checked by the use of his nomogram for pressure and rigidity. Daily observations were not made, as this has already been done, whereas the observation over a longer period of time has not been reported so far as known.

In reply to Dr. Verhoeff, this adaptation of the Souter tonometer has not been used because of lack of courage. The possibility of an abrasion of the cornea because of the edges of the plastic tips has been a deterrent factor.

The interest in this problem was prompted by Terry's discussion of Harrington's paper in 1941. Further work will be necessary before the value of the adaptation is demonstrated.

CYCLOELECTROLYSIS FOR GLAUCOMA* †

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The subject of cycloelectrolysis (cyclocatholysis) for the reduction of intra-ocular pressure in various types of glaucoma is presented for several reasons: (1) because of the great importance of any operation which may partially or completely control tension, especially in patients with intractable glaucoma, (2) encouraging results obtained in 65 eyes of 61 patients critically analyzed for a period of 6 months to 4 years, (3) to discuss the electrochemical effects of the new operative procedure on the ciliary body and processes, (4) to evaluate the possible advantages of this operation in prefer-

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ence to cyclodiathermy (penetrating and nonpenetrating) from both theoretical and clinical standpoints, (5) to describe the indications, contraindications and technic of the operation, (6) to evaluate briefly the results obtained in the patients subjected to this procedure and to refer to some findings in animal experiments,* (7) because no description of the use of cycloelectrolysis for the control of tension in glaucoma has been found in the literature by us or the library of the American College of Surgeons.

The concept of applying galvanic current to the ciliary body arose from a study by one of us (C. B.) of its effect in retinal detachment operations.[1] Galvanic current was first applied to the retina by H. Schoeler[2] in 1889, but the application of this method to the ciliary body as a treatment for glaucoma by inducing localized atrophy of the tissues by chemical action was first used by one of us (C. B.) in 1945. The procedure has been twice referred to briefly.[3, 4]

Cycloelectrolysis is a new operative technic devised for the purpose of reducing intra-ocular pressure in various types of glaucoma and differs from perforating cyclodiathermy primarily in the type of current employed to produce an atrophy of part of the ciliary body.

In cycloelectrolysis there is a controlled chemical decomposition of tissue which is produced by means of galvanic current. In cyclodiathermy (penetrating and nonpenetrating) a high frequency current of more than a million oscillations per second is employed. The needle or ball electrode remains cold but the resistance of the tissues to the passage of current through them generates enough heat to cause an instantaneous coagulation of the protein present. A high frequency current produces no chemical (electrolytic) changes in the tissues. In cyclodiathermy the surface tissue is dehydrated and shrunken and some sparking of tissue may occur, with subsequent undesirable carbonization.

* A complete report of the experiments on rabbits and the pathologic findings in human and rabbit eyes is in preparation.

In cycloelectrolysis the amperage determines the amount of chemical tissue destruction in the ciliary body in a specified time, whereas in cyclodiathermy the amperage indicates only the current passing through the ciliary body and cannot be used as a measure of the amount of tissue destruction, since the resistance of the tissues is a variable factor in each case. The essential difference between the 2 procedures accounts for the apparently greater effectiveness of cycloelectrolysis in the control of intra-ocular pressure, the lessened congestion of the ciliary body and eyeball as well as the minimal amount of destruction and contraction of the sclera observed after cycloelectrolysis as compared with cyclodiathermy.

It has been pointed out by Vogt,[5] Wagner[6] and Stocker[7] that there is an immediate postoperative rise of intra-ocular pressure in nonperforating cyclodiathermy due to a puckering of the sclera, with reduction in the size of the globe. This elevation in tension is also increased by the application of cyclodiathermy through congestion and shrinking of the eyeball. There is less marked increase of intra-ocular pressure following cycloelectrolysis since there is only a mild reaction in the tissues and insignificant shrinking of the eyeball.

Many of the objections stressed by surgeons[8, 9] who prefer nonperforating to perforating diathermy are overcome, and some of the complications noted following nonperforating diathermy are eliminated.

Several patients have developed sympathetic ophthalmitis following cyclodiathermy when no sympathetic ophthalmitis has so far followed cycloelectrolysis. Chemical destruction versus heat destruction may account for the difference if it can be proved to be statistically significant. Trichloracetic acid applied to a prolapsed iris seems to be less dangerous than heat cauterization of the uveal tissue.

In cycloelectrolysis, the negative pole of a galvanic current attached to a fine needle is used as the "active" electrode, and the positive pole or "dispersive" electrode is placed beneath the patient's shoulder. When the current is applied and the

needle penetrates the ciliary body, the sodium chloride, present in solution in all body tissues, is ionized. The sodium ion migrates to the cathode, is neutralized, then reacts with water to form sodium hydroxide with a release of hydrogen. Sodium hydroxide is a strong caustic agent which causes a chemical liquefaction of the cells around the needle. By regulating the amperage and the duration of the application, the amount of tissue dissolution may be controlled accurately.

We have elected to use the negative pole as the active electrode on human eyes since we found in animal experiments that when the positive pole of the galvanic current was connected to the needle, the tissues became hardened through the action of the hydrochloric acid formed and adhered to the needle. There was also more damage to the sclera, increasing the possibility of herniation of the ciliary body.

There are 2 main mechanisms to be considered in the maintenance of normal intra-ocular pressure: (1) the production of fluids, generally considered to be a function of the ciliary body and its processes and (2) an adequate drainage system.

Cycloelectrolysis is a procedure designed to reduce the production of aqueous by a chemical destruction and subsequent atrophy of a part of the ciliary body and its processes with the least possible trauma and a minimum of complications.

In a subsequent paper, we propose to present data concerning the value of cycloelectrolysis compared with both perforating and nonperforating cyclodiathermy which also are operations designed to diminish the production of aqueous.

Indications for Cycloelectrolysis:

1. Chronic Primary Glaucoma (21 cases are reported in Table 1).

a. Chronic primary glaucoma, especially in Negroes. It is a well-established fact that the Negro tends to have excessive keloid formation and consequently does not usually respond to filtering operations.

Because cycloelectrolysis causes so little reaction and discomfort to the patient, it may be advisable, when we have gained more experience, to consider cycloelectrolysis more frequently as a primary procedure in whites as well as in Negroes.

2. Glaucoma in Aphakia (9 cases are reported in Table 1).

a. Cyclodialysis has been the operation of choice heretofore because of the limited application of filtration operations. Cycloelectrolysis must be considered a valuable procedure in this type of glaucoma.

3. Cycloelectrolysis is especially indicated in narrow angle types of glaucoma.

4. Absolute Glaucoma (7 cases are reported in Table 1).

a. Cycloelectrolysis has been proved to be of great value in those cases of absolute glaucoma with intractable pain, and this procedure may be recommended in some cases in preference to enucleation.

5. Uveitis with Secondary Glaucoma (4 eyes reported in Table 1).

a. The comparative freedom from reaction has encouraged us to try cycloelectrolysis in uveitis with uncontrolled pressure. Case number 62 was operated upon for glaucoma secondary to uveitis in sarcoidosis.

6. Other forms of Glaucoma. Cycloelectrolysis may prove of benefit in the following types of glaucoma:

a. Central venous thrombosis (3 cases)
b. Hydrophthalmos and Buphthalmos (5 eyes)
c. Rubeosis of the iris (4 cases)
d. Hemorrhagic glaucoma (5 cases)
e. Acute glaucoma (5 cases)
f. Secondary glaucoma resulting from trauma (3 cases)

Contraindications for Cycloelectrolysis:

1. Intra-ocular tumor. It is obvious that every precaution should be taken to rule out any possibility of an intra-ocular tumor before attempting cycloelectrolysis.

TABLE 1.—CYCLOELECTROLYSIS FOR GLAUC

Chronic Simple Glaucoma—21 Cases, 23 Eyes

Cases	*Diagnosis*	*Preoperative Vision and Tension (Schiötz)*	*Previous Operations—Postoperative Vision and Tension (Schiötz)*	*Cycloelectrolysis*	*Additional Surgery*	*Postoperative Vision and Tension (Schiötz)*	*Visual Fields and Remarks*
1. J. W., aged 52, female, white	Chronic simple, wide angle O.D. Slight cupping O.D.	V. O.D. 4/200 sc. 20/200 cc. T. O.D. 35	10/48 Iridocorneosclerectomy O.D. V. 20/200 T. 48 10/48 Posterior Sclerectomy O.D. V. 20/100 T. 50	12/48 Cycloelectrolysis O.D.—50 punctures 5 ma. 5 sec. T. 40	12/48 Iridocorneosclerectomy O.D.	5/49 V. O.D. 20/200 T. O.D. 20	Preoperative gunbarrel field unchanged. Tension controlled 5 mos. Vision improved. Miotics continued.
2. F. C., aged 75, female, white	Chronic simple Nuclear sclerosis Aphakia O.D. Endophthalmitis	V. O.D. 20/70 sc. and cc. T. O.D. 34	9/48 Iridocorneosclerectomy and Tenon's capsule transplant O.D. V. H.M. T. 22 11/48 Cataract extraction O.D. T. 45	11/48 Cycloelectrolysis O.D.—50 punctures 5 ma. 5 sec. T. 34–47	2/49 Cyclodialysis and aspiration A.C. O.D.	5/49 V. O.D. 20/60 T. O.D. 24	Postoperative visual fields unchanged. Vision improved. Tension controlled with miotics.
3. S. A., aged 58, male, white	Chronic simple, wide angle O.S.	V. O.S. 4/500 cc. T. O.S. 40	4/44 Iridocorneosclerectomy and incarceration O.S. 12/44 Intracapsular extraction and iridocorneosclerectomy O.S. O.S. V. H.M. T. 50	6/45 Cycloelectrolysis and superficial keratectomy O.S.—48 punctures	None	3/49 V. O.S. H.M. T. O.S. 19	Tension controlled 4 yrs. without miotics. Full fields with light unchanged.
4. E. S., aged 62, female, white	Chronic simple O.S. Onset 6 yrs. Shallow A.C.	V. O.S. 5/200 cc. T. O.S. 47	4/42 Cyclodialysis O.S. 10/42 Cyclodialysis O.S. O.S. V. L.P. T. 29	6/45 Cycloelectrolysis O.S.—48 punctures 5 ma. 5 sec.	1/46 Superficial keratectomy O.S.	3/49 V. O.S. L.P. T. O.S. 17	Tension controlled 4 yrs. without miotics. Slight field loss with light.
5. C. M., aged 49, female, white	Chronic simple O.D. Onset 3 yrs. Normal A.C. Aphakia	V. O.D. 20/20 cc. T. O.D. 49	None	5/48 Cycloelectrolysis O.D.—50 punctures 5 ma. 5 sec.	None	5/49 V. O.D. 20/40 T. O.D. 20	Tension controlled 1 yr. with miotics. Preoperative concentric contraction unchanged.
6. S. H., aged 72, male, white	Chronic simple O.S. Onset 2 yrs. Shallow A.C.	V. O.S. 20/50 cc. T. O.S. 48	None	3/48 Cycloelectrolysis and paracentesis O.S.—50 punctures 5 ma. 5 sec.	10/48 Cyclodialysis O.S.	1/49 V. O.S. 3/200 T. O.S. 50	No improvement.
7. M. B., aged 40, female, white	Chronic simple O.D. Onset 7 yrs. Shallow A.C.	V. O.D. N.L.P. T. O.D. 50	Had 1 operation O.D. previously No light perception O.D. Severe pain	3/48 Cycloelectrolysis O.D.—30 punctures 5 ma. 5 sec.	None	5/49 V. N.L.P. O.D. T. O.D. 18	Tension controlled 14 mos. without miotics. No pain.
8. N. E., aged 74, male, white	Chronic simple O.D. Onset 4 yrs. Marked uveitis Cupping O.D.	V. O.D. H.M. T. O.D. 47	5/47 Iridencleisis O.D. Complete subluxation lens O.D.	5/48 Cycloelectrolysis O.D.—32 punctures 5 ma. 5 sec.	None	3/49 V. O.D. L.P. T. O.D. 22	Tension controlled with miotics. No pain. Vision same. No fields.
9. A. S., aged 64, male, white	Chronic simple O.D. Onset 3 yrs. Marked cupping Shallow A.C.	V. O.D. L.P. T. O.D. 90	None	5/48 Cycloelectrolysis O.D.—50 punctures. Upper half 5 ma. 5 sec.	None	5/49 V. O.D. L.P. T. O.D. 20	Tension controlled 12 mos. without miotics. No pain. Vision same; no fields.
10. O. V., aged 52, female, white	Chronic simple O.S. Onset 2 yrs. Slight cupping Normal A.C.	V. O.S. 20/200 cc. T. O.S. 90	3/47 Iridocorneosclerectomy O.S. V. O.S. 20/200 T. 45	5/47 Cycloelectrolysis O.S.—50 punctures. Lower half 5 ma. 5 sec.	None	5/49 V. O.S. 20/200 T. O.S. 20	Tension controlled 2 yrs. without miotics. Preoperative concentric contraction field with light unchanged postoperatively.
11. R. L., aged 68, male, white	Chronic simple O.D. Onset 6 mos. Disc and A.C. normal	V. O.D. 20/200 cc. T. O.D. 90	None	10/48 Cycloelectrolysis O.D.—50 punctures. Upper half 5 ma. 5 sec.	None	5/49 V. O.D. 20/30 T. O.D. 20	Tension controlled 7 mos. without miotics. Vision improved. No change in visual fields.
12. H. R., aged 70, female, white	Chronic simple O.S. Onset 1 yr. Cupping, atrophy, shallow A.C. Pinhole pupil O.U.	V. O.S. 20/30 cc. T. O.S. 42	4/37 Trephine O.S. 11/42 Combined intracapsular extraction O.S. T. 45 V. F. 3′	11/48 Cycloelectrolysis O.S.—50 punctures 5 ma. 5 sec.	None	5/49 V. O.S. 20/50 T. O.S. 20	Tension controlled 6 mos. without miotics. Vision improved. No change in visual fields.
13. T. G., aged 49, male, white	Chronic simple O.D. Onset 3 mos. Advanced cupping Normal A.C.	V. O.D. 20/100 T. O.D. 65	4/47 Iridocorneosclerectomy O.D. T. 20–50 10/47 Paracentesis O.D. T. 40	11/47 Cycloelectrolysis O.D.—50 punctures 5 ma. 5 sec. T. O.D. 32–40	11/47 Trephine and iridencleisis O.D.	3/49 V. O.D. 20/40 T. O.D. 20	Tension controlled 15 mos. with miotics. Vision improved. No fields.
14. P. B., aged 58, male, white	Chronic simple O.D. Onset 13 mos. Slight cupping Normal A.C.	V. O.D. 20/30 cc. T. O.D. 40	None	3/48 Cycloelectrolysis O.D.—50 punctures with paracentesis 5 ma. 5 sec.	None	3/49 V. O.D. 20/50 cc. T. O.D. 20	Tension controlled 12 mos. with miotics. Slight contraction visual fields.
15. L. B., aged 59, male, white	Chronic simple O.D. Onset 10 yrs. Slight cupping Normal A.C.	V. O.D. 20/50 cc. T. O.D. 47	None	4/48 Cycloelectrolysis O.D.—38 punctures 5 ma. 5 sec. O.D. T. 50	6/48 Trephine O.D.	3/49 V. O.D. L.P. T. O.D. 30	Tension lowered. Complicated cataract O.D. No fields.
16. A. D., aged 49, male, white	Chronic simple O.D. Onset 4 yrs. Slight cupping Normal A.C.	V. O.D. L.P. T. O.D. 90	3/48 Iridectomy O.D. T. 90	3/48 Cycloelectrolysis and iris inclusion O.D. T. 10	Enucleation O.D.		Eye becomes soft and dangerous—removed.
17. H. R., aged 41, male, Negro	Chronic simple O.U. Onset 3 days Normal disc Shallow A.C. O.U.	V. O.D. 20/40–1 sc. O.S. 20/30–2 sc. T. O.D. 48–65 O.S. 30–45	None	1/47 Cycloelectrolysis O.D. 36 punctures. T. 20–50 2/48 Cycloelectrolysis O.D. 32 punctures. 5 ma. 5 sec. 4/48 Cycloelectrolysis O.S. 50 punctures. 5 ma. 5 sec.	None	3/49 V. O.D. 20/20 sc. O.S. 20/20 sc. T. O.D. 20 O.S. 20	Tension controlled O.D. 13 mos. O.S. 11 mos. without miotics. Vision and visual fields improved O.U.
18. G. H., aged 41, female, Negro	Chronic simple O.S. Onset 1 yr. Shallow A.C. Disc normal	V. O.S. 20/20 cc. T. O.S. 45	3/45 Iridocorneosclerectomy O.S. V. 20/50 T. 40	3/48 Cycloelectrolysis and aspiration A.C. O.S.	None	3/49 V. O.S. 20/30 cc. T. O.S. 20	Tension controlled 1 yr. without miotics. Slight contraction fields.
19. H. K., aged 43, female, Negro	Chronic simple O.U. Onset 2 yrs. Cupping and atrophy Shallow A.C. O.U.	V. O.D. 20/50 cc. O.S. 20/70 cc. T. O.D. 40 O.S. 48	3/47 Perforating cyclodiathermy O.D. V. 20/70 T. 65	3/47 Cycloelectrolysis O.S. 32 punctures 9/47 Cycloelectrolysis O.D. 32 punctures	12/47 Trephine O.D. 2/48 Iridencleisis and sclerectomy O.D. 4/48 Cycloelectrolysis. 50 punctures O.D.	5/49 V. O.D. 20/30 cc. O.S. 20/30 cc. T. O.D. 20 O.S. 22	Tension controlled 2 yrs. O.S. without miotics; cycloelectrolysis done as primary procedure. Preoperative gunbarrel fields unchanged postoperatively O.U.
20. A. D., aged 52, female, Negro	Chronic simple O.S. Onset 3 yrs.	V. O.S. 20/40 cc. T. O.S. 23	7/38 Iridocorneosclerectomy O.S. T. 50 4/40 Trephine O.S. T. 40 12/48 Aspiration A.C. T. 32	2/49 Cycloelectrolysis O.S. 30 punctures 5 ma. 5 sec.	None	5/49 V. O.S. 20/70 cc. T. O.S. 22	Pain relieved. Case requires further observation.
21. L. W., aged 45, male, Negro	Chronic simple O.D. Onset 9 mos. Marked cupping O.D.	V. O.D. 20/50 cc. T. O.D. 70	4/47 Iris inclusion operation O.D.	5/48 Cycloelectrolysis O.S. 50 punctures 5 ma. 5 sec.	None	5/49 V. O.S. 20/70 T. O.S. 20	Tension controlled 1 yr. without miotics.
Secondary Glaucoma Following Cataract Extraction—9 Eyes							
22. H. B., aged 60, male, white	Immature cataract Thrombosis central vein O.D.	V. O.D. 20/200cc.	6/43 Combined extraction O.D. 6/47 V. O.D. F. 1′ T. O.D. 65	8/48 Cycloelectrolysis O.D. 42 punctures 5 ma. 5 sec.	None	3/49 V. O.D. H.M. T. O.D. 40	Tension lowered. Miotics continued. Vision decreased O.D. No fields.
23. A. W., aged 63, male, white	Postcapsular cataract O.S.	V. O.S. 20/70 cc.	4/43 Optical iridectomy O.S. 6/43 Extracapsular extraction O.S. 8/43 V. O.S. 5/100 T. 43 10/43 Cyclodiathermy O.S. T. 30 1/44 Iris inclusion O.S. T. 40 3/44 Discission O.S. V. 20/40 T. 40	11/48 Cycloelectrolysis O.S. 30 punctures 5 ma. 5 sec.	None	3/49 V. O.S. 20/40 cc. T. O.S. 30	Tension lowered; miotics continued. Vision improved. Small entral field retained postoperatively.
24. B. G., aged 62, male, white	Immature senile cataract O.D.	V. O.D. 20/70 cc.	3/44 Combined intracapsular extraction O.D. T. 40 4/44 Iridencleisis O.D. 6/44 Cyclodiathermy O.D. T. 40 2/45 Iridectomy O.D. T. 55–65	12/47 Cycloelectrolysis 32 punctures O.D. T. 55	2/48 Trephine O.D.	3/49 V. O.D. H.M. T. O.D. 50	No improvement.
25. A. B., aged 65, male, white	Immature cataract Secondary iritis Aphakia O.S.	V. O.S. 3/200 cc.	4/47 Preliminary iridectomy O.S. 9/47 X.A.P. O.S. T. 47–58 9/47 Cyclodialysis O.S.	10/47 Cycloelectrolysis and aspiration A.C. O.S. 38 punctures 5 ma. 5 sec.	None	5/49 V. O.S. 20/30 cc. T. O.S. 18	Tension controlled without miotics 19 mos. O.S. Visual fields unchanged postoperatively.
26. F. I., aged 6, male, white	Immature cataract O.S.	V. O.S. 20/200 cc.	5/47 Cataract extraction O.S. T. 90 8/47 Iridocapsulotomy O.S. T. 38 10/47 Cyclodialysis O.S. T. 60 11/47 Paracentesis O.S. T. 50	11/47 Cycloelectrolysis O.S. 32 punctures 5 ma. 5 sec.	None	3/49 V. O.S. 20/100 cc. T. O.S. 50	No improvement in tension.
27. R. F., aged 57, female, white	Incipient cataract O.S.	V. O.S. 20/200 cc.	2/42 Extra-intracapsular extraction O.S. T. 16–60 V. 20/20 cc. 5/44 Shallow A.C. cupping and atrophy Cyclodialysis and iridectomy O.S. V. O.S. 4/100 T. 65	2/48 Cycloelectrolysis O.S. 40 punctures 5 ma. 5 sec.	3/48 Enucleation O.S.		Eye became hypotonic.
28. S. G., aged 74, male, white	Hypermature cataract O.D.	V. O.D. L.P.	1/47 Combined extracapsular extraction O.D. V. 20/40 T. 33–40	2/48 Cycloelectrolysis O.D. 40 punctures 5 ma. 5 sec.	None	3/49 V. O.D. H.M. T. O.D. 20	Tension controlled 13 mos. without miotics O.D.
29. F. W., aged 68, male, white	Postcortical cataract-sclerosis O.U.	V. O.S. 20/200 T. O.S. 17	6/48 Intracapsular extraction and peripheral iridectomy O.S. T. 60	7/48 Cycloelectrolysis O.S. 50 punctures 5 ma. 5 sec.	7/48 Cyclodialysis O.S. T. 65 8/48 Aspiration (3 times) O.S. 8/48 Cyclodialysis. 9/49 Iridocorneosclerectomy O.S. 10/48 Cyclodiathermy. Evisceration		Retina detached following cyclodiathermy. Iris was completely adherent to vitreous. Eye became dangerously soft. Eviscerated 12/48 O.S.
30. V. M., aged 73, male, white	Mature cataract O.D.	V. O.D. H.M.	6/47 Cataract extraction O.D. V. H.M. T. 40 Shallow anterior chamber	11/47 Cycloelectrolysis O.D. 32 punctures 5 ma. 5 sec.	None	5/49 V. O.D. F. 2′ T. O.D. 20	Tension controlled O.D. 18 mos. without miotics. Slight improvement vision.

TABLE 1—CYCLOELECTROLYSIS FOR GLAUCOMA (*Continued*)

Cases	Diagnosis	Preoperative Vision and Tension (Schiötz)	Previous Operations—Postoperative Vision and Tension (Schiötz)	Cycloelectrolysis	Additional Surgery	Postoperative Vision and Tension (Schiötz)	Visual Fields and Remarks
Secondary Glaucoma following Trauma—3 Eyes							
31. H. S., aged 68, male, white	Struck in O.D. Dislocated lens and secondary glaucoma	V. O.D. F.1′ T. O.D. 48	9/47 Cataract extraction O.D.	1/48 Cycloelectrolysis O.D. 36 punctures 5 ma. 5 sec.	None	5/49 V. O.D. 20/70 T. O.D. 17	Tension controlled O.D. 16 mos. without miotics. Vision improved.
32. J. S., aged 50, male, white	Sulphuric acid burn. Secondary glaucoma O.S.	V. O.S. 20/100 T. O.S. 70–75	5/45 Keratectomy and peridectomy O.S. 6/45 Cataract extraction O.S. T. 72	7/45 Cycloelectrolysis O.S. 40 punctures 5 ma. 5 sec.	None	3/49 V. O.S. 20/100 T. O.S. 30	Tension controlled O.S. 3½ yrs. with miotics. Vision same.
33. M. C., aged 45, male, white	Alkali burns. Keratitis-secondary glaucoma O.S.	V. O.S. N.L.P. T. O.S. 22	7/48 Radium treatment; conjunctival flap over perforating wound O.S.	12/48 Cycloelectrolysis and electroparacentesis O.S. 35 punctures	Beta irradiation continued	1/49 V. O.S. N.L.P. T. O.S. 12	Tension controlled without miotics.
Secondary Glaucoma Associated with Uveitis—4 Eyes							
34. B. I., aged 34, female, white	Mature cataract O.S. Myopia. Choroidal atrophy, aphakia, secondary glaucoma, uveitis O.S.	V. O.S. 20/100 T. O.S. 48	3/48 Combined extracapsular extraction O.S. V. 20/100 T. 48 5/48 Cyclodialysis O.S. T. 35	6/48 Cycloelectrolysis O.S. 50 punctures 5 ma. 5 sec.	12/48 Iridocorneosclerectomy O.S.	3/49 V. O.S. 20/100 T. O.S. 25	Tension controlled with miotics. Postoperative fields unchanged.
35. J. G., aged 74, male, white	Secondary glaucoma, uveitis O.S. Bullous keratitis. Edema K.P. Shallow A.C.	V. O.S. L.P. Temporal side only T. 65	Had cataract extraction 20 yrs. ago O.S. 10/31 Ant. sclerotomy O.S. 4/34 Ant. sclerotomy O.S. 5/43 Cyclodiathermy O.S.	3/48 Cycloelectrolysis O.S. 50 punctures Electroparacentesis. Sup. keratectomy	None	5/49 V. O.S. L.P. T. O.S. 22	Tension controlled O.S. 14 mos. No visual improvement.
36. A. E., aged 45, female, white	Secondary glaucoma. Uveitis O.U.	V. O.D. L.P. O.S. H.M. T. O.D. 60–65 O.S. 40	None	2/48 Cycloelectrolysis. 55 punctures O.U. 5 ma. 5 sec.	None	5/49 V. O.D. L.P. V. O.S. H.M. T. O.D. 20 O.S. 20	Tension controlled O.U. with miotics 15 mos. No fields.
Secondary Glaucoma (Miscellaneous) 4 Eyes							
37. V. S., aged 36, female, white	Secondary glaucoma O.S. Onset 1 yr. High myopia. Interstitial keratitis. Positive serology	V. O.S. 20/70 T. O.S. 30–40	None	4/48 Cycloelectrolysis O.S. 40 punctures 5 ma. 5 sec.	None	3/49 V. O.S. 20/50 T. O.S. 19	Tension controlled O.S. without miotics 11 mos. Vision improved. Fields unchanged postoperatively
38. C. R., aged 65, female, white	Secondary glaucoma O.S. Onset 4 yrs. Normal A.C.	V. O.S. 20/70 T. O.S. 35	10/45 Iridencleisis and iridectomy O.S. T. 40 6/45 Iridocorneosclerectomy O.S. T. 50 7/45 Aspiration A.C. T. 40	7/45 Superficial keratectomy and cycloelectrolysis O.S. 55 punctures	7/45 Paracentesis O.S. 8/45 Trephine O.S. 10/45 Iridencleisis and iridectomy O.S.	10/47 V. O.S. 5/200 T. O.S. 26	Tension controlled with miotics. Decrease in vision.
39. T. S., aged 85, female, white	Secondary glaucoma O.S. Onset 5 yrs. Aphakia-cupping. Shallow A.C.	V. O.S. L.P. T. O.S. 50	None	6/48 Cycloelectrolysis O.S. 40 punctures	None	1/49 V. O.S. L.P. T. O.S. 50	No improvement.
40. H. M., aged 74, male, white	Secondary glaucoma. Thrombosis central vein O.D. Shallow A.C. Disc cupped	V. O.D. H.M. T. O.D. 65+	None	2/48 Cycloelectrolysis and posterior sclerotomy. 50 punctures O.D.	None	1/49 V. O.D. H.M. T. O.D. 20	Tension controlled O.D. 13 mos. without miotics.
Acute Glaucoma—5 Eyes							
41. J. G., aged 62, male, white	Acute hemorrhagic glaucoma. Extensive edema. Posterior synechiae. Shallow A.C. O.D.	V. O.D. N.L.P. T. O.D. 70	None	4/47 Cycloelectrolysis O.D. 45 punctures 5 ma. 5 sec.	None	5/49 V. O.D. N.L.P. T. O.D. 15	Tension controlled O.D. 23 mos. without miotics. No pain.
42. M. R., aged 69, male, white	Acute glaucoma O.D. Shallow A.C. Diabetes mellitus-hypertension O.D.	V. O.D. 20/100 cc. T. O.D. 60	None	1/48 Cycloelectrolysis O.D. 40 punctures 5 ma. 5 sec.	None	3/49 V. O.D. 20/200 cc. T. O.D. 19	Tension controlled O.D. 14 mos. without miotics. No pain.
43. C. T., aged 67, female, white	Acute hemorrhagic O.D. Incipient cataract. Diabetic retinopathy. Chorioretinitis O.D.	V. O.D. 20/200 cc. T. O.D. 80	11/48 Iridocorneosclerectomy O.D. T. 70	11/48 Cycloelectrolysis O.D. 50 punctures 5 ma. 5 sec.	None	5/49 V. O.D. 20/70 cc. T. O.D. 20	Tension controlled O.D. 6 mos. with miotics. Vision improved.
44. N. Y., aged 62, male, white	Acute glaucoma O.D. Shallow A.C. Disc cupped	V. O.D. H.M. T. O.D. 65+	None	1/48 Cycloelectrolysis and paracentesis O.D. 50 punctures 5 ma. 5 sec.	None	3/49 V. O.D. H.M. T. O.D. 25	Tension controlled O.D. 14 mos. with miotics. No pain. No visual improvement.
45. A. F., aged 57, male, white	Acute glaucoma O.D. Bullous keratitis. Corneal edema; deep A.C.; deep cupping disc O.D.	V. O.D. L.P. T. O.D. 70+	None	2/48 Cycloelectrolysis and paracentesis O.D. 40 punctures 5 ma. 5 sec.	None	5/49 V. O.D. 20/200 cc. T. O.D. 22	Tension controlled O.D. 15 mos. with miotics. No pain. Vision improved.
Hemorrhagic Glaucoma—5 Eyes							
46. W. L., aged 51, male, white	Hemorrhagic glaucoma O.S. Traumatic cataract. Disc cupped; deep A.C. Hemorrhage in macular region O.S.	V. O.S. 20/80 T. O.S. 40	6/48 Cyclodialysis O.S. V. H.M. T. 50	7/48 Cycloelectrolysis O.S. 40 punctures 5 ma. 5 sec. T. 40	1/49 Cycloelectrolysis O.S. 50 punctures 5 ma. 5 sec.	5/49 V. O.S. 20/100 cc. T. O.S. 20	Tension controlled with miotics. Postoperative visual fields unchanged.
47. I. G., aged 72, male, white	Hemorrhagic glaucoma. Diabetic retinopathy. Rubeosis iridis O.S. Aphakia; lenticular changes O.S.	V. O.S. H.M. T. O.S. 65	11/47 Trephine O.S. V. H.M. T. 50	1/48 Cycloelectrolysis O.S. 50 punctures 5 ma. 5 sec. T. 35	1/48 Cycloelectrolysis O.S. 40 punctures 5 ma. 5 sec.	2/49 V. O.S. H.M. T. O.S. 20	Tension controlled with miotics. No visual improvement. No fields.
48. A. N., aged 72, male, white	Hemorrhagic glaucoma. Atrophy; edema of cornea O.D. Disc cupped. Poor vision 10 yrs. untreated	V. O.D. H.M. T. O.D. 65	None	3/48 Cycloelectrolysis and aspiration A.C. O.D. 50 punctures 5 ma. 5 sec.	None	5/49 V. O.D. N.L.P. T. O.D. 20	Tension controlled O.D. 14 mos. with miotics. Vision lost.
49. H. B., aged 60, male, white	Hemorrhagic glaucoma. Multiple thrombosis (central and secondary veins). Rubeosis iridis. Traumatic cataract 37 yrs. ago O.D.	V. O.D. F. 1′ T. O.D. 55–65	None	2/48 Cycloelectrolysis O.D. 50 punctures 5 ma. 5 sec.	None	5/49 V. O.D. 10/200 cc. T. O.D. 25	Tension controlled O.D. 15 mos. with miotics. Vision improved. No fields.
50. E. S., aged 65, female, white	Hemorrhagic glaucoma. Diabetic retinopathy O.S. Onset 3 yrs.	V. O.S. 20/70 cc. T. O.S. 35–40	5/45 Iridocorneosclerectomy and iridectomy O.S. T. 30 6/45 Iridocorneosclerectomy O.S. T. 55 7/45 Aspiration A.C. O.S. T. 65	7/45 Cycloelectrolysis and aspiration A.C. O.S. T. 46	7/45 Paracentesis O.S. T. 65 8/45 Trephine and peripheral iridectomy O.S.	2/49 V. O.S. 20/200 cc. T. O.S. 26	Tension controlled O.S. 32 mos. with miotics.
Buphthalmos and Hydrophthalmos—4 Cases, 5 Eyes							
51. O. E., aged 14, female, white	Hydrophthalmos - microcornea; congenital cataract. Shallow A. C. Nasal iris missing O.D.	V. O.D. L.P. T. O.D. 60	None	4/48 Cycloelectrolysis O.D.	None	3/49 V. O.D. H.M. T. O.D. 25	Tension lowered with miotics O.D.
52. K. M., aged 5, male, white	Buphthalmos O.U. Disc normal O.U. Myopia	V. O.D. 20/50 cc. O.S. 20/70 cc. T. O.D. 55 O.S. 65	2/46 Elliott Trephine O.U. T. O.D. 55 O.S. 65	5/46 Cycloelectrolysis O.D. 55 punctures 6/46 Cycloelectrolysis O.S. 55 punctures	None	5/49 V. O.D. 20/40 cc. O.S. 20/40 cc. T. O.D. 22 O.S. 22	Tension controlled O.U. 3 yrs. without miotics. Vision improved. Preoperative concentric fields unchanged postoperatively.
53. A. P., aged 23, male, white	Hydrophthalmos and Lagophthalmos O.U. Congenital cataract O.D. Corneal ulcers	V. O.D. L.P. T. O.D. 50	O.S. Operated upon at infancy. Atrophy following surgery with loss of vision	4/48 Cycloelectrolysis and iridocapsulotomy O.D. Sup. keratectomy O.D. 32 punctures	None	2/49 V. O.D. 20/70 T. O.D. 18	Tension controlled. Vision improved. No fields.
54. M. N., aged 16 months, female, white	Hydrophthalmos O.S. Brain hemorrhages at birth; congenital cataract. A.C. absent O.S.	V. O.S. ? T. O.S. 47	Iridectomy and needling O.U. at age of 3 mos.	2/48 Cyclodiathermy O.S. 25 punctures 5 ma. 5 sec.	None	5/49 V. O.S. ? T. O.S. 20	Tension controlled with miotics. Too young to accurately measure vision.
Absolute Glaucoma—7 Eyes							
55. C. R., aged 65, female, white	Absolute glaucoma O.D. Onset 4 yrs.	V. O.D. N.L.P. T. O.D. 80	5/45 Cyclodiathermy with alcohol injection O.D. T. 80	7/45 Superficial keratectomy and cycloelectrolysis O.D.	2/46 Evisceration O.D.		Eye became soft and dangerous.
56. M. R., aged 69, female, white	Absolute glaucoma Diabetes mellitus Hypertension O.S.	V. O.S. N.L.P. T. O.S. 60–70	None	1/48 Cycloelectrolysis O.D. 50 punctures 5 ma. 5 sec.	2/48 Cycloelectrolysis O.D. T. 40; 40 punctures ~~3/48 Cycloelectrolysis. 50~~ punctures	5/49 T. O.D. 19	Tension controlled 14 mos. without miotics. No pain.
57. N. C., aged 20, female, white	Absolute glaucoma Leukoma cornea and central scar O.S. Coloboma iris	V. O.S. N.L.P. T. O.S. 69	7/47 Corneal tattoo	2/48 Cycloelectrolysis O.S. 50 punctures	None	3/49 T. O.S. 26	Tension controlled without miotics 13 mos. No pain.
58. J. G., aged 70, female, white	Absolute glaucoma Keratitis. Large central scar O.D.	V. O.D. N.L.P. T. O.D. 90	None	4/48 Cycloelectrolysis and aspiration A.C. O.D. 50 punctures	None	5/49 T. O.D. 22	Tension controlled 13 mos. without miotics. No pain.
59. R. G., aged 75, male, white	Absolute glaucoma O.D. Onset 7 yrs.	V. O.D. N.L.P. T. O.D. 65+	None	5/48 Cycloelectrolysis O.D. 50 punctures. Paracentesis	5/48 Enucleation O.S.		Eye became hypotonic.
60. R. M., aged 69, male, white	Absolute glaucoma O.S. Diabetic hypertension	V. O.S. N.L.P. T. O.S. 65+	None	11/48 Cycloelectrolysis O.S.	None	2/49 T. O.S. 50	Tension lowered slightly. No pain.
61. P. D., aged 76, male, white	Absolute glaucoma O.S. Bullous keratitis. Lens edema. Mature cataract O.S.	V. O.S. N.L.P. T. O.S. 65	None	3/48 Cycloelectrolysis O.D. 50 punctures 5 ma. 5 sec.	None	5/49 T. O.D. 20	Tension controlled without miotics 14 mos. No pain.

2. Glaucoma capsulare.
3. Lens dislocated into the anterior chamber.

Preoperative Preparation:

1. Preoperative sedation of nembutal (grs. iii) is given 1 hour before operation.
2. Tonometer readings are made before and after surgery.

Anesthesia:

1. Topical anesthesia is obtained by instillation of pontocaine (1%).
2. Retrobulbar injection (1.0 cc. of 2% procaine with minims iii of epinephrine hydrochloride (1:1,000) into the ciliary ganglion.

Apparatus Required:

A galvanic machine with a potential of at least 22.5 volts and a milliampere scale sufficiently large to show small variations between 0 and 10 milliamperes.

The positive pole or dispersive electrode is placed somewhere on the patient's skin, using an electrolytic jelly to insure a good contact. The negative pole or active electrode is a specially designed platinum straight conical electrolysis needle* (Berens) measuring 1.5 or 2 mm. in length, and 0.18 mm. in diameter.

We have found in our animal experiments that a needle which is long enough to penetrate through the ciliary body causes exudation at the site of the puncture.

The setting of the rheostat is determined by applying the needle to the conjunctiva and adjusting the rheostat so that the milliammeter registers 5 ma. Experience has indicated that 5 ma. for 5 seconds gives an optimum amount of destruction in the ciliary body with minimum ocular reaction.

* Made by Mueller & Co., Chicago, Ill.

Technic:

The eyeball is immobilized with a bipronged scleral hook.

The inferior half of the globe is usually selected as the preferable site for operation, conserving the upper half for possible subsequent surgery.

Procedure when the conjunctiva is unusually fibrosed and thick:

The globe is retracted superiorly and the conjunctiva is incised 10 mm. from the limbus, extending over the lower half of the globe.

The conjunctiva is thoroughly undermined to within 1 mm. of the limbus (Figure 1) and the punctures applied through the sclera (Figure 2), using a 1.5 mm. special electrolysis needle.

When the conjunctiva is normal, cycloelectrolysis punctures may be applied directly through the conjunctiva, using a 2 mm. electrolysis needle in 2 rows, 1.0 and 3.0 from and parallel to the surgical limbus (Figure 3) (the peripheral border of Descemet's membrane lying over the root of the iris), which is determined by transillumination. In this manner the ciliary body and processes are affected as demonstrated by the measurements of Troncoso.[10] Possibly the position of the aqueous veins[11] should be determined and avoided when their position is known.

From 30 to 70 punctures have been used, depending upon the degree of intra-ocular pressure. In cases which did not respond satisfactorily to the original treatment, the procedure has been repeated in another area with no apparent deleterious effects upon the eye. Too few operations have been performed to establish a workable formula whereby the number of punctures may be accurately calculated. At the present time we believe that in many of the cases in which cycloelectrolysis was employed an insufficient number of punctures was made and that the initial number of cyclo-

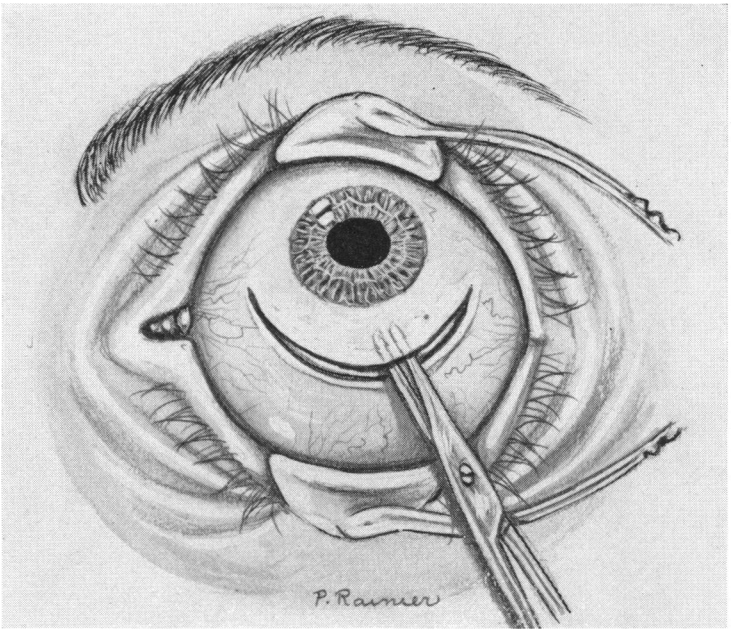


Fig. 1.—If the conjunctiva is especially thick and fibrosed, it is incised 10 mm. from the limbus, extending over approximately ½ the circumference of the eyeball, undermined to within 1 mm. of the corneal limbus with Stevens scissors.

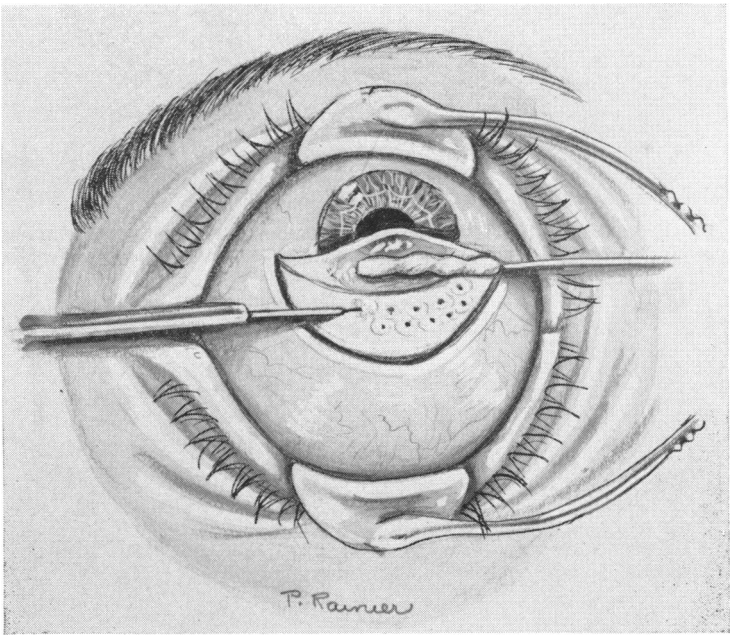


Fig. 2.—Galvanocautery punctures are applied to the sclera 1 and 3 mm. from the surgical limbus, using a 1.5 mm. straight needle.

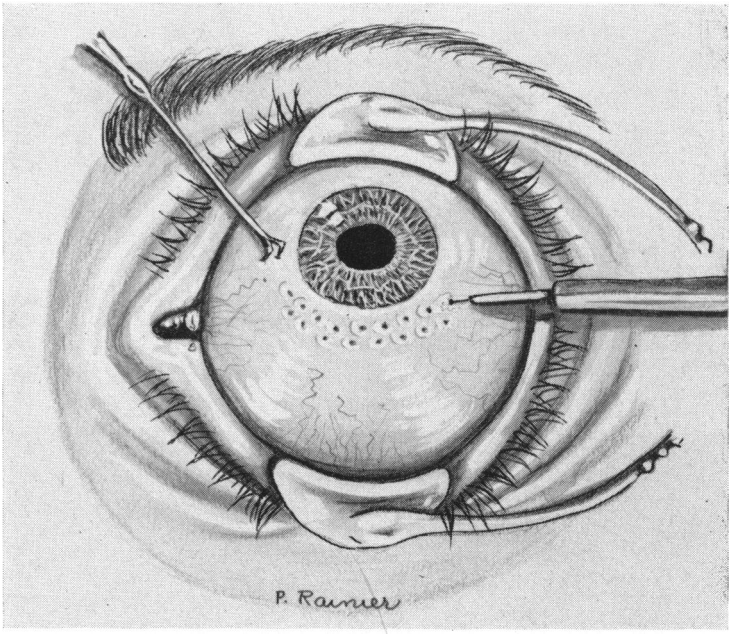


Fig. 3.—If the conjunctiva is normal, the galvanocautery punctures are applied through the conjunctiva, using a 2 mm. straight conical electrolysis needle.

electrolysis punctures at one operation should be between 50 and 75.

Cycloelectrolysis performed through the conjunctiva has been found to be a safe procedure, causing so slight a reaction that it may be considered an office procedure in some cases.

If a conjunctival flap has been made, the wound is closed with silk or plain 5-0 catgut.

If the intra-ocular pressure remains high immediately following surgery, from 0.5 to 1.0 cc. of aqueous is aspirated from the anterior chamber.

A solution of atropine (1%) is instilled, 1:3,000 metaphen unguent ophthalmic applied and a monocular dressing placed over the eye.

Postoperative Treatment:

Postoperative care is important. The head and torso should be elevated but rest in bed is unnecessary. Atropine (1%) or hyoscine (¼%) solution should be used to immobilize the iris and ciliary body and to lessen congestion. The use of neosynephrin (1 to 2½% solution) may be helpful in lessening congestion and in producing mild dilation of the pupil.

Complications:

We have previously stated that because cycloelectrolysis produces such a mild reaction the complications which may result are relatively infrequent.

1. Iridocyclitis. A mild reaction is present in the ciliary body following cycloelectrolysis. This may be controlled by the use of atropine postoperatively and will prevent the formation of synechiae. A positive aqueous beam, when present, is usually of short duration.

2. Corneal anesthesia. Some of our patients have had bullous keratitis preceding surgery, due to persistent high tension, but we have not found this complication following cycloelectrolysis. The relief of pain is a most striking and

consistent postoperative finding following cycloelectrolysis. It is probable that the corneal anesthesia which may be present subsequent to the operation is caused by trophic changes affecting the branches of the ciliary nerve.

3. Intra-ocular hemorrhage. The complications of intra-ocular hemorrhage, opacities in the lens, sympathetic ophthalmia, and herniation of the ciliary body into or through the sclera have not been observed in our series of cases.

4. Hypotony and detachment of the retina. In one case (Table 1, Case 29) in which cycloelectrolysis was performed (50 punctures) hypotony developed following a series of operations for glaucoma following cataract extraction, including cyclodiathermy, and was followed by retinal detachment. A severe hyperplastic sphenoiditis and serious psychologic factors complicated this case. The vision had been lost before cycloelectrolysis because the glaucoma secondary to uveitis had been diagnosed as facial neuralgia by a general physician.

Results of Cycloelectrolysis:

The results of cycloelectrolysis obtained in 65 eyes are tabulated in Tables 1 through 7.

TABLE 2.—RESULTS OF CYCLOELECTROLYSIS FOR GLAUCOMA ON VISUAL ACUITY, TENSION AND VISUAL FIELDS ON 65 EYES OBSERVED FROM 6 MONTHS TO 4 YEARS.

No. of Eyes		*Tension*	*No. of Eyes*	
Vision improved...25 (39%) Vision unchanged..21 (32%) Vision decreased...14 (21%)	71%	Controlled without miotics.....28 (43%) Controlled with miotics.....27 (41%) Uncontrolled..... 5 (8%)		84%
3 2	(8%)	Enucleated..... Eviscerated.....	3 2	(8%)
65.....		Total.....	65	

Visual fields not recorded because of poor preoperative or postoperative vision: 42 eyes

Results of visual fields in remaining 18 eyes:

Improvement..... 2 (11%) Stationary.....12 (67%) Slight contraction..... 4 (22%)	78%

TABLE 3.—RESULTS OF CYCLOELECTROLYSIS FOR CHRONIC PRIMARY GLAUCOMA IN 21 PATIENTS, 23 EYES

No. of Eyes		*Tension*	*No. of Eyes*	
Vision improved...10 (44%)	70%	Controlled without miotics.....13 (57%)		92%
Vision unchanged.. 6 (26%)		Controlled with miotics..... 8 (35%)		
Vision decreased... 6 (26%)		Uncontrolled..... 1 (4%)		
1 (4%)		Enucleated (Case 16)	1 (4%)	
23.....Total.....23				

Visual fields:

Improved.....	2 (15%)	77%
Stationary.....	8 (62%)	
Contraction.....	3 (23%)	
Not recorded (poor vision).....10		

Patients observed from 6 months to 4 years.

TABLE 4.—RESULTS OF CYCLOELECTROLYSIS FOR SECONDARY GLAUCOMA

Secondary Glaucoma Following Cataract Extraction—9 Eyes

No. of Eyes		*Tension*	*No. of Eyes*	
Vision improved...4 (44%)		Controlled without miotics.3 (33%)		55%
Vision decreased...3 (33%)		Controlled with miotics....2 (22%)		
		Uncontrolled.....2 (22%)		
1 Enucleation—detached retina.....1				(22%)
1 Evisceration—hypotonic.....1				
9.....Total.....9				

Secondary Glaucoma Following Trauma—3 Eyes

Vision improved...1 (25%)	100%	Controlled without miotics.....2 (75%)		100%
Vision unchanged..2 (75%)		Controlled with miotics.....1 (25%)		
3.....Total.....3				

Secondary Glaucoma Associated with Uveitis—4 Eyes

Vision unchanged..4 (100%)		Controlled without miotics..2 (50%)		100%
		Controlled with miotics....2 (50%)		
4.....Total.....4				

Secondary Glaucoma, Miscellaneous—4 Eyes

Vision improved...1 (25%)	75%	Controlled without miotics.....2 (50%)		75%
Vision unchanged..2 (50%)		Controlled with miotics.....1 (25%)		
Vision decreased...1 (25%)		Uncontrolled.....1 (25%)		
4.....Total.....4				

Patients observed from 10 to 34 months.

TABLE 5.—RESULTS OF CYCLOELECTROLYSIS FOR ACUTE GLAUCOMA—5 EYES

No. of Eyes		*Tension*	*No. of Eyes*	
Vision improved...2 (40%)	80%	Controlled without miotics.....2 (40%)		100%
Vision unchanged..2 (40%)		Controlled with miotics.....3 (60%)		
Vision decreased...1 (20%)				
5.....Total.....5				

Results of Cycloelectrolysis for Hemorrhagic Glaucoma—5 Eyes

No. of Eyes		*Tension*	*No. of Eyes*
Vision improved...1 (20%)	40%	Controlled with miotics.....5 (100%)	
Vision unchanged..1 (20%)			
Vision decreased...3 (60%)			
5.....Total.....5			

Patients observed from 12 to 32 months.

TABLE 6.—CYCLOELECTROLYSIS FOR GLAUCOMA—4 CASES, 5 EYES

Hydrophthalmos	*No. of Eyes*		*Tension*	*No. of Eyes*	
Vision improved...4 (80%)		100%	Controlled without miotics.....2 (40%)		100%
Too young to examine.....1 (20%)			Controlled with miotics.....3 (60%)		
5.....Total.....5					

Patients observed from 11 to 26 months.

TABLE 7.—CYCLOELECTROLYSIS FOR GLAUCOMA—7 EYES

Absolute Glaucoma—Preoperative Vision—7 Eyes

	Tension		
No light perception	Controlled without miotics.....3 (43%)		57%
	Controlled with miotics.....1 (14%)		
	Uncontrolled.....1 (14%)		
	Enucleated.....1	(29%)	
	Eviscerated.....1		
	Total.....7		

Patients observed from 11 to 13 months.

Discussion

The tables show the results in 65 eyes following cycloelectrolysis for various types of glaucoma on patients observed from 6 months to 4 years.

Because most of these operations were performed on eyes with advanced glaucoma, many of which were considered hopeless and had had previous operations, no final evaluation of the procedure can be considered until many more operations have been performed and the results have been critically analyzed. However, the results are sufficiently encouraging for the procedure to be recommended to others for trial.

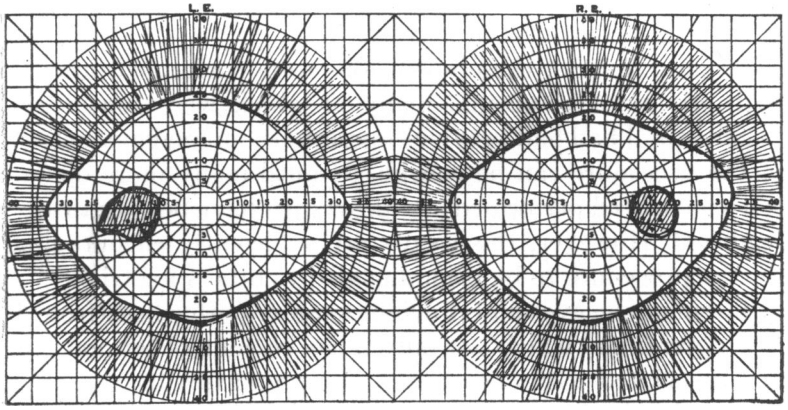
Twenty-nine eyes had previous surgery performed (from 1 to 4 operations) which not only failed to control tension but was associated with decrease in vision and further constriction of visual fields. Fourteen eyes required additional surgery following cycloelectrolysis to lower further or control tension. In 3 of these cases, cycloelectrolysis had to be repeated, apparently due to the fact that an insufficient number of punctures was applied at the first operation.

Case Reports

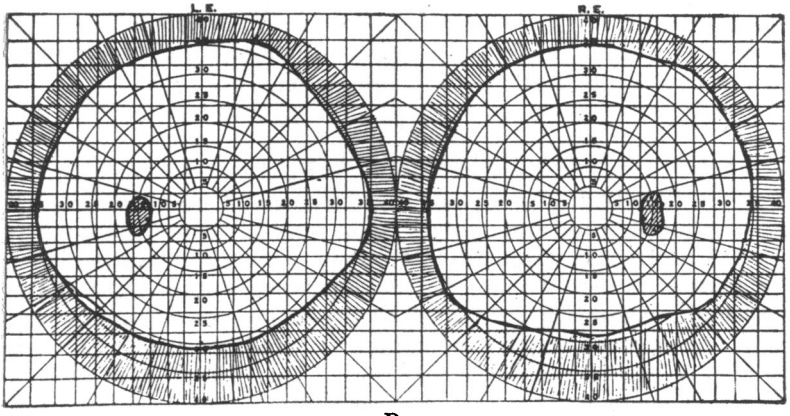
Case 17.—H. R., Negro male, aged 54 years. Patient complained of blurring of vision and rainbow colors for 3 days prior to examination. Uncorrected vision O.D. 20/40−1; O.S. 20/30. Intra-ocular pressure O.D. 48 to 65 mm. Hg. Schiötz; O.S. 30 mm. Hg. Schiötz. Slit-lamp examination revealed edema of the corneal epithelium O.D. No cupping of the discs. Anterior chamber was normal O.U. There was a generalized constriction of the peripheral fields and bilateral enlargement of the blindspots (Figure 4A). A diagnosis of chronic primary glaucoma was made and the patient was given medical treatment for 6 months.

Thirty-six cycloelectrolysis punctures (5 ma. for 5 sec.) were made over the ciliary body in the lower half of the right eyeball by Dr. Truman Boyes. Intra-ocular pressure O.D. was reduced to 20 mm. Hg. Schiötz, and maintained for 10 days but then gradually increased over a period of 3 months to 50 mm. Hg. Schiötz despite medical treatment. Vision was 20/20 sc. in both eyes. Tension O.S. 20 mm. Hg. Schiötz.

Thirty-two additional punctures were made through the conjunctiva (5 ma. for 5 sec.) in the upper half of the right eyeball.



A



B

Fig. 4.—Comparison of preoperative (A) and postoperative (B) fields in a Negro patient with chronic simple glaucoma.

A. Preoperative fields, July 1, 1946, 2/1000 white test object. Peripheral fields generally constricted and a bilateral enlargement of the blindspots.

B. Postoperative fields, April 17, 1949, 2/1000 white test object. Peripheral fields and scotoma normal O.U.

The tension was reduced to 20 mm. Hg. Schiötz and vision was 20/70−3 O.D.

Two months later, tension of the left eye fluctuated from 25 to 45 mm. Hg. Schiötz. Fifty cycloelectrolysis punctures (5 ma. for 5 sec.) were made through the conjunctiva with a 2.0 mm. needle on the inferior half of the left eye, combined with aspiration of 0.5 cc. of aqueous. Tension in both eyes remained normal for 11 months without medication and vision improved to 20/20 in each eye, without correction. The peripheral visual fields and blindspots returned to normal (Figure 4B).

CASE 19 (Chronic primary glaucoma).—H. K., Negro female, aged 43 years. Cycloelectrolysis was employed as a primary procedure on the left eye, and cyclodiathermy was performed on the right eye. The tension in the eye where cycloelectrolysis was performed was controlled without further surgery, but the eye in which cyclodiathermy was employed required cycloelectrolysis, trephining, iridencleisis and sclerotomy before the tension was finally controlled.

CASE 62 (Iridocyclitis [Sarcoidosis] with secondary glaucoma. [Not included in Tables because 6 months have not elapsed from time of operation.])—P. S., Negro male, aged 26 years, entered the hospital on December 22, 1948, complaining of failing vision in each eye with occasional pain which, at times, was severe in the left eye. Past history: Patient had been told that there was an increase in the intra-ocular pressure in June, 1948, which was controlled by miotics. Vision on admission was 20/70 in the right eye and 20/200 in the left eye. The tension was 35 mm. Hg. Schiötz O.D. and 40 mm. Hg. Schiötz O.S. Slit lamp showed the usual findings of iridocyclitis. Examination of a lymph node revealed sarcoidosis.

Under conservative treatment the tension of the left eye varied from 30 to 65 mm. Hg. Schiötz. The tension was not controlled with miotics, mydriatics or vasoconstrictors which were used in conjunction with aspiration of the anterior chamber. The left visual field showed definite constriction of the superior nasal quadrant and it was considered wise, even in the face of a moderately advanced iridocyclitis, to perform cycloelectrolysis. On January 13, 1949, 30 punctures were made over the inferior nasal quadrant by one of us (L. B. S.) using 5 ma. for 5 seconds of negative galvanic current. The tension subsided slightly but again became elevated to 42 mm. Hg. Schiötz, and cycloelectrolysis was repeated on March 3, using 70 punctures, 5 ma. for 5 seconds over the temporal half of the globe. During the subsequent 2 weeks the tension in the left eye dropped to 14 mm. Hg. Schiötz but gradually became elevated to

40 mm. Hg. Schiötz where it has remained with very little fluctuation. Patient retains 20/200 vision in the left eye, has no pain, and the field is unchanged.

Comment: The iridocyclitis was not aggravated by either of the above cycloelectrolysis operations.

SUMMARY AND CONCLUSION

1. Cycloelectrolysis (cyclocatholysis) is a new operative technic in the field of glaucoma, giving the surgeon an accurately controlled method of chemically destroying the tissues of the ciliary body.

2. This procedure has been used over a period of 4 years and critical investigations have been carried out on 65 human (observed from 6 months to 4 years) and 80 animal eyes.

3. The technic of cycloelectrolysis is simple and requires no elaborate equipment, and only ordinary skill on the part of the surgeon.

4. The procedure consists essentially of treating the lower half of the eyeball with from 50 to 75 punctures made with a fine conical straight needle. A needle 1.5 mm. in length is used through the sclera, and a 2 mm. needle through the conjunctiva between 1.0 and 3 mm. from and parallel to the surgical limbus using 5 milliamperes of galvanic current (cathode) for 5 seconds.

5. Because the operative and postoperative reaction is slight and complications infrequent, the operation may be performed as an office procedure.

a. There is no marked postoperative rise in intra-ocular pressure such as that which occurs following nonperforating cyclodiathermy because of contraction of the sclera and greater secondary congestion.

b. There is no carbonization of tissue around the puncture wounds or thinning of the sclera, thereby avoiding the possibility of herniation of the ciliary body into the scleral defect.

c. The punctures may be safely made through the con-

junctiva. In cycloelectrolysis the minute punctures are sterilized chemically and are immediately sealed with serum, reducing the likelihood of infection.

d. There is less congestion of ocular tissues in cycloelectrolysis as compared with cyclodiathermy.

e. The chemical destruction of the ciliary body from electrolysis may be less dangerous than the destruction produced by diathermy from the standpoint of sympathetic ophthalmitis (chemical versus thermal destruction).

6. Cycloelectrolysis is indicated particularly in elderly people where the complications of thrombosis, pneumonia and infections may occur due to the recumbent position. Patients need not be confined to bed following this operation.

7. The Negro race is susceptible to cicatrix and keloid formation and it is generally recognized that Negroes usually do not respond to a filtering operation. Cycloelectrolysis therefore should be of value in the Negro and was successful in controlling tension in 7 eyes.

8. The relief of pain is the most striking and consistent postoperative finding. There has been a decrease of tension in most cases (84%), no loss of vision has been found in many of the cases (71%). The visual fields were retained without deterioration in the majority of cases (78%).

9. Results following cycloelectrolysis are so encouraging that the procedure warrants consideration, investigation and clinical trial by other ophthalmologists.

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We wish to express our appreciation to the following surgeons for their permission to include a report of their cases in this paper: Truman L. Boyes, M.D., Daniel B. Kirby, M.D., Raymond E. Meek, M.D., Brittain F. Payne, M.D., Wendell L. Hughes, M.D., Walter F. Johnson, M.D., Hunter H. Romaine, M.D., J. Gordon Cole, M.D., and Virginia Lubkin, M.D.

DISCUSSION

PROFESSOR G. B. BIETTI, Pavia, Italy (by invitation): I would like to express my sincere congratulations to Dr. Berens for his outstanding paper. He gives us the advantage of a large statistical analysis on a new method which, I am sure, will gain more and more favor in the future. When an idea arises at nearly the same time in 2 different brains it is most probably a very good one. In effect I, too, used in a few cases perforating electrolysis instead of diathermy to coagulate the ciliary body, deriving the idea from Vogt's catholysis for retinal detachment. But electrolysis was particularly employed by Schreck, although with somewhat different aims and technic. In a paper read at the last meeting of the German Ophthalmological Society in Heidelberg in August, 1948, Schreck reported the results he obtained by using anodic, that is, positive, acid electrolysis in glaucoma. He introduces a cyclodialysis spatula-shaped electrode between the sclera and the ciliary body (as did Thiel with diathermy to reduce the heating effects) and performs first an electrolytic cyclodialysis or fistula between the suprachoroidal space and the anterior chamber, then coagulates the long posterior ciliary artery by placing the spatula parallel to the limbus just under the tendon of the lateral or medial rectus and in some instances also the external surface of the ciliary body in the upper quadrants. Schreck has operated, so far, 44 eyes showing different types of glaucoma. The tension was controlled with or without miotics in 33 cases (75%).

I, too, began lately to use this procedure called cilocyclo-anolysis, especially for more severe cases. I have already operated upon 10 cases of glaucoma and the tension was so far controlled in 8, but the time elapsed since the operation is still too short to say if the results of Schreck's method are as permanent as those shown by Dr. Berens with his technic, which is moreover simple and deserves all our attention.

DR. H. R. HILDRETH, St. Louis, Mo.: I enjoyed the paper very much, and the results speak for themselves. I would like to raise what might be considered a theoretical question. Dr. Berens mentioned some experimental work on animals. Several years ago, when we heard more about this work with retinal detachments, I could never find out exactly what the dosage should be. I ran a series on a rabbit, starting with a control puncture, and ran on up to a dosage in intensity and duration that would be far beyond anything that had been recommended in the literature. I am speaking of electrolysis for retinal detachment. I asked our pathologist, who was then Dr. Lamb, to make a study of these punctures. The curious thing was that the pathologic response was the same in all the punctures. It is very easy to be sure that electricity was passing through the machine because the meter was functioning and hydrogen bubbles formed at the cathode. I would be very much interested if Dr. Berens could tell what his experimental studies showed.

DR. L. BENJAMIN SHEPPARD, Richmond, Va. (by invitation): I want to thank Dr. Berens for the opportunity to be associated with him and to assist in one of his initial experiments. It was especially a pleasure to follow through on some of the animal work.

To answer Dr. Hildreth's question, we are not yet in a position to state definitely what the animals will show. The pathologic slides are now in the process of going through the laboratory, so complete reports are not available at this time. Our early slides indicate that changes take place in the region of the ciliary body when cycloelectrolysis has been used. A final answer will have to await the results of further observations.

DR. CONRAD BERENS, closing: I appreciate the discussion, particularly that of Professor Bietti, and I am delighted that he referred to his method of applying carbon dioxide snow. I have not had the opportunity of trying it. His paper was received only 2 days before I left New York, but it appears to me to be an excellent procedure, and one which will produce little unnecessary tissue destruction. It may control the tension as well as these other procedures, which are more destructive in their nature. Certainly cyclodiathermy and cycloelectrolysis produce a certain amount of tissue atrophy.

Just one word to Dr. Hildreth concerning retinal detachment. Electrolysis was employed by Dr. Verhoeff as early as 1915. I have been using electrolysis for retinal detachment for 15 years and have found no reason for change. There is a downgrowth of the

episcleral tissue with these puncture wounds which seems to make a pretty firm adhesion, so far as my experience is concerned. The question of whether we should use 1 or 3 ma. depends on how long we are going to apply the current. We have selected 5 ma. for 5 seconds for cycloelectrolysis. People who have timed me with a stop watch say I have been using it up to 7 seconds.

One thing we have not mentioned is the fact that with this procedure we apparently can, as Professor Bietti can with his snow procedure, vary the dose of the application we wish to use. We can use 50 to 70 punctures, and if that is not sufficient we can go back and use 30 to 40 more. In our earlier experiments when we used only 20 to 30 punctures in the more advanced and hopeless cases of glaucoma we often obtained little result, and improvement was not at all permanent.