follows this by discussing the questions of pensions and indemnities for the blind, devoting a chapter to the consideration of the compensation laws for working men blinded in the course of their employment.

The last chapter of the book, containing the author's conclusions with respect to the work for the blind in the United States, gives a brief survey of his laborious enquiries. While he fully recognizes that all is not done that should be done, he concludes that there is good reason to believe that the efforts being made by the Government and the public of the United States are tending towards diminution in the number of the blind; and to an all round improvement in measures to lessen the hardships of blindness.

J. B. LAWFORD.

The Medical Annual, 1919. Liverpool: John Wright & Sons, Ltd. Price £1 net.

This valuable work of reference on the past year's literature has again made its annual appearance. We notice with regret that the price has been doubled. Foster Moore has taken over the ophthalmic part of the book, and contributes abstracts of recent work on the welfare of the blind, cataract operation, trachoma, anaphylaxis, hemeralopia, sympathetic ophthalmitis, glioma, foreign body and other injuries of the eye, visual disturbances in cerebral lesions, visual standards, relation of intraocular pressure to blood pressure, plastic socket operations and one or two minor matters. The illustrations comprise two plates on trachoma, and two from Priestley Smith's paper on the blood pressure in the eye. In addition, there are some text illustrations reproduced from the BRITISH JOURNAL OF OPHTHALMOLOGY. The book is fully up to the usual high standard, and is a most useful work of reference.

E. E. H.

CORRESPONDENCE

TONOMETRIC VALUES

To the Editor of THE BRITISH JOURNAL OF OPHTHALMOLOGY.

SIR,—Having carefully read Colonel Elliot's criticism of my recent article, and Dr. McLean's fresh communication (B. J. O., Sept., 1919), I should like to add a little to what I have previously said on this subject.

First, as to the apparent inaccuracies of the Schiötz tonometer. McLean has shown beyond dispute, I think, that the Schiötz chart puts the intraocular pressure considerably lower than it really is. This does not surprise me, for my own experiments pointed in that direction (B. J. O., 1918, p. 268). It is the magnitude and irregularity of the apparent errors about which I am sceptical. In my article, I ventured to suggest that the large discrepancies were *possibly* due to non-closure of the tap between the manometer and the eye. I now gladly abandon that idea, for I see that it was effectually disposed of at Oxford, but I still hesitate to believe that the Schiötz, as ordinarily used, makes such large and irregular mistakes as it made in McLean's experimental tests. Here is one instance (p. 391): when the manometer registered 90 mm. Hg. the Schiötz said 76, and when the manometer said 110, the Schiötz said 72; meanwhile the McLean was at fault by only 3 mm. Hg. Why did the Schiötz behave in this erratic manner while the McLean was working so well? A detail referred to by Elliot in his letter will perhaps afford the answer.

During his experiments, McLean kept the cornea constantly wet with normal saline, and he has raised the question whether Schiötz and I "failed in this precaution." I did not wet the cornea and I doubt whether it was desirable to do so. The surface of the living cornea is not, as a rule, discoverably wet: it yields no visible moisture when touched with blotting-paper. But this is not all. McLean himself has observed that fluid remaining on the cornea may rise by capillary action into the barrel of the Schiötz, and may impair the reading, and he cites Paul Knapp to the same effect (p. 386); in constructing his own instrument he wisely avoided that possibility. May it not be that by constantly wetting the cornea in his test-experiments, he unintentionally put the Schiötz at a disadvantage, and caused it to make errors that it does not ordinarily make? That would be a satisfactory solution: it would largely exculpate the Schiötz, and it would show the value of the McLean modification. If the suggestion fail, like my previous one, I shall not regret having made it, for a true solution is often ultimately reached by a process of elimination. It will be a heavy blow to the tonometric work of recent years if we have, after all, to admit that the Schiötz, as ordinarily used, makes mistakes of 20 and 30 mm. Hg. and even more, as it did in these experiments.

Now a few words as to the accuracy of the McLean tonometer, a subject which I hardly touched in my article. I do not doubt that the instrument is admirably made, or that its novel features are improvements; indeed, I predicted a good while ago the adoption of a single weight, and of a scale showing approximate mercury-equivalents instead of a separate chart (B. J. O., 1918, p. 267 footnote). In short, the mechanism is not in question: I assume that

the pointer acts in accordance with the depression of the cornea. But *with what degree of accuracy does the depression of the cornea indicate the intraocular pressure?* We know that human eyes differ from each other as regards the thickness and other characters of the cornea and sclera, and that such differences must influence the yielding of the cornea to *some* extent, and therewith the position of the pointer, but I think we do not yet know what *amount* of error is likely to arise in this way, through no fault of instrument, operator, or patient. Schiötz's test-experiments, and my own, suggested that it may reach 8 or 10 mm. Hg., but as I have previously said, these results may not be quite applicable to living eyes. We want more evidence on this point. (May I say that I was relying on these observations, and not on the pig's eye dipped in formalin, when I said that eyes having the same internal pressures may give different readings, etc. The small formalin experiment was given as an illustration of what an artificially stiffened envelope will do, and showed it rather prettily, I thought.)

Elliot puts the question thus: "Have we in the McLean tonometer an accurate instrument whereby we can measure the intraocular pressure with the same accuracy as we estimate body temperature with the clinical thermometer?" and he answers it as follows: "I have been using the instrument side by side with my trusted Schiötz for some weeks past, and I think we have." I hope he is right, but how did he arrive at this opinion? One cannot test the accuracy of a new instrument by comparing it with an old one that is believed to be inaccurate. No doubt he found the McLean to be excellent in various respects, but he did not compare its readings with known intraocular pressures. That can be done only by means of the manometer.

Under McLean's manometric tests, conducted evidently with elaborate care, the instrument gave some exceedingly good results. Thus, in the case of three living cats under ether, the actual pressures according to the manometer were respectively 25, 22 and 22 mm. Hg, and the tonometer said 22, 23 and 24. Again, when manometric pressures ranging from 20 to 110 mm. Hg. were established in these same eyes, the tonometer was in no case at fault by more than 4 mm Hg. And again, when these eyes were excised and again treated as just stated, the maximum error was 4 mm. Hg. (The Schiötz meanwhile made errors ranging irregularly from 9 to 42 mm. Hg.; they grew larger, as a rule, as the pressure rose, and were always on the minus side). This is a fine record for the McLean; so far as I know it is unrivalled, but it relates to cats. What is the record for human eyes?

To measure the intraocular pressure with a manometer in a living human eye is a delicate and difficult undertaking, but McLean has accomplished it in four cases (glaucomatous eyes, under ether,

immediately before enucleation). He tested the Schiötz against the manometer on these four eyes and in each case it put the pressure too low, the errors ranging from 14 to 27 mm. Hg. He tested his own tonometer in the last two cases only—it was only then completed—and it gave excellent readings: 58 instead of 60 mm. Hg. in the one case, and 63 instead of 65 in the other.

These results show a high degree of accuracy, and they do more. They tend to show that a tonometer which reads truly on excised eyes is likely to read truly on living eyes of the same kind; and further they tend to show that a tonometer which is true for cats' eyes is likely to be true for human eyes; in short, to show that errors due to differences in the size of the eyeball and in the character of its envelope are probably very small—if true, a very welcome simplification of eye-tonometry. But the observations before us are too few to justify positive conclusions; one can only say what they *tend* to show, and look for further evidence.

What we want to know, of course, is the margin of inevitable error when the tonometer is used on living human eyes. We cannot ask that this shall be ascertained by *direct* experiment: that would mean testing the tonometer against a manometer in a large number of living human eyes, normal and abnormal—an impossibility; but *indirectly* we may probably get very near it. McLean has made a very large number of tests and may, I hope, be able to settle the matter from data already in his possession. I will, therefore, venture to ask for further information on certain points: (1) On what class of eyes did he regulate his tonometer (by *regulate* I mean test it against the manometer, and so fix the mercury-equivalents); on cats' eyes, dogs', rabbits', excised human eyes, or on these collectively? (2) What were the largest discrepancies between tonometer and manometer in one class of eyes, e.g., cats' or dogs'—unsatisfactory trials being, of course, excluded? (3) Did eyes of different classes, but with equal internal pressures, give equal tonometric readings, or how far did the readings differ? (4) Has the tonometer been tested against the manometer in excised human eyes lost through various disorders, and if so with what amount of discrepancy? I fear these are troublesome questions, but I make bold to put them because I am sure that in answering them McLean will enhance the value of his researches.

May I say, in conclusion, that I sincerely admire the patience, ingenuity and skill which McLean has devoted to this work and fully recognize its importance. Also that I am most heartily with my friend Colonel Elliot in his desire to promote advances in scientific tonometry. If I am over-cautious in this matter, it is because I have seen many disappointments. My own first efforts towards improvement in tonometry were published just forty years ago, and during many years thereafter I habitually, in certain cases,

turned to my tonometer for an "unbiased second opinion"—but without complete confidence. The Fick was correct in principle but proved impracticable. The Maklakoff was distinctly better, but not precise enough. The Schiötz, as everyone knows, altered the situation greatly: now, for the first time, it was possible to estimate and record changes of pressure in a given eye with great precision, and, with somewhat less precision probably, to compare one eye with another. On the other hand, its mercury-equivalents were obviously questionable, and it was not the inventor's fault if what he offered as approximations were used as certainties; it now appears that they are considerably at fault, but we hardly yet know how far. The McLean tonometer, if I may venture an opinion, seems likely to go further still: to be more convenient, and to measure the intraocular pressure correctly "to within a few mm. of Hg.," which is what McLean claims for it, and all that can be reasonably expected; but, remembering the past, I still plead for caution.

Yours, etc.,

PRIESTLEY SMITH.

BIRMINGHAM, *Sept.* 2, 1919.