emeraldinsight

Aircraft Engineering and Aerospace Technology

Climb and Service Ceiling: Over a Wide Range of Aeroplane Types Time to Ceiling is practically Constant

J.L. Hutchinson, B.A., A.F.R.Ae.S.,

Article information:

To cite this document:
J.L. Hutchinson, B.A., A.F.R.Ae.S., (1932) "Climb and Service Ceiling: Over a Wide Range of Aeroplane Types Time to Ceiling is practically Constant", Aircraft Engineering and Aerospace Technology, Vol. 4 Issue: 8, pp.203-203, https://doi.org/10.1108/eb029580
Permanent link to this document:
https://doi.org/10.1108/eb029580

Downloaded on: 03 September 2017, At: 21:56 (PT)
References: this document contains references to 0 other documents.
To copy this document: permissions@emeraldinsight.com
The fulltext of this document has been downloaded 66 times since 2006*

Users who downloaded this article also downloaded:

(1932),"Flying in the Stratosphere: A Theoretical Examination of the Possibilities of Achieving Great Speeds at very High Altitudes", Aircraft Engineering and Aerospace Technology, Vol. 4 Iss 8 pp. 204-209 https://doi.org/10.1108/eb029581

University of Glasgow Library

Access to this document was granted through an Emerald subscription provided by emerald-srm:410639 []

For Authors

If you would like to write for this, or any other Emerald publication, then please use our Emerald for Authors service information about how to choose which publication to write for and submission guidelines are available for all. Please visit www.emeraldinsight.com/authors for more information.

About Emerald www.emeraldinsight.com

Emerald is a global publisher linking research and practice to the benefit of society. The company manages a portfolio of more than 290 journals and over 2,350 books and book series volumes, as well as providing an extensive range of online products and additional customer resources and services.

Emerald is both COUNTER 4 and TRANSFER compliant. The organization is a partner of the Committee on Publication Ethics (COPE) and also works with Portico and the LOCKSS initiative for digital archive preservation.

*Related content and download information correct at time of download.

Downloaded by UNIVERSITY OF GLASGOW At 21:56 03 September 2017 (PT)

Climb and Service Ceiling*

Over a Wide Range of Aeroplane Types Time to Ceiling is practically Constant

By J. L. Hutchinson, B.A., A.F.R.Ae.S.

IT has long been a subject of comment at Martlesham Heath that practically all the aircraft put through performance trials there take approximately the same time to reach the service ceiling—about 40 minutes.

Tabulated below are values for ten aircraft tested at Martlesham of widely different types chosen at random:

Type	Service Ceiling Height ft.	Time. Min.
Early Troop Carrier	9,000	40
Heavy Bomber	12,000	40
Light Aeroplane	12,500	47
Torpedo Carrier, 1923	12,800	48
Single Seater Scout, 1922 ..	15,000	41
Two-engined Bomber, 1923 ..	16,000	47
General Purpose	18,000	40
Two-engined Bomber, 1927 ..	21,000	46
Single-Seater Fighter	29,000	42
Modern Fleet Fighter	31,000	42

It will be seen that the time varies from 40 to 48 minutes only, though the table includes a wide variety of aircraft from light aeroplanes to multi-engined troop carriers with service ceilings from *9,000 to 31,000 ft.*

To be strictly comparable the climb should be made at full throttle throughout, but the list contains aircraft with gated and supercharged engines. Simple calculation shows, however, that in no case does the throttling at low altitudes make more than 2 or 3 minutes difference.

At first sight it might be expected that, as the height of the service ceiling varies so much between different aircraft, the time to get there would vary over a wide range. The examples given show that this is not the case and, on reflection, it is perhaps not so surprising since the higher the service ceiling the greater is the climbing ability of the aircraft. In fact, a machine chasing its ceiling is not unlike a dog chasing its tail—the greater the effort the faster does the objective recede.

It is interesting to establish a formula for the time as follows:—

If at any height h the rate of climb is C the time required is

$$t = \int_{s\,l.}^{s\,c.} dt.$$

* The author is indebted to the Air Ministry for permission to publish this paper, for which, however, he is solely responsible.

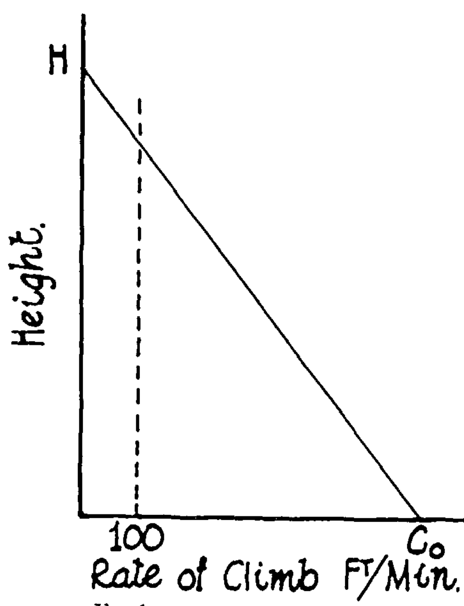

Fig 1.

where *s c.* represents service ceiling and *s.l.* sea level. This can be written

$$t = \int_{s\,l.}^{s\,c.} \frac{dt}{dh}\frac{dh}{dC}\,dC$$

Now $\frac{dh}{dt}$ = rate of change of height with time $= C$.

and as it is found in practice that the curve of rate of climb against height always conforms closely to a straight line, the slope of the line, $\frac{dh}{dC}$, is constant. If H is the absolute ceiling and C_0 the rate of climb at sea level, from Fig. 1

$$\frac{dh}{dC} = \frac{-H}{C_0}$$

Hence

$$t = \frac{-H}{C_0} \times \int_{s\,l.}^{s.c.} \frac{dC}{C}$$

$$= \frac{-H}{C_0}\Big[\log_e C\Big]_{s.l.}^{s\,c.}$$

$$= \frac{-H}{C_0}\Big[\log_{10} C \,\log_e 10\Big]_{s\,l.}^{s\,c.}$$

$$= 2{\cdot}303\,\frac{H}{C_0}\log_{10}\frac{C}{100}$$

In this article the author examines the theoretical reasons for the puzzling phenomenon that many different types of aeroplanes, of widely differing characteristics, all take approximately the same time to reach their own particular ceiling. This is one of those "Curiosities of Aeronautics" of which there are several other examples

since the service ceiling is the height at which C is 100ft./min.

This formula can be expressed as a quotient

$$0{\cdot}02303\,H \div \times \frac{C_0}{100} \Big/ \log_{10}\frac{C_0}{100}$$

in which the divisor $\dfrac{C_0/100}{\log_{10}\frac{C_0}{100}}$ increases as C_0 increases, and the dividend H generally increases with C_0 also, which is consistent with the supposition that the quotient will be roughly constant and independent of C_0.

It now remains to evaluate H and C_0 in general terms Useful expressions for our purpose, established by Diehl in terms of wing and power loading are given below. For their derivation reference can be made to Warner's *Airplane Design*, Chapter XVI.

$$C_0 = \frac{2100}{w^1} - 300\sqrt{w}$$

showing how intimately dependent is rate of climb on power loading.

For the absolute ceiling

$$H = 40{,}000 \log_{10}\frac{88}{w^1\sqrt{w}}$$

is fairly representative of American practice.

The final formula for the time to the service ceiling therefore becomes, in terms of the fundamental aeroplane characteristics, wing and power loading

$$t = 921 \log_{10} \frac{88}{w^1\sqrt{w}} \div \frac{\left(\frac{210}{w^1} - 3\sqrt{w}\right)}{\log\left(\frac{210}{w^1} - 3\sqrt{w}\right)} \text{ minutes}$$

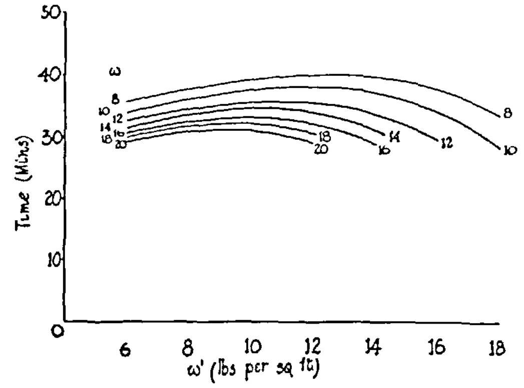

Fig 2.

In design various considerations operate to reduce the range of practicable loadings. C. of A. requirements stipulate a certain minimum performance and preclude the use of excessively high wing loadings with their inevitable high landing speeds, and high power loadings with their small speed range.

Facts which tend to keep loading up are

(1) Low wing loading reduces top speed;

(2) Low power loading is expensive in initial costs, in fuel and in maintenance.

Details of the aircraft at the International Aero Show at Olympia in 1929 (published in AIRCRAFT ENGINEERING of September 1929) show that for the majority of aircraft exhibited

w ranges from about 8 to 16
and w^1 from 6 to 18

I have calculated the values of t from the formula over these ranges of w and w^1. The results are presented in Fig. 2.

The numerical values of t are underestimated by the formula and the choice of the constants could possibly be improved. But the important point is illustrated—that there is a wide range of aircraft over which the time to the service ceiling is practically constant.

1. *Variation of* t *with power loading.*

The curves of t against w^1 at constant w are flat topped and reach a maximum within the range of w^1 considered. Or, in other words, the variation in t over a range of w^1 around the critical value is small. With further increase of w^1 t falls rapidly, as is true in fact, e.g., when the power loading is so high that the rate of climb at sea level is only 100 ft./min.

2. *Variation of* t *with wing loading*

As w increases t decreases. This is exemplified in practice when the wing area is so inadequate that the service ceiling is at sea level. The rate of fall-off of time is small for normal values of w^1. When $w^1 = 10$ the average fall-off is less than 1 min. per 1 lb. per sq. ft. change in wing loading.

According to the Figure t would be unusually small for a combination of abnormally high wing loading and small power loading. In this connection it is unfortunate that figures for the Schneider Trophy aircraft are not available.

Downloaded by UNIVERSITY OF GLASGOW At 21:56 03 September 2017 (PT)
© Emerald Backfiles 2007