped away from model	Struck the bottom of inboard wing and then up with respect to model
$0.25\frac{b}{2}$	Away from spin axis, inboard tank forward of wing, outboard tank back of wing, and both down with respect to model	Away from spin axis, inboard tank forward of wing, outboard tank back of wing, and both down with respect to model	Away from spin axis, inboard tank forward of wing, outboard tank back of wing, and both up with respect to model	Away from spin axis, inboard tank forward of wing, outboard tank back of wing, and both up with respect to model	Away from spin axis, inboard tank forward of wing, outboard tank back of wing, and both down with respect to model	Both tanks went almost straight up with respect to model
$0.50\frac{b}{2}$	--------do------------	---------do----------	--------do-----------	---------do----------	----------do---------	Away from spin axis, inboard tank forward of wing, outboard tank back of wing, and both up with respect to model
$0.75\frac{b}{2}$	--------do------------	---------do----------	--------do-----------	---------do----------	----------do---------	Do.
Wing tips	--------do------------	---------do----------	--------do-----------	---------do----------	----------do---------	Do.

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TABLE II.- RESULTS OF TANK-JETTISON TESTS WITH MODELS 2 TO 11 IN THE LANGLEY 20-FOOT FREE-SPINNING TUNNEL

Model	Tank location (a)	Direction of spin	Loaded tanks		Empty tanks	
			Flat erect spins	Steep erect spins	Flat erect spins	Steep erect spins
2	Plane of symmetry	Right	Dropped almost straight down from model	Away from spin axis, forward of inboard wing, and down		
3	$0.15\frac{b}{2}$ R and L	Right	Away from spin axis, inboard tank forward of wing, outboard tank back of wing, and down with respect to model	Away from spin axis, inboard tank forward of wing, outboard tank back of wing, and down with respect to model		
4	$0.38\frac{b}{2}$ L	Right	Away from spin axis, back of wing, and down with respect to model	Away from spin axis, back of wing, and down with respect to model	Away from spin axis, back of wing, and up with respect to model	Away from spin axis, back of wing, and up with respect to model
4	$0.38\frac{b}{2}$ L	Left	Away from spin axis, forward of wing, and down with respect to model	Away from spin axis, forward of wing, and down with respect to model	Away from spin axis, forward of wing, and up with respect to model	Away from spin axis, forward of wing, and up with respect to model
5	$0.38\frac{b}{2}$ R	Right	Away from spin axis, forward of wing, and down with respect to model	Away from spin axis, forward of wing, and down with respect to model	Away from spin axis, forward of wing, and up with respect to model	Away from spin axis, forward of wing, and up with respect to model
5	$0.38\frac{b}{2}$ R	Left	Away from spin axis, back of wing, and down with respect to model	Away from spin axis, back of wing, and down with respect to model	Away from spin axis, back of wing, and up with respect to model	Away from spin axis, back of wing, and up with respect to model
6	$0.41\frac{b}{2}$ R and L	Right	----do----	----do----		
7	$0.42\frac{b}{2}$ R and L	Right	Away from spin axis, inboard tank forward of wing, outboard tank back of wing, and down with respect to model	Away from spin axis, inboard tank forward of wing, outboard tank back of wing, and down with respect to model	Away from spin axis, inboard tank forward of wing, outboard tank back of wing, and up with respect to model	Away from spin axis, inboard tank forward of wing, outboard tank back of wing, and up with respect to model
8	$0.42\frac{b}{2}$ R and L	Right	----do----	----do----	----do----	Do.
9	$0.55\frac{b}{2}$ R and L	Right		----do----		Do.
10	$0.58\frac{b}{2}$ R and L	Right	----do----	----do----	----do----	Do.
11	Wing tips	Right			----do----	Do.

[a]R means one tank on right wing.
L means one tank on left wing.

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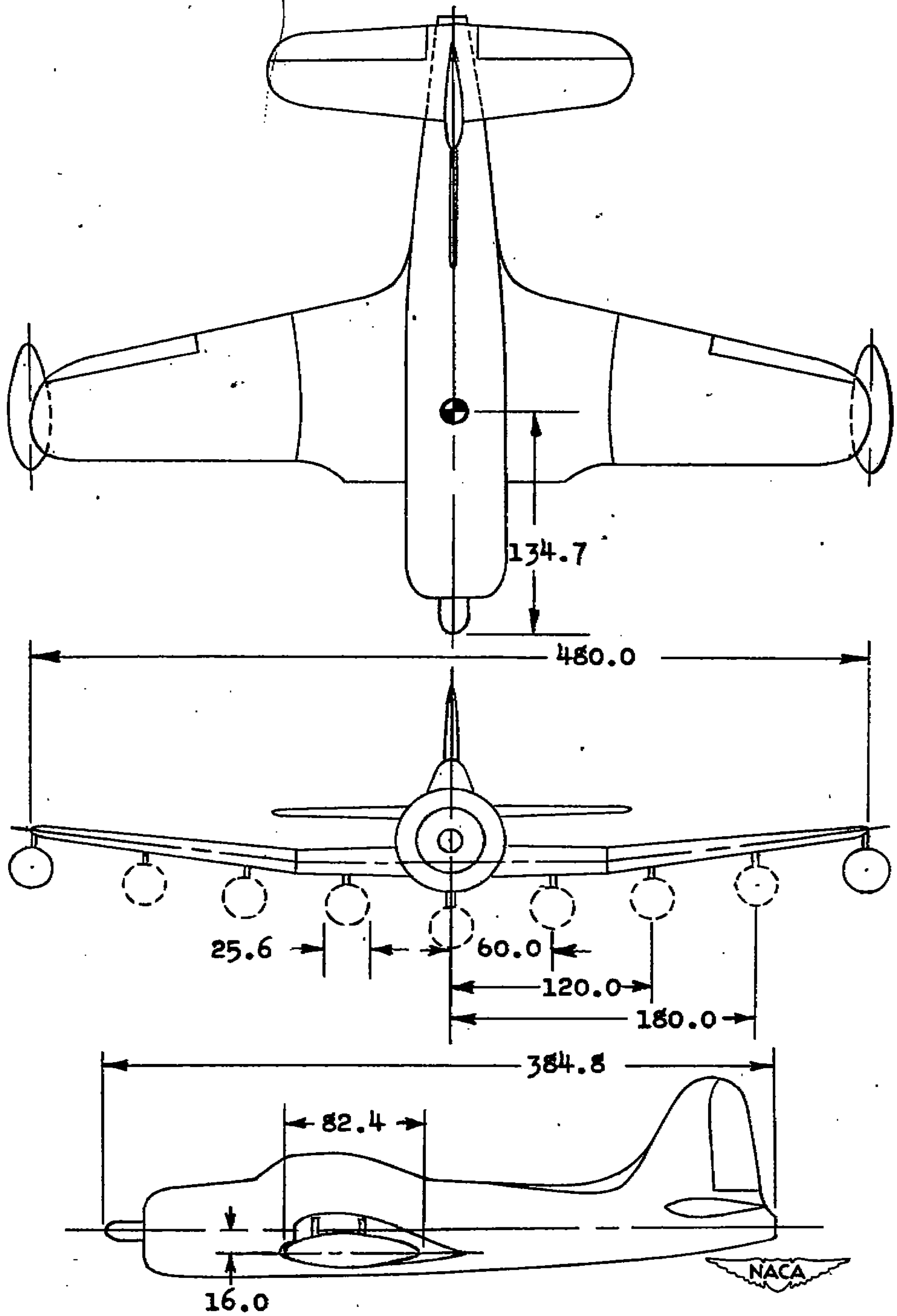
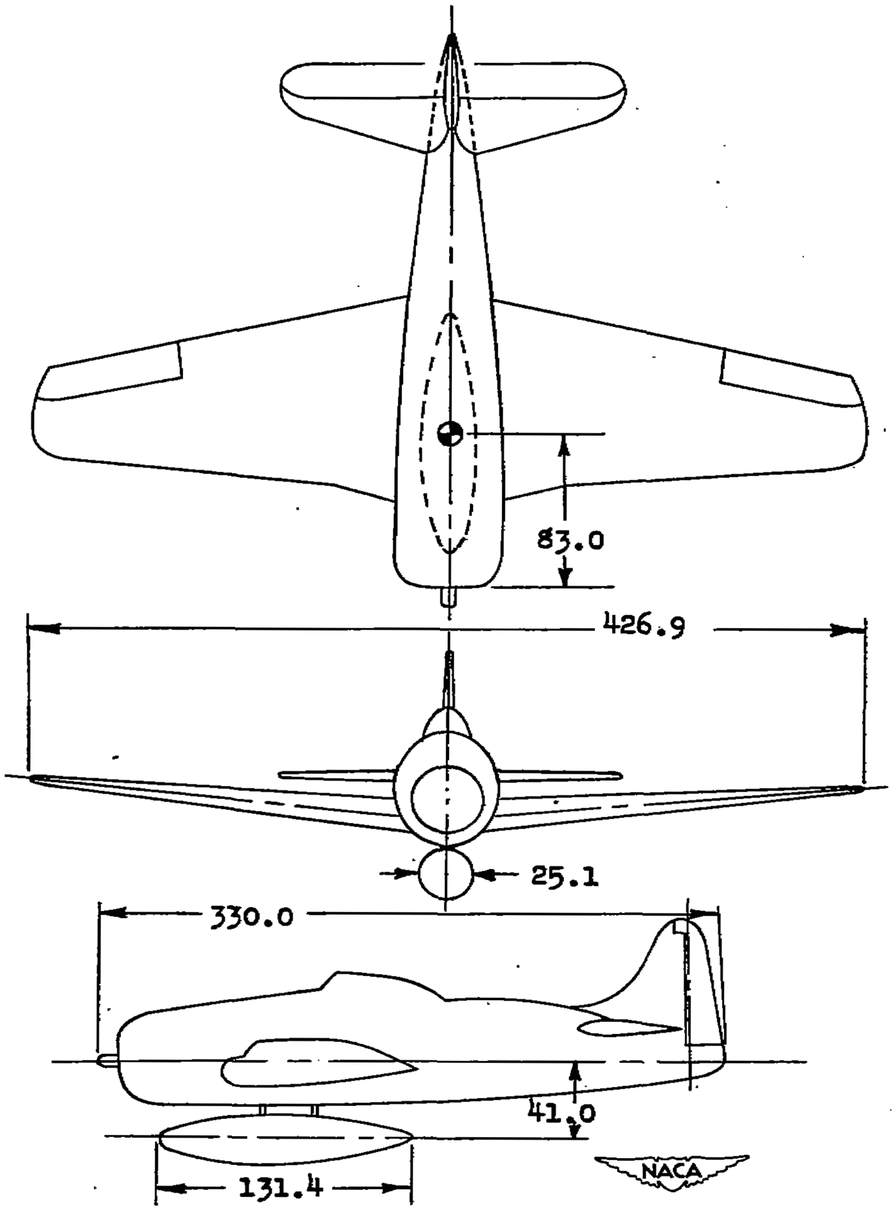


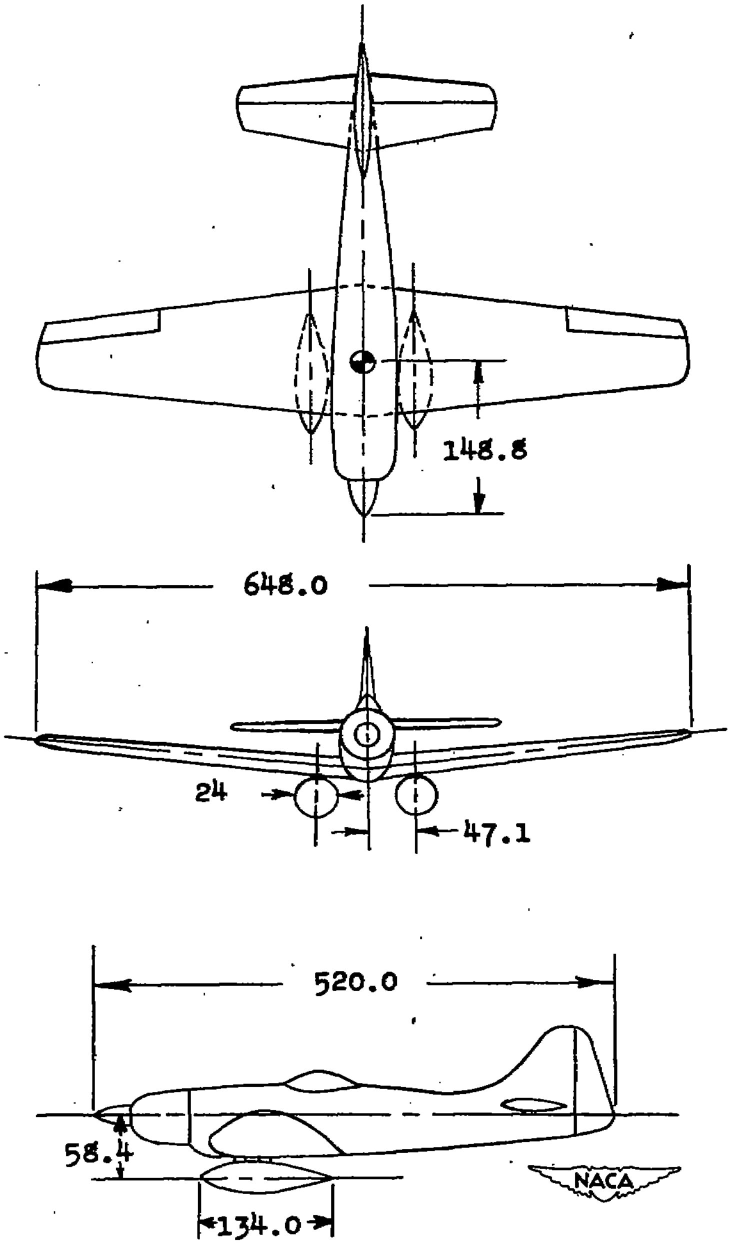
(a) Model 1.

Figure 1.- Three-view sketch of models 1 to 11 as tested. Dimensions are full scale, inches.



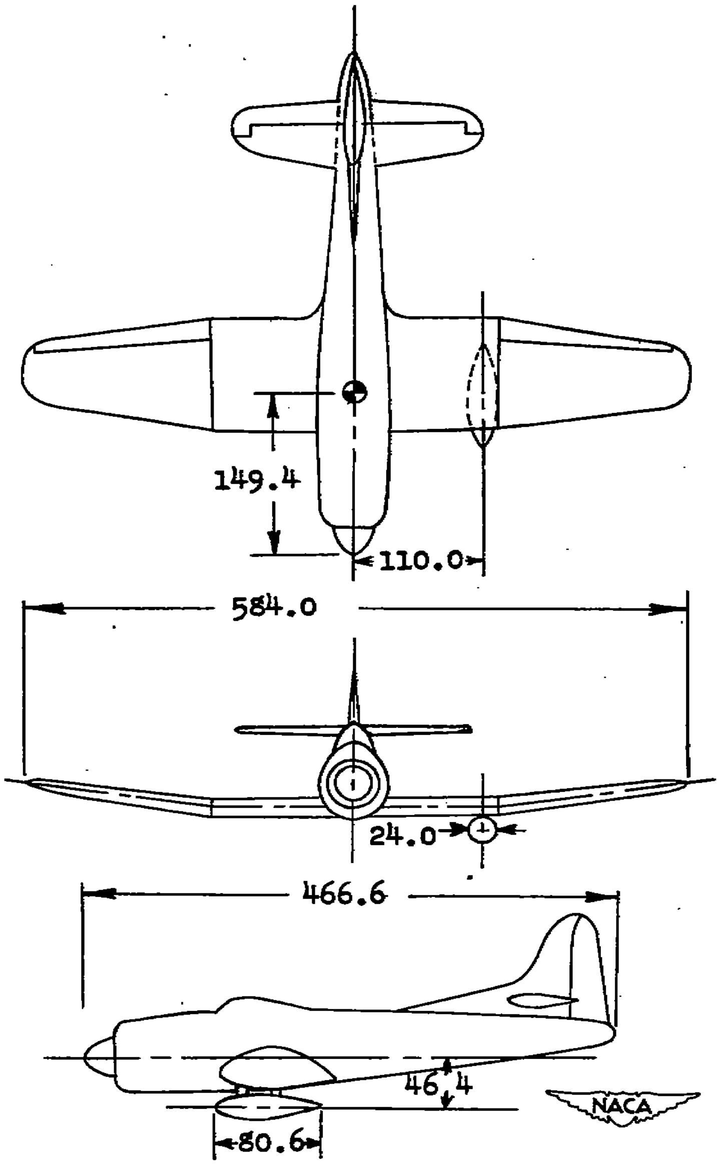
(b) Model 2.

Figure 1.- Continued.



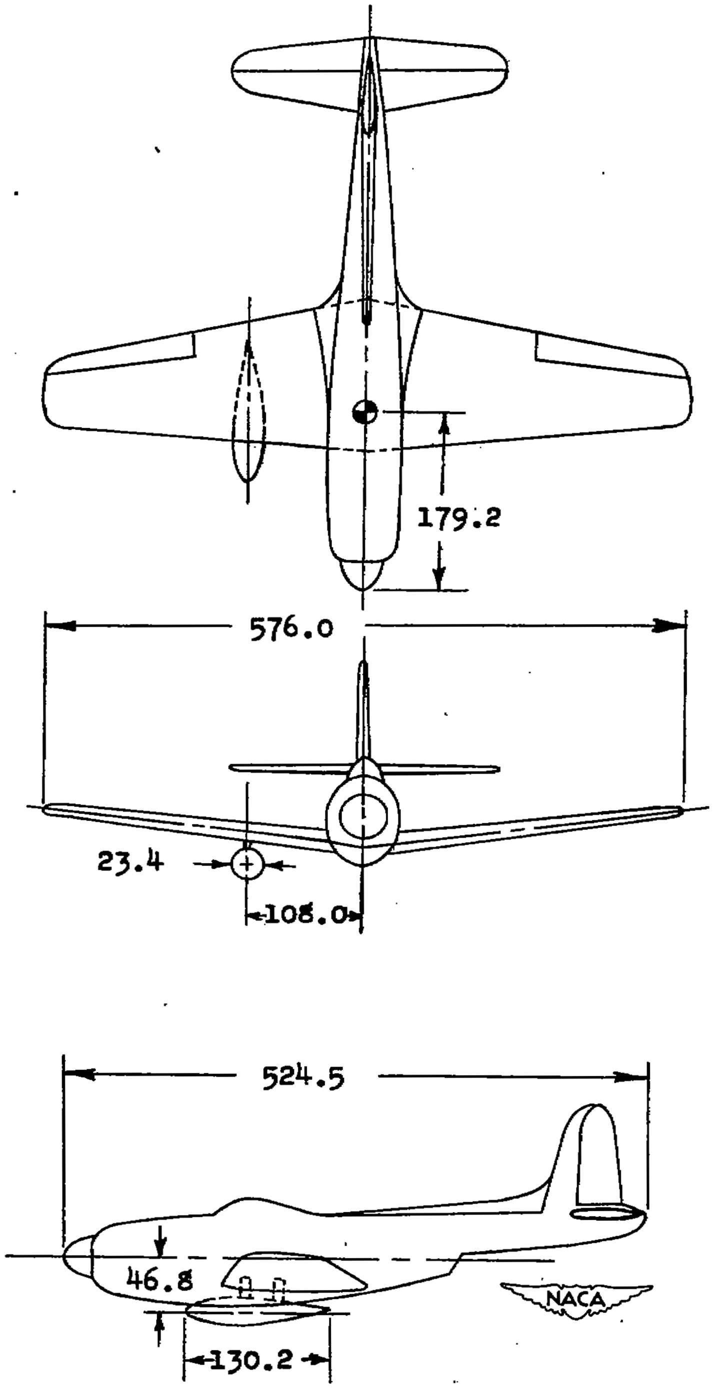
(c) Model 3.

Figure 1.- Continued.



(d) Model 4.

Figure 1.- Continued.



(e) Model 5.

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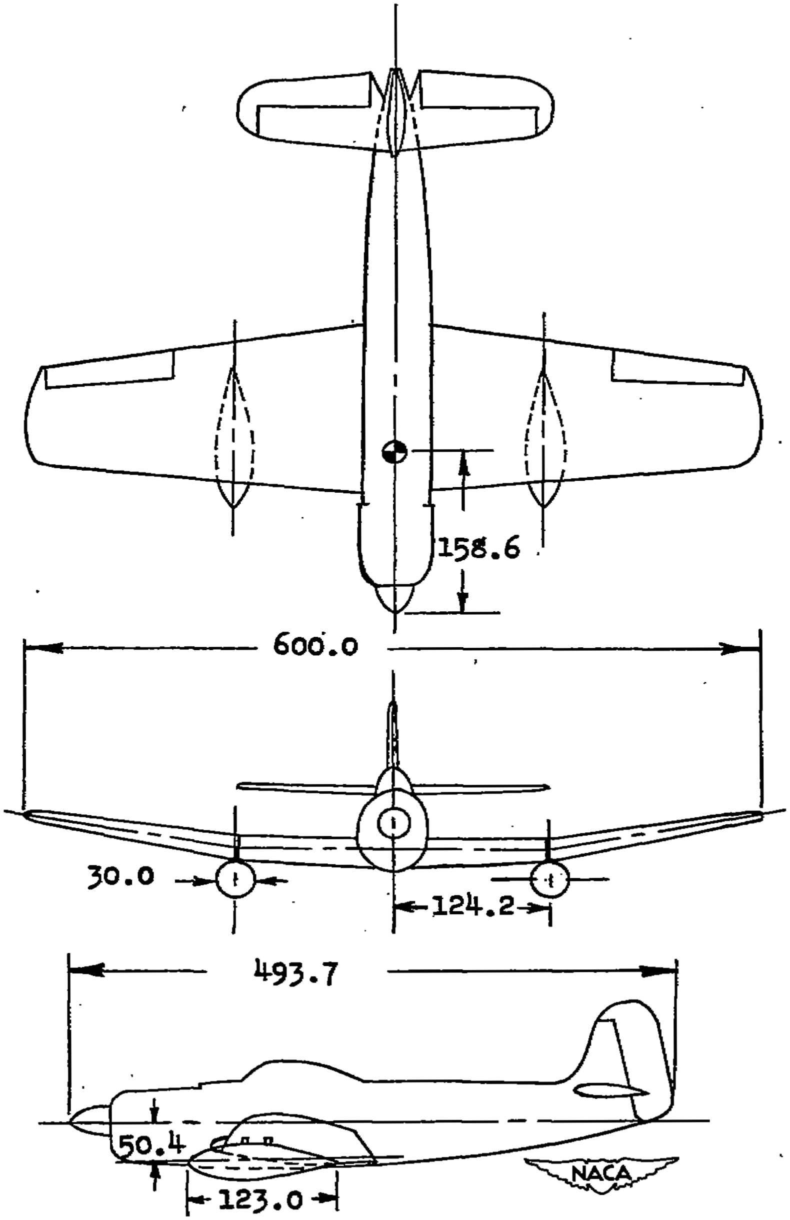
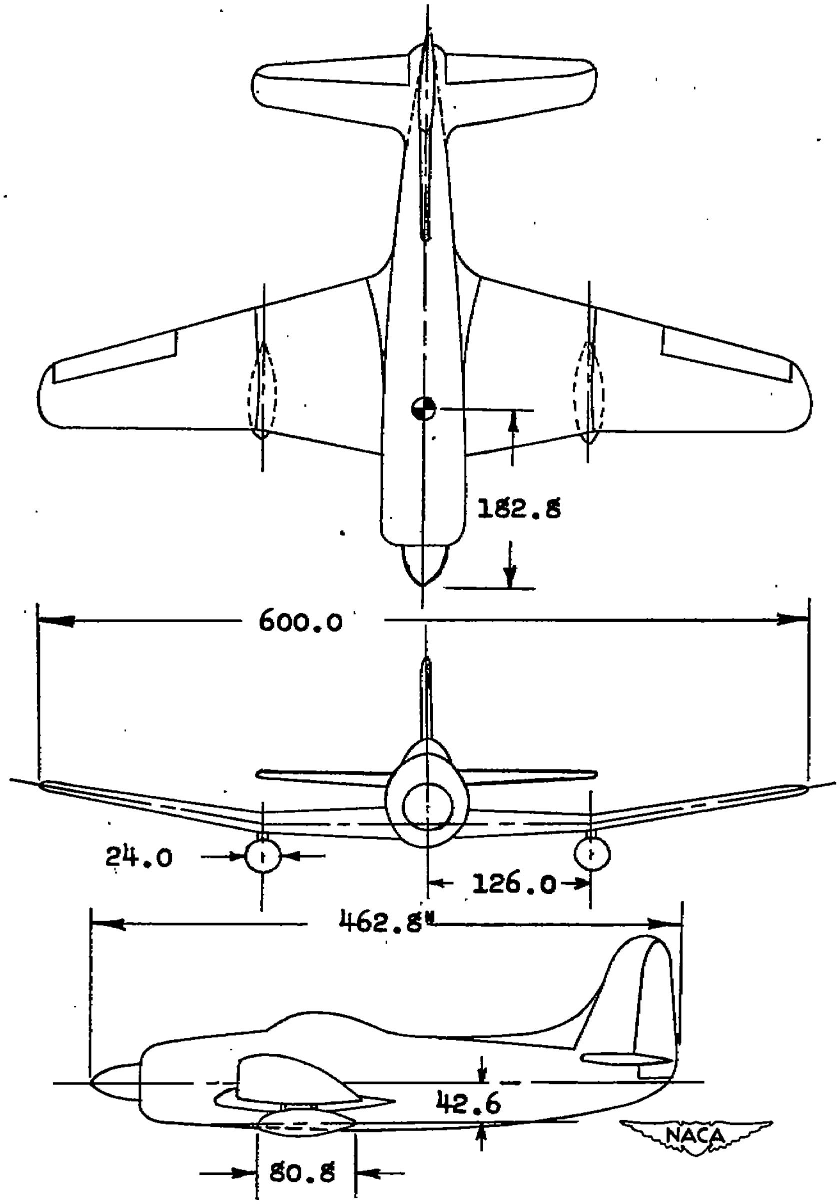


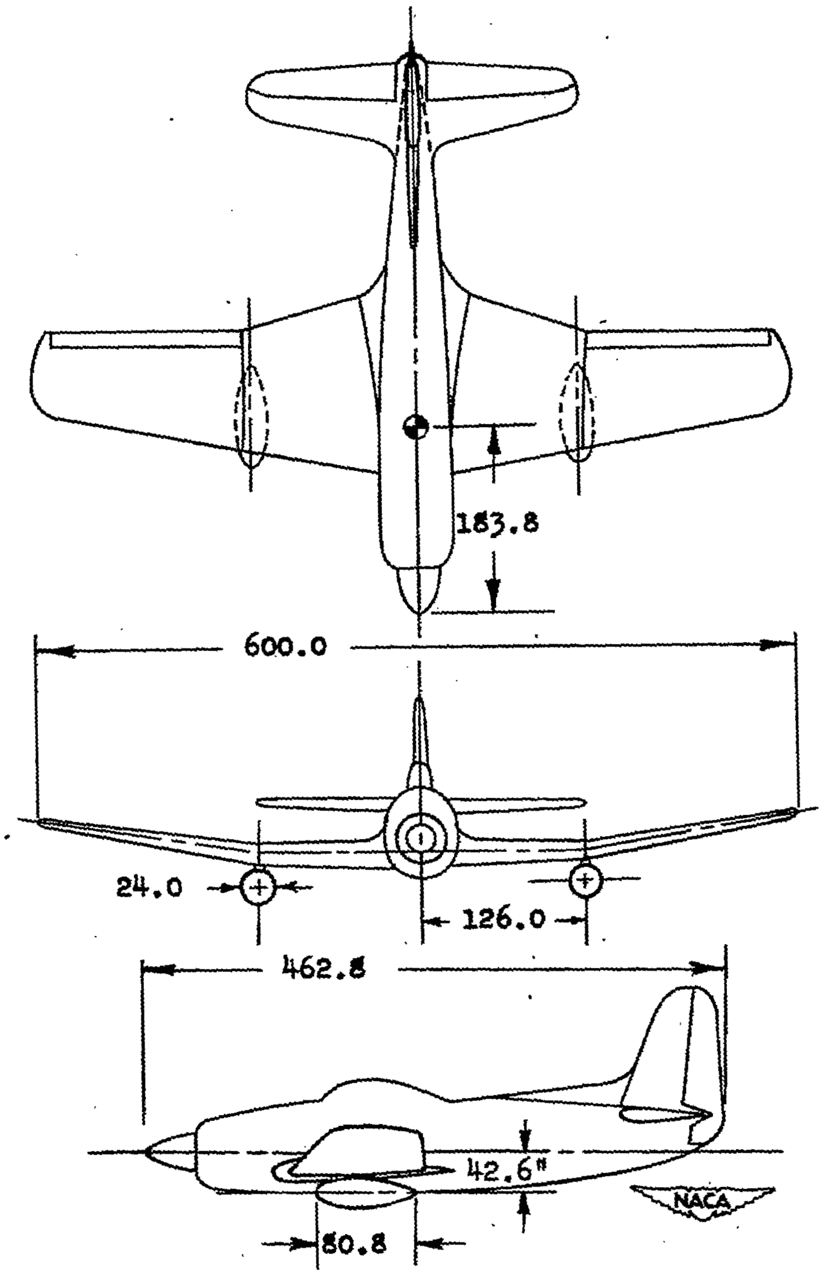
(f) Model 6.

Figure 1.- Continued.



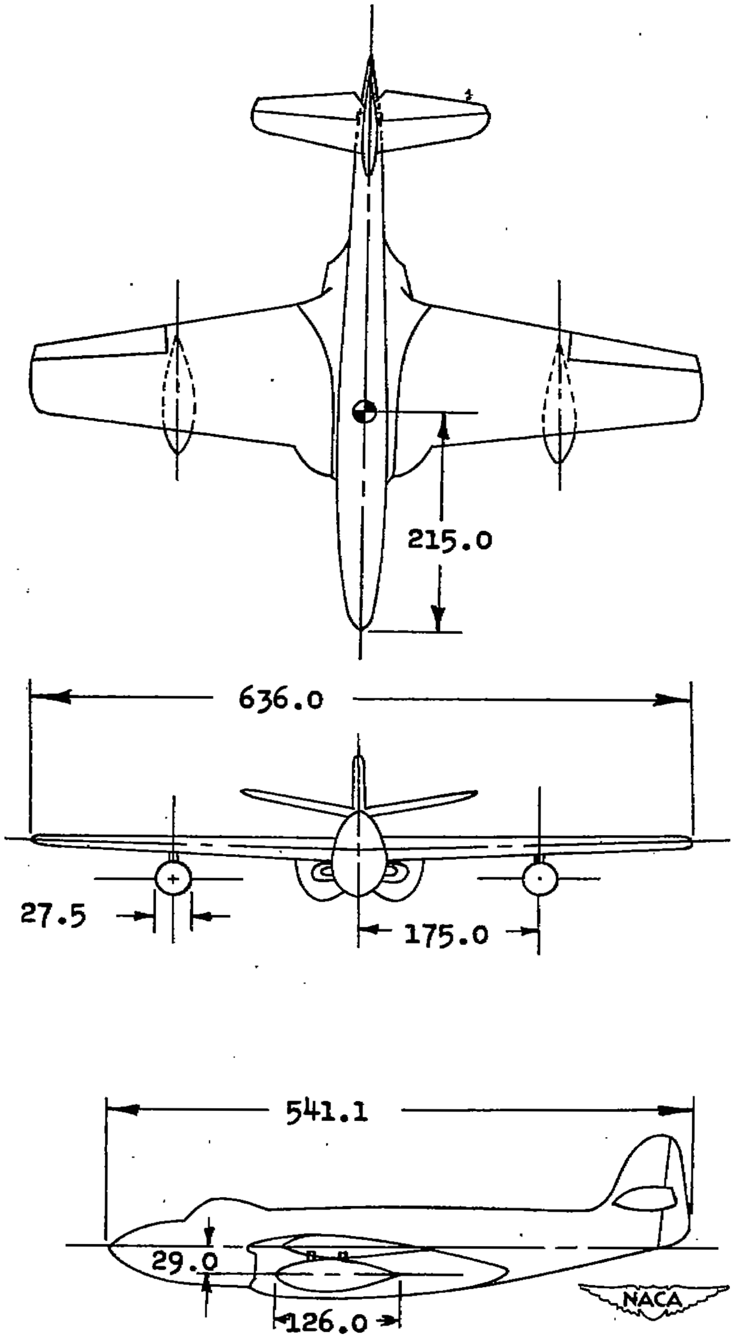
(g) Model 7.

Figure 1.- Continued.



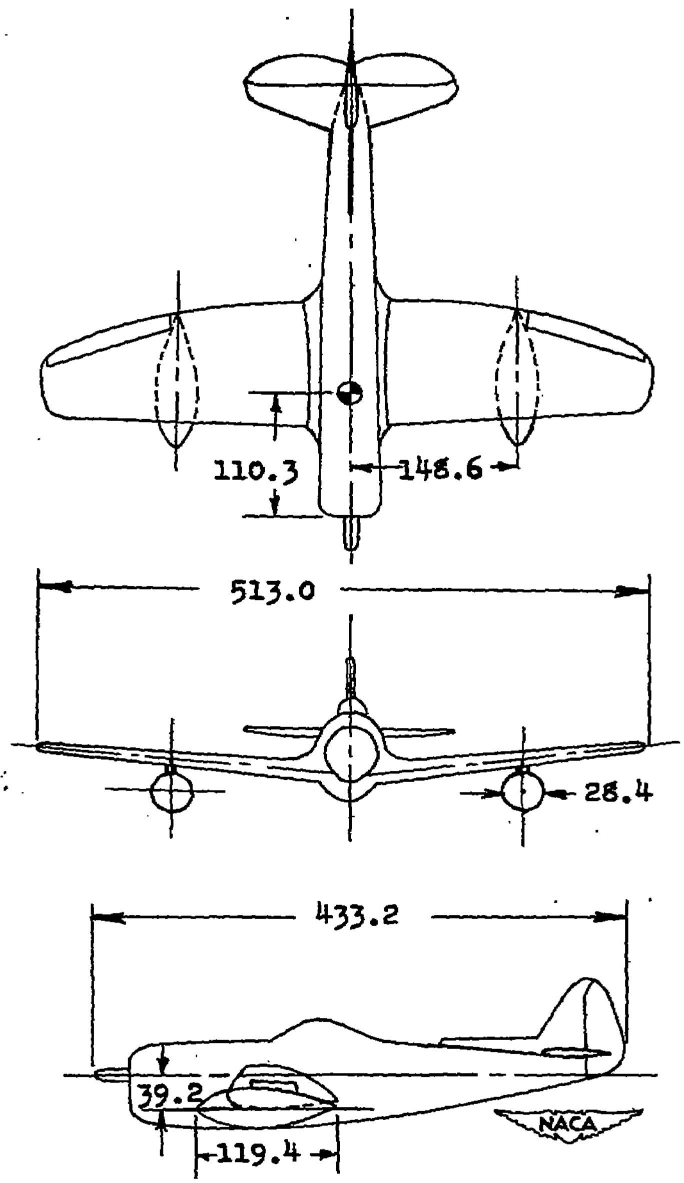
(h) Model 8.

Figure 1.- Continued.



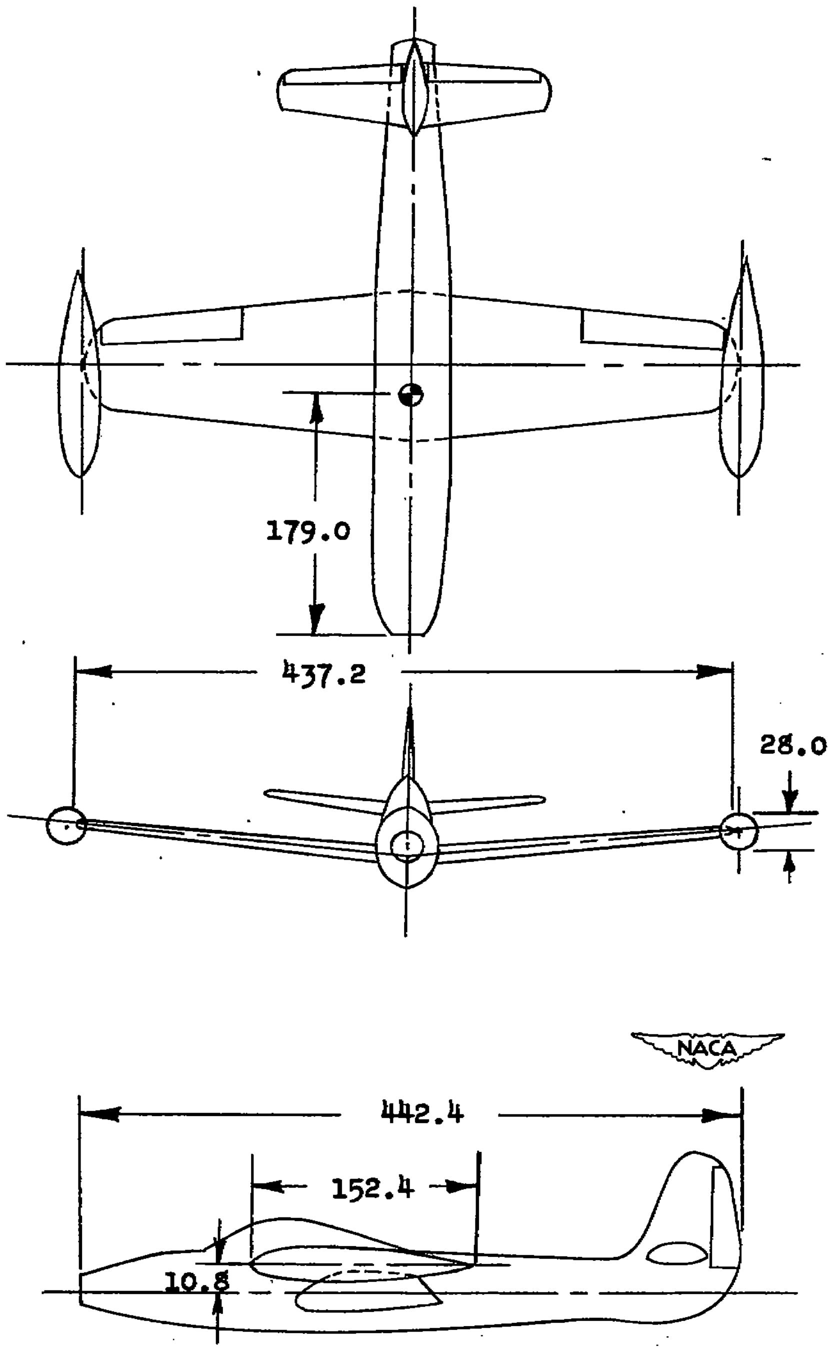
(i) Model 9.

Figure 1.- Continued.



(j) Model 10.

Figure 1.- Continued.



(k) Model 11.

Figure 1.- Concluded.