DISCUSSION.

LIEUT. OLECHNOVITCH : I should be very much obliged if Professor Coker could kindly give us the names of any works dealing with the subject of his lecture.

PROFESSOR COKER : The literature of this subject is not very extensive from the engineering aspect. Prof. Filou has dealt very thoroughly with the physical aspects of photo-elasticity in various papers, mainly in the Transactions and Proceedings of the Royal Society, and Mr. A. R. Low has published a paper on aeronautical investigations in the Proceedings of The Royal Aeronautical Society. A list of over thirty of my own papers on this subject is given in the Journal of The Franklin Institute for October, 1923. M. Mesuager, of Paris, has also done a large amount of work in this field, and some of his investigations are published in the " Annales des Ponts et Chausseès." A great many physicists have worked at the optical properties of materials in polarised light, and there is an extensive literature in this field.

DR. THURSTON : I should like to record my most sincere thanks for this extremely valuable lecture. To describe these slides as beautiful seems to me very inadequate, and one really wants more graphic language than usually falls to the lot of engineers. In dealing with aeroplane structures, of course, the problem is a very complex one, and the best designer, it seems to me, is the man who can get down the quickest to the actual state of affairs in every part. In an aeroplane you never get all the maximum stresses operative at once, and the chief problem at present is to find out what are the stresses that come upon the aeroplane, and how to design them to get the most efficient shape or structure with the material available. It therefore seems to me that if we could only get our authorities to hand a good round cheque to Professor Coker and ask him to go ahead, he would provide such insight into the problems as would enable our aeroplanes to be designed in a superior way. There would be no difficulty if we had a round-table conference of our leading designers to suggest fifty problems which could be immediately placed in Professor Coker's hands, and the result would enable us to work with more certainty than we can at present.

An engineering design is always one of compromise. We go through our various mathematics and mechanics, and think we know everything and can design perfectly. After basic theory come assumptions, and then the practical engineer must square his point of view with his assumptions.

I now come to our most difficult material—wood, which is made up of many tubes gummed together, and is a most wonderful structure for taking loads. It is as strong for its weight as the best steel, but the problem is, how such a material is going to take all the various strains and loads that

https://doi.org/10.1017/S2976690700000863 Published online by Cambridge University Press

are put upon it. Could you make a piece of wood absorb stuff to make it transparent, so as to place portions of it under the polariscope to investigate the behaviour under various loads? Because wood is, roughly, twice as strong in tension as compression, and is very weak in one direction as compared with another. If you touch it up with a little water the tubes swell and lose their resisting power, and it is quite possible to load an aeroplane and find the strength is less than one-half in the morning what it was at night.

Another point is a mere suggestion. In designing an aeroplane, if you connect your spars together with plates as with joints it would be a very interesting problem of the effect on the wing structure to connect the spars by plates or joints at the points of inflection. It would be very interesting if we could plate certain portions of an aeroplane with silver, deposit some of your colour on it, and then submit it to the polariscope. Is that feasible at all?

It seems to me that if you could carry out some of your experiments on these lines it would be possible for a very difficult problem in the design of aircraft structures to be solved. All we can do at present is to adopt a barbarous method, assume that certain wires are not there, and design, say, the front parts, then the other parts, and so one. The result is that our aeroplanes fly, but the wonder is that they fly at all when the wires are broken or the spars shot away.

In conclusion, I would again thank Professor Coker very much for his extremely interesting lecture, and, like Oliver Twist, would express the feeling of all our members that we would like some more.

Professor Coker: I thoroughly appreciate the very kind remarks and suggestions of Dr. Thurston.

I hope, however, that among the problems which he suggests should be put to me, the one "How would you make wood transparent?" will not be included, as it seems to me much too difficult for solution. With regard to the other question—relating to a film on a transparent metal body—there seems no doubt that a film could be used in this way and some effect obtained, bu I am very doubtful if it would represent what is happening in the material it encases. It might, however, be a useful thing to investigate what connection there is between the stress in a film and the stress in the interior of the body so coated. As is well known, such methods have been used to find the places of failure in tests of girders, pillars and the like by the cracks developed in coatings of rust or in thin washes of cement. The chief difficulty in such cases is to interpret the phenomena observed.

Mr. Andrews: We are all very much obliged to Professor Coker for his lecture, giving us a very interesting insight into optical stress analysis. At the same time, it seems to me that there is a very great need for a large number of research workers in this direction, especially with regard to aeronautical problems. Would it be possible for him or the College to enable part-time research workers to take part in optical stress investigations

https://doi.org/10.1017/S2976690700000863 Published online by Cambridge University Press

at University College?

PROFESSOR COKER: There are definite arrangements at University College for advanced work of this kind, and research work is always going on with apparatus derived from various sources, but as this equipment is not very extensive some selection has to be made from those who desire to prosecute such work, according to ability and the time at disposal.

Experience has shown that a certain amount of training is requisite in order to obtain the necessary skill and knowledge of technique, and very little of a useful nature can be accomplished without at least three months' continuous preliminary work.

MR. ANDREWS: I would suggest that the part-time worker might get on much better than the whole-time student who has the whole day to work in.

PROFESSOR COKER: No. I think that in general a research student who can devote the whole of his time to the work can accomplish more than another who has only a part of his time available.

MR. MANNING (Chairman): There are one or two questions I should like to ask Professor Coker.

I think that all the specimens he showed us indicated that the section over which the stresses occurred was approximately rectangular. Possibly the distributions are varied considerably for other sections.

I think it is a very good thing to have brought home to one occasionally how different the true stresses are from what one is bound to assume in ordinary work. I was impressed by that in the photographs of the pinion. As a matter of fact, in a commercial pinion it is possible that the stresses are even more complicated than as shown. In heat treatment the stress is superimposed on the stresses caused by the interior of the pinion, or by the teeth.

With regard to shear, if there are any particular bending stresses on any particular section it would produce a certain colour on that section. Supposing that shear exists at the same time; what effect has that on the colour distribution?

PROFESSOR COKER: All the specimens which have been shown on the screen were cut from plates of uniform thickness, but there is no difficulty in showing the stress in H sections on T sections. The model of a roof truss on the lecture table has in fact members of T shaped cross section, and the distribution of stress in these can be measured without any difficulty.

Bodies of circular cross section behave like lenses with an imperfectly defined focus, but the stress effects in such cases can be readily observed when the specimen is surrounded by a jacket with plane faces as described in an earlier paper.*

When shear and bending occur together, the stress system at a point

* "Photo-elastic Measurements of the Stress Distribution in Tension Members used in the Testing of Materials." By E. G. Coker. Min. Proc. Instn. C.E., Vol. CCVIII., Part II.

https://doi.org/10.1017/S2976690700000863 Published online by Cambridge University Press

can still be represented by a pair of principal stresses, and the directions and magnitudes of these latter can always be found by a combination of optical and mechanical measurements. As shear stress can be resolved into a pair of equal unlike principal stresses, and the optical effect is proportional to the algebraic difference of these latter, shear stress gives a very marked optical effect, but the precise effect produced by a combination of shear stress and bending will depend entirely on their relative proportion. In any case the stress system can be measured and its components found in any direction required.

CHAIRMAN: On behalf of the Institution I should like to express our very grateful thanks to Professor Coker for giving us a lecture on this subject, which is of immense importance from the aeronautical point of view, where less material has to be made to do more work than in any other type of engineering. Therefore, any method which will enable us to analyse more accurately the stresses used is of the utmost importance. The aeronautical engineer has always been to the front in the adoption of new scientific methods, and I think they might be more adopted than they are at present. We are all agreed that Professor Coker's lecture is one of the most interesting we have had, and I hope it will not be the last we can expect him to give us. I have much pleasure in proposing a very hearty vote of thanks to Professor Coker for his lecture to-night.

PROFESSOR COKER: I thank you very much indeed for your very kind vote of thanks. It has given me very much pleasure to deliver this lecture, and I desire to thank you again for your very kind attention and appreciation.

For diagrams referred to in this paper see following pages.

https://doi.org/10.1017/S2976690700000863 Published online by Cambridge University Press

DIAGRAMS.

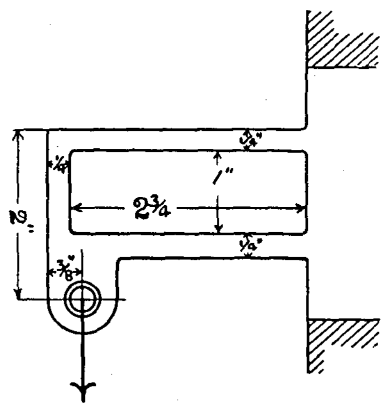

Fig. 1.

https://doi.org/10.1017/S2976690700000863 Published online by Cambridge University Press

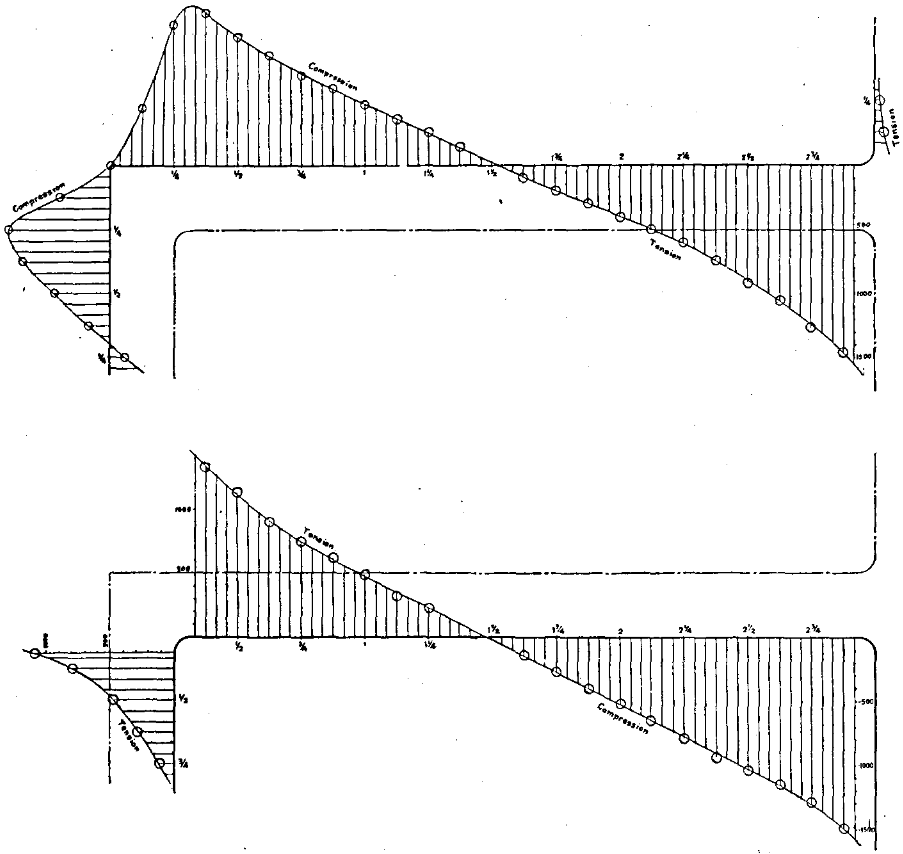

Fig 2. Stress along outside edges.

Stress Distribution
along outer contour.

x	y	STRESS
	3/4	107
	5/8	-169
	1/2	-428
0	3/8	-673
	1/4	-796
	1/8	-382
	0	0
1/8		-457
1/4		-1119
3/8		-1192
1/2		-1040
5/8		-856
3/4		-704
7/8		-597
1		-474
1 1/8		-367
1 1/4		-260
1 3/8		-139
1 1/2	0	-
1 5/8		107
1 3/4		199
1 7/8		231
2		392
2 1/8		505
2 1/4		597
2 3/8		735
2 1/2		919
2 5/8		1055
2 3/4		1254
2 7/8		1438
3		-
3	-1/8	77
3	-1/4	31

x	y	STRESS
	3/4	107
	5/8	291
1/4	1/2	474
	3/8	795
	5/16	1100
3/8		1330
1/2		1132
5/8		887
3/4		734
7/8		612
1		475
1 1/8		321
1 1/4		230
1 3/8		-
1 1/2		-
1 5/8	1/4	-138
1 3/4		-275
1 7/8		-398
2		-520
2 1/8		-642
2 1/4		-795
2 3/8		-933
2 1/2		-1055
2 5/8		-1148
2 3/4		-1300
2 7/8		-1470
3		-

Stress Distribution
along inner contour.

https://doi.org/10.1017/S2976690700000863 Published online by Cambridge University Press

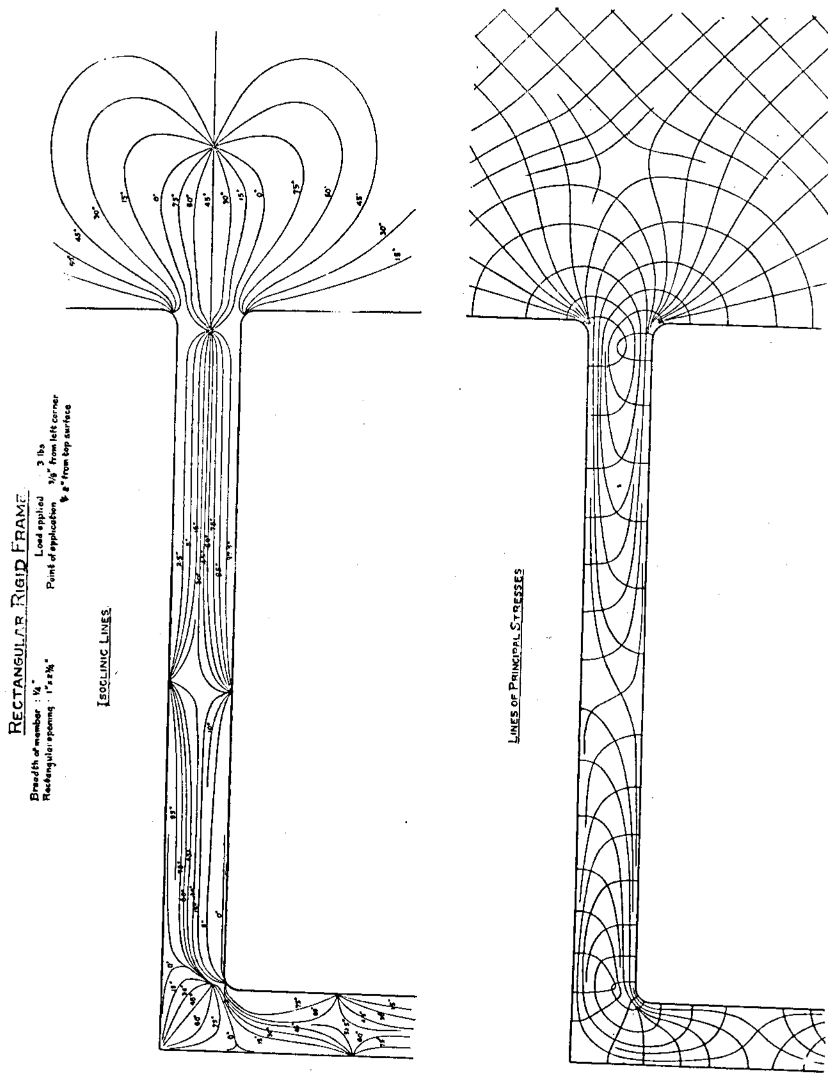

Fig. 3.

https://doi.org/10.1017/S2976690700000863 Published online by Cambridge University Press

TEN-SIDED FRAME.

Thickness=0·18″. Load=20 lbs.

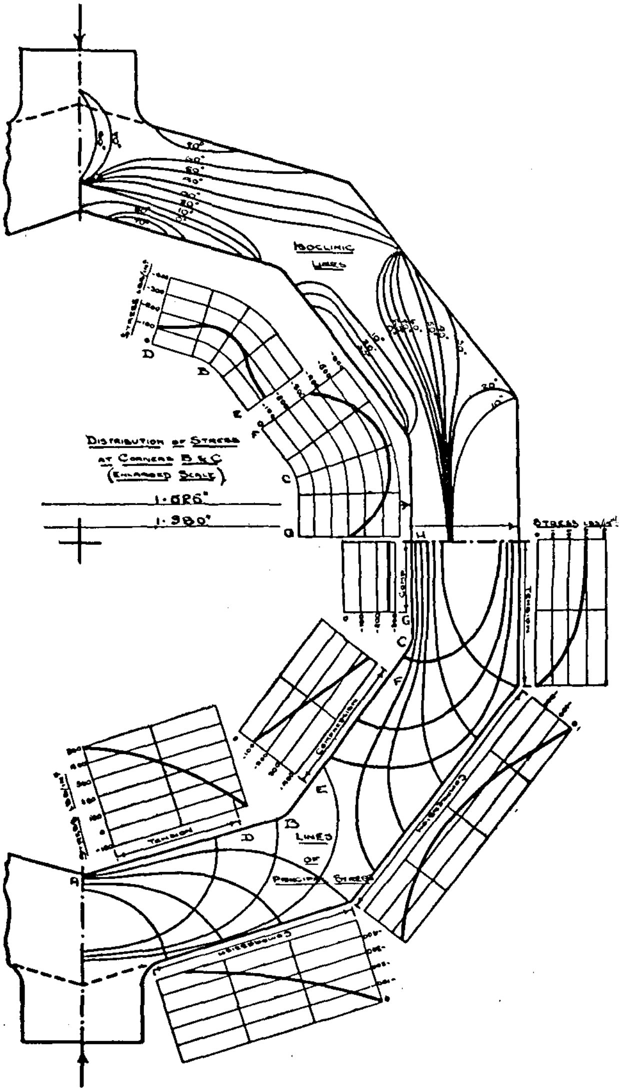

Fig. 4.

https://doi.org/10.1017/S2976690700000863 Published online by Cambridge University Press

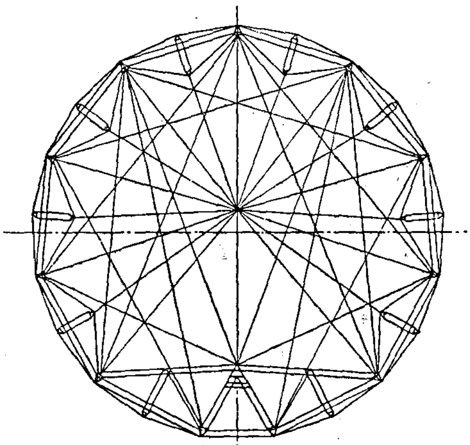

Fig. 5. A frame from Airship R.80

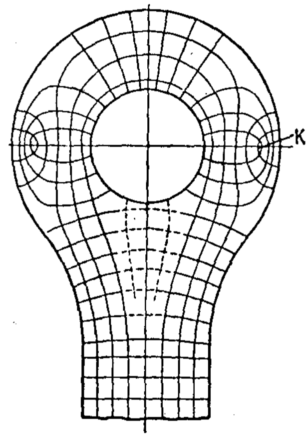

Fig. 8. Lines of Stress in an eye-bolt.

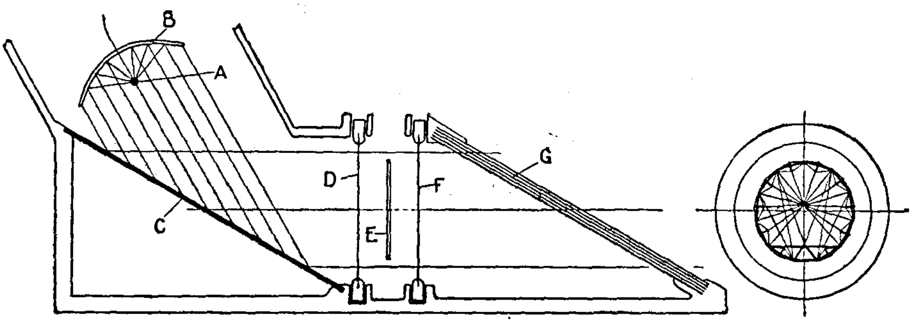

Fig. 6. Design for a polariscope for very large models.

https://doi.org/10.1017/S2976690700000863 Published online by Cambridge University Press

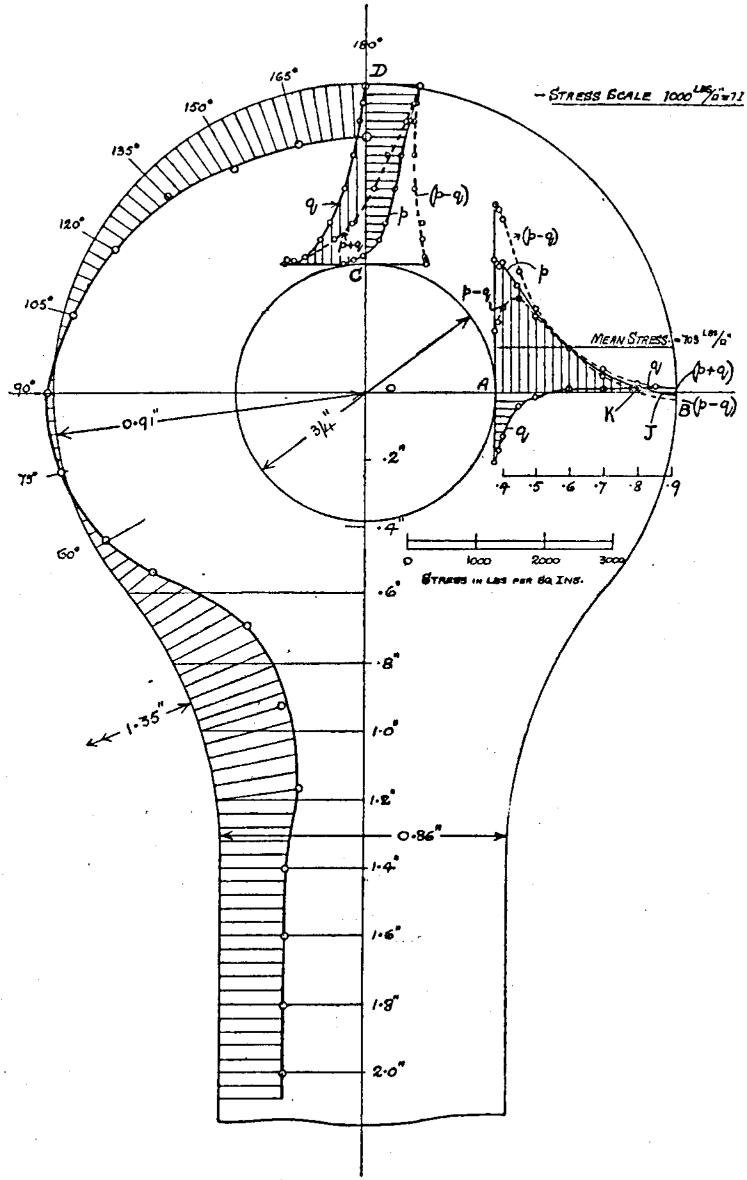

Fig. 7. Stress distribution in an eye-bolt.

https://doi.org/10.1017/S2976690700000863 Published online by Cambridge University Press