REPORT No. 5.

RELATIVE WORTH OF IMPROVEMENTS ON FABRICS.

By THE GOODYEAR TIRE AND RUBBER COMPANY.

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If one seeks to determine the qualities which offer the best chance for improvement, without knowing as yet the exact means for effecting such improvement, the procedure is as follows:

Assume that in a theoretically perfect fabric each of the following qualities would be reduced to zero:

Weight (per unit strength).
Diffusion.
Rate of depreciation (dollars per year).
Heating coefficient.
Interest and insurance.
Moisture absorption.

It may be admitted that, in practice, certain of the above qualities can not possibly be reduced below the well-recognized minimum of terrestrial materials, but this minimum is in every case so near zero, compared to the figures for ordinary balloon fabric, that the point is of no practical importance.

Applying the results to a dirigible and taking the items one at a time: If the weight of fabric is reduced to the assumed minimum it will save $\frac{W}{U}$ of the total running expense of the dirigible; where W is the total weight of fabric saved and U is the useful load carried.

If diffusion is entirely eliminated it will save the entire cost of gas (including labor and overhead) except that which escapes through the valves, the interest on the original inflation, and liability to accidental deflation.

If the fabric is made infinitely durable it will save all the depreciation of the gas bag except that due to accidental injury.

If the heating coefficient is reduced to zero it will save the running expense of that part of the control system which serves to correct the effects of heating, plus $\frac{w'}{u}$ of the total running expense of the dirigible; where w' is the weight of apparatus saved.

If cost is entirely eliminated it will save the interest and insurance on the fabric (exclusive of building up).

If the moisture absorption is reduced to zero, it will save the cost of apparatus to correct it, plus $\frac{w''}{u}$ of the total running expense of the dirigible, where w'' is the weight of apparatus saved.

Assume now a modern nonrigid dirigible of 500,000 cubic feet capacity and speed of 40 miles per hour. Other data could be reasonably expected as follows:

W = weight of fabric = 5,000 pounds.
U = average useful load = 6,000 pounds.
10,000 miles per year.
Gross running expense, $100,000 per year.
Gas leakage, 0.5 per cent per day.
Reinflation every three months.
Gas and inflation cost at $0.01 per cubic foot (plus allowance of $10,000 for idle time), $40,000 per year.
Depreciation of gas bag (from weathering and ordinary wear), $20,000 per year.
w' = weight of heat-control apparatus (planes, fuel, and ballast), 1,200 pounds.
Interest and insurance (military) on fabric, $15,000 per year.
w'' = weight of apparatus to counteract moisture absorption (planes and ballast), 500 pounds.

The above data works into the following figures which show the gross expense chargeable to each of the items named:

	Per year.
Weight	$82,000
Diffusion	40,000
Depreciation	20,000
Heating	20,000
Interest and insurance	15,000
Moisture absorbtion	8,000

(These figures are of course largely overlapping and can not be summed up into a total.)

Expressed on a percentage basis for the various qualities sought for, we get roughly the following:

Quality:	Relative importance.
Lightness	44
Gas tightness	22
Durability (dollars per year)	11
Low heating	11
Cheapness	8
Low moisture absorbtion	4
	100

For proportional improvement it will be seen that lightness is by far the most desirable quality, while mere cheapness of fabric is almost the last thing to be sought.

The table also furnishes means of determining whether a proposed change in the design of a fabric is worth while.

In effecting a certain improvement other qualities are generally affected at the same time, sometimes adversely. To determine the degree of net improvement multiply the per cent improvement in each quality by its quality gauge number, and add up the products. If the result is positive a net improvement has been effected proportional to the magnitude of the figure. For instance a 5 per cent saving in weight would he worth while even if accompanied by a 20 per cent increase in cost, other things remaining the same.

It should be carefully noted that this particular scale of improvements is strictly applicable only to a ship of approximately the characteristics above named, and to that only under certain fixed conditions of operation. It is only taken as a rough guide to present day dirigibles in general. Whenever the fabric, the dirigible or its conditions of use are much changed, the fabric improvement scale must be changed accordingly.

It has been argued by some that the economic basis of design can not be applied at all to military work. With this I decidedly do not agree. It is true only to the extent that certain items of cost such as initial investment are often of small, sometimes negligible, importance compared with other items. But if the analysis is complete, it may be put squarely on an economic basis, it being only necessary to estimate the *true* saving for each of the possible improvements above named, *applied to the particular requirements and conditions governing the case in hand.*

It is evident from what has been said that for a dirigible of certain required specifications a definite equation exists connecting all the major qualities of the fabric, from which the fabric may be rigidly designed with respect to maximum ultimate economy.

The same principles apply to balloons and aeroplanes. For an 80,000 cubic foot spherical balloon (the *Goodyear*), the following order prevails if used for passenger flights (1 day trips).

Lightness	32
Durability	22
Low heating	20
Cheapness	16
Low moisture absorbtion	8
Gas tightness	2

For a 100 horsepower tractor biplane the same six qualities run approximately:

Lightness	60
Durability	20
Cheapness	15
Low moisture absorbtion	5
Air tightness	trifling.
Low heating	0

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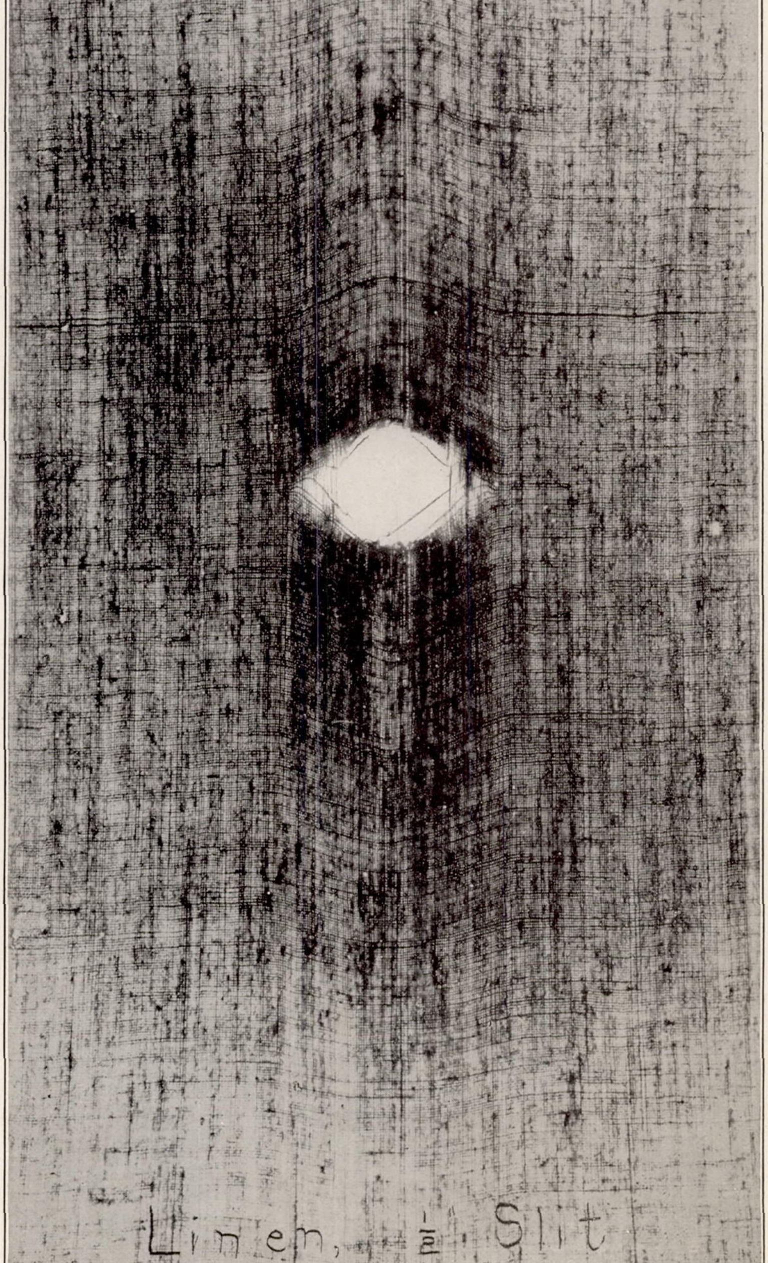
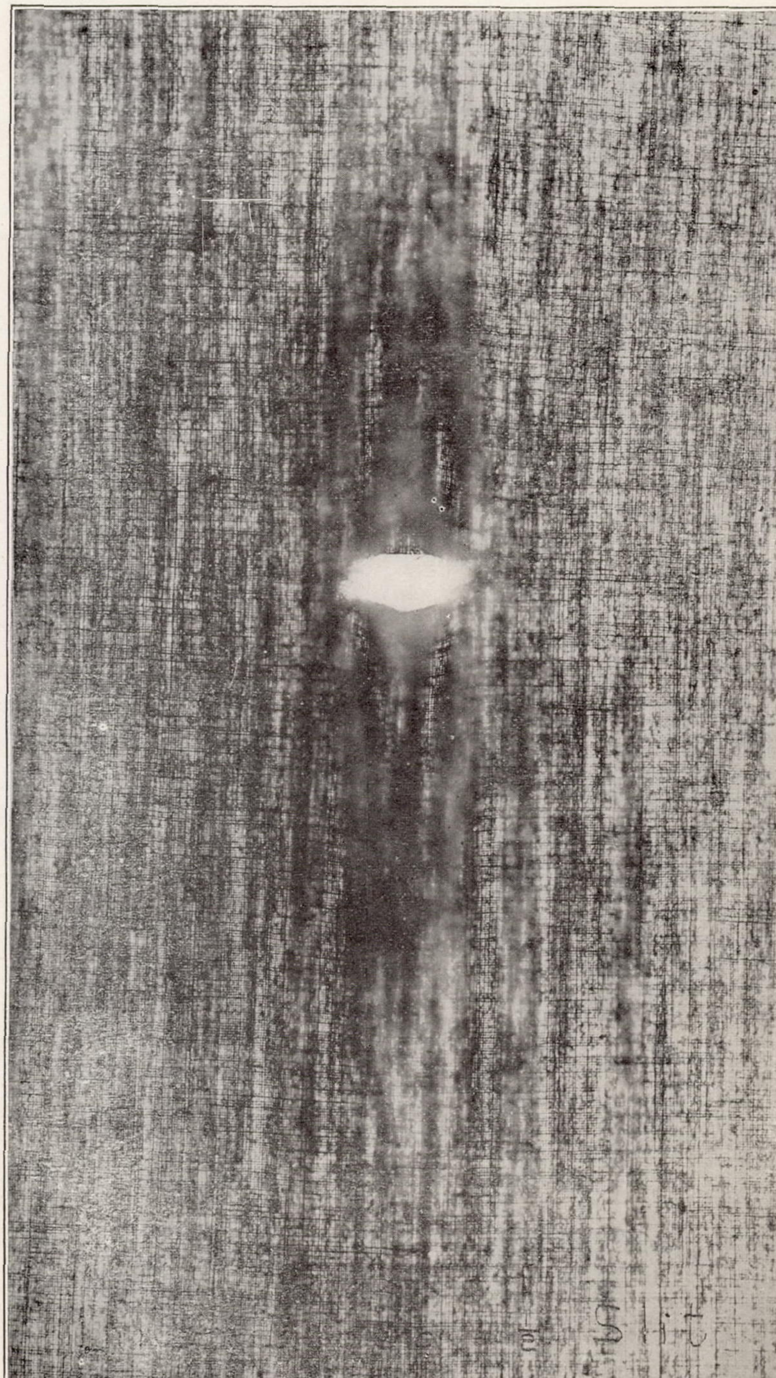
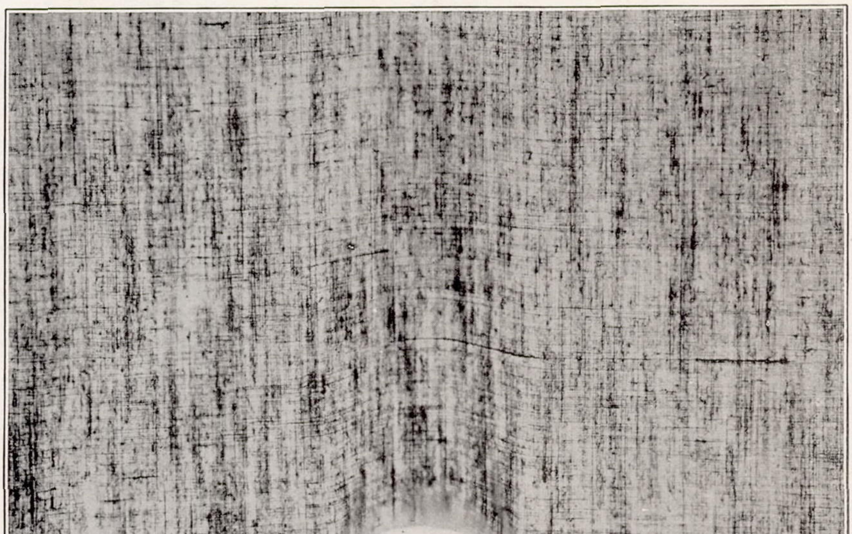

Linen, ½" Slit





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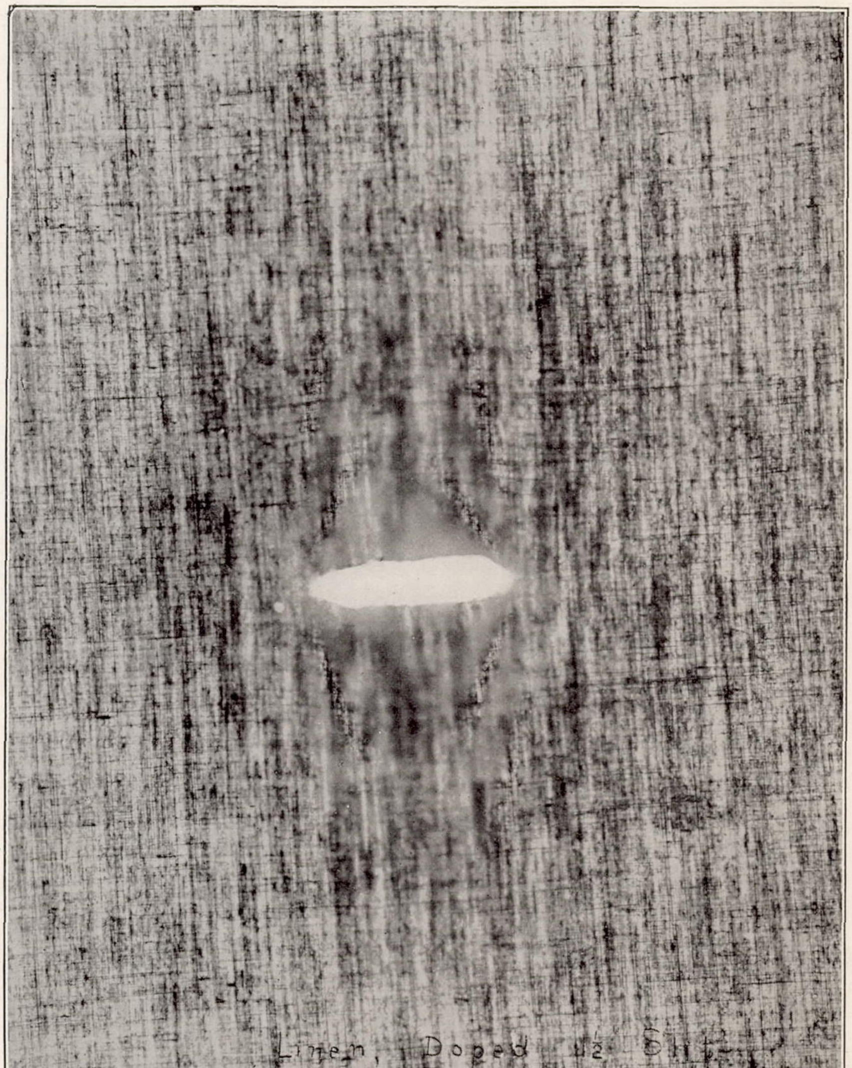
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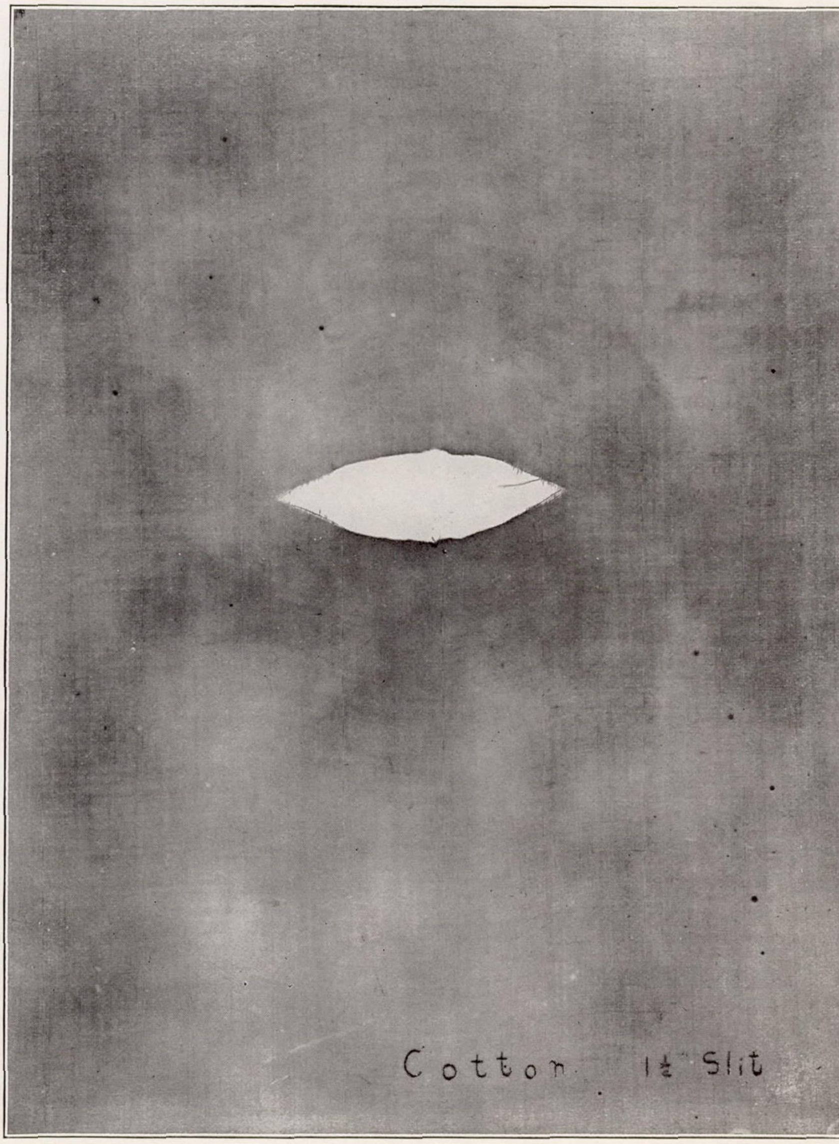
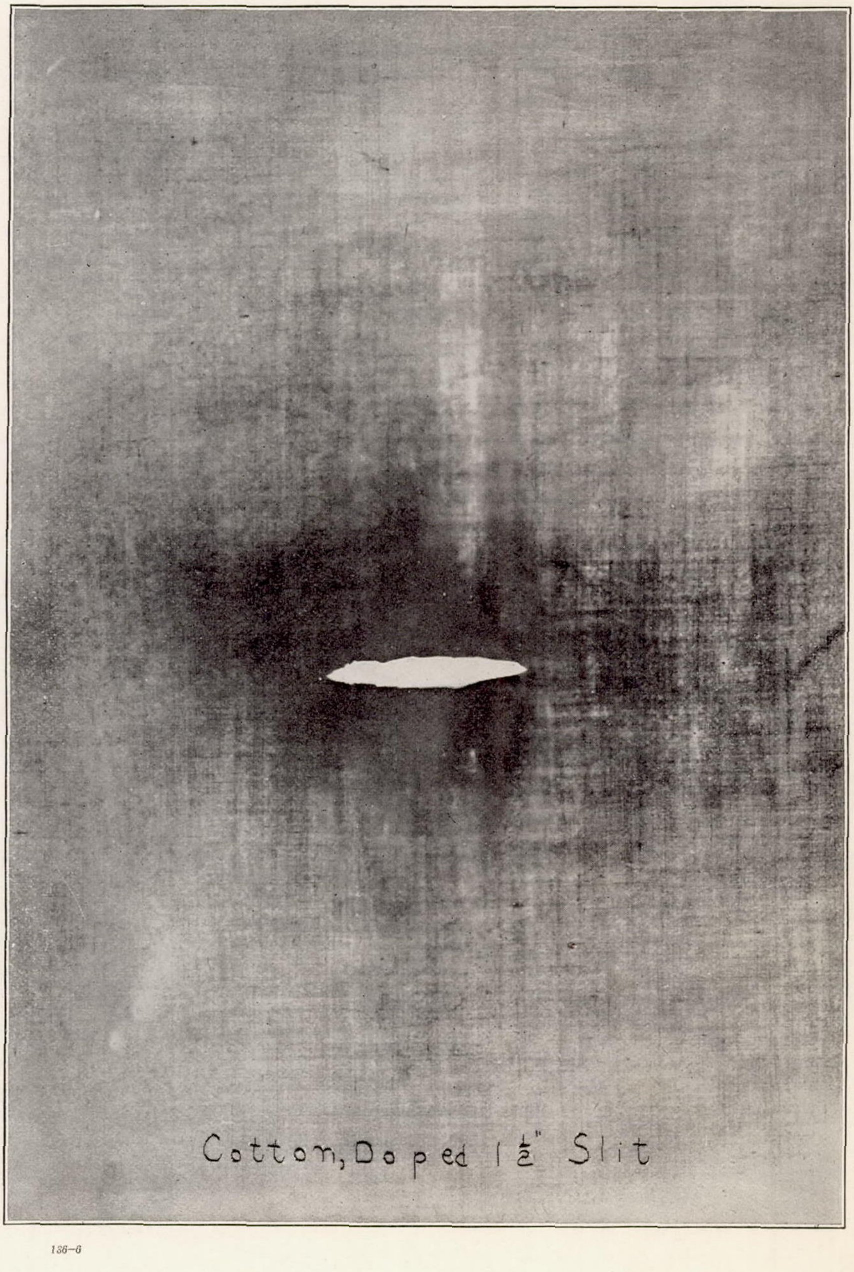

Cotton 1½ Slit


Cotton, Doped 1½" Slit