AMERICAN JOURNAL OF OPHTHALMOLOGY

Vol. 4 FEBRUARY, 1921 No. 2

EFFECTS OF CARBON MONOXID UPON THE EYE.

W. H. WILMER, M.D., L.L.D.

WASHINGTON, D. C.

This paper gives a general survey of the subject and includes a graphic description of the subjective and general nutritional effects of carbon monoxid poisoning, by one of the victims; and incidentally throws light on the origin of a story of a haunted house. It gives an account of the ocular symptoms of such poisoning, revealing a distinct tendency of the poison to cause neuritis and especially to affect the optic nerve.

Read by invitation before the Ophthalmic Section of the College of Physicians, Philadelphia, Pa., October 21, 1920. For discussion see p. 127.

The exposure of the human organism to the ravages of carbon monoxid, is a constantly increasing menace in all walks of life. The fact that the details in regard to eye involvements are very meager, despite the voluminous literature upon its general effects, has led the writer to present, in this great ophthalmologic centre, a consideration of the injurious effects of this gas upon certain ocular tissues.

While the ophthalmologist is chiefly interested, clinically speaking, in the chronic form of carbon monoxid poisoning, it will be necessary to consider, in a general way, the universality of this gas; the insidious somatic effects with their sequelae; its combinations in the blood, and the well recognized pathologic changes found in fatal cases, in order that there may be a full appreciation of the action upon the central nervous apparatus and, thru this system, upon the eye itself.

Carbon monoxid has existed in nature, in varying amounts, ever since the first occurrence of the phenomenon of combustion in the presence of a limited amount of oxygen. It formed a part of volcanic gases, and the "Blacksmith Gods" of the old mythology produced it in their forges. In ancient Rome, he who felt that there was "no way except the Bridge of Death" sought its aid in the fumes of charcoal. In modern France, the favorite method of committing suicide is by the inhalation of this gas.

The first production by artificial means was in 1776 when Lassone obtained this gas by heating zinc oxide with carbon.

The gas "is formed wherever combustion of carbon-containing material occurs," tho the proportion of carbon monoxid varies from the almost negligible amount produced by a burning straw to the 30% contained in carburetted water gas. Cogshall estimates that the gasoline torch produces 7% to 10%, while Gardner says that he has found carbon oxid in the vapors of drying paint. According to Apfelbach, the blast in the steel industry produces about 26% of carbon oxid; producer 23%; exhaust from gas engine 9.3%; and he quotes the analyses made by Schumacker of the air of five motor garages in which the average of the five was 0.042%.

Henderson gives the percentage of carbon monoxid in coal gas as 6% to 8%. He also says that carbon monoxid "is the chief constituent of illuminating gas, and to illuminating gas in turn may be traced an unfortunately large number of fatalities in American cities." Seventy-eight per cent of the gas used in the United States is water gas. In a large majority of gas works no attempt is made to remove the carbon monoxid. Ordinarily tests are made for only sulphureted hydrogen.

To these figures must be added the large increase (60% since 1914) in the use of gas for cooking and heating pur-

poses—induced by the great difficulty in getting coal. Apfelbach mentions thirty-one industries in which carbon monoxid poisoning has been observed, and he says in regard to coal gas, producer gas, water gas, furnace gas, etc., "It should be constantly kept in mind that they all contain carbon oxid in varying quantities, and that it has been fairly well established that carbon oxid is the toxic agent in all these cases"; "that the toxicity will vary because of the differences of carbon oxid contents"; and "that gases containing carbon oxid cause more industrial sickness and deaths than the other gases referred to."

In addition to the production of carbonic oxid in buildings, mines, etc., there is a constant pouring out of this gas from the exhaust of automobiles, particularly in the traffic tunnels. Henderson estimates that "there are more than six million automobiles in the United States, not to mention trucks" —all adding their quota to the pollution of the atmosphere. He further states that it is fatal to man to breathe for an hour air that is normal in other respects, but which contains as much as 0.4% of carbon monoxid.

The gas is recognizable by the "lambent blue flame" that appears whenever fresh coal is put upon the cheerful open fire. But by itself, it is colorless, odorless, tasteless, nonirritating, tho none the less persistent and penetrating. The ordinary war gas mask gave no protection against this gas. It was not until 1918 that the discovery of the absorbent qualities of the oxides of various metals, manganese, copper, etc., made possible the protection of persons exposed to the fumes—following mine explosions, etc. From the clinical standpoint, the gas enters the system only by means of respiration, so that unless it is associated with some evil smelling gas, the victims become helpless before its presence is suspected. Fortunately, newspaper accounts of the fatal results of this gas in closed garages, from the instantaneous gas heater (frequently in the bath room) and from the common stove, help to warn the public of the danger.

While the tragic results of acute carbon monoxid poisoning always arouse much interest, it is a fact that outside of the industrial centres, very little attention has been paid to the headaches, anemia, gastric disturbances and psychic effects that are caused by chronic poisoning by carbon monoxid from the old fashioned latrobes, hot air furnaces, etc. Yarrow says: "I have made a careful investigation of leaky gas fixtures, and have observed that it is the exception rather than the rule to find them perfect in our houses."

McGurn says: "In all probability there is no better known chemical substance, with which a high percentage of our urban and suburban population is brought into such frequent contact, that has attracted so little attention and yet is so capable of inducing such insidious and wide-spread destruction of health as carbon monoxid gas."

In the autumn of 1917, the writer, together with other Army officers, had offices over a garage. Dull headaches, a slight feeling of subnausea, and general listlessness became common occurrences with many of the office personnel as the day advanced; but the symptoms passed away upon getting out into the fresh air. Many aviators complained of nausea following a whiff of the gases from the exhaust of the motor when flying at high altitudes. This is especially apt to occur when the exhaust escape pipe of the motor ends in front of the pilot's seat. The amount of carbon monoxid inhaled at ordinary elevations is negligible, but a very minute quantity of this gas is sufficient to cause symptoms at an elevation of fifteen thousand feet, when the system is already suffering from oxygen want. This gas will also have its influence upon reducing the strength and power of coordination of the ocular muscles which are so important to good flying.

Surgeon General Stokes, U. S. N., found that a great many of the so-called "heat prostrations" in the stoke-rooms are due to carbon monoxid. It is quite possible that this gas is

responsible for the ocular illusions that occur in coal mines. The writer has been told by one experienced in mines that when a miner sees the "old gray mare" he is immediately taken up to the fresh air.

The susceptibility to the toxic influence of this gas varies greatly with individuals and in certain persons there are distinct adaptive changes (as occurs in oxygen want) which enable the individual to further resist the toxic influence. However, it is certain that distinct toxic symptoms will be felt by practically every individual when the percentage of this gas in the atmosphere reaches the point of 0.05%. In cases of "gassing," the subject is rendered unconscious at practically the first inspiration. McGurn says: "It is a fact that repeated inhalations of very minute quantities of carbon monoxid are far more dangerous to the future health of the individual than one exposure where the patient is rendered unconscious."

In chronic cases, where small doses are inhaled intermittently over a long period of time, the more common symptoms are headaches, vertigo, tinnitus aurium, flashes of light before the eyes, weakness or absence of tendon and pupillary reflexes, nausea, pain in the epigastric region, palpitation, languor, muscular weakness and lack of coordination, convulsive movements, mental disturbances, hallucinations of sight and hearing. Anemia is not always present. In fact, there are at certain stages polycythemia.

McGurn says: "On investigation it was found that these gases are capable not only of producing many diseases and conditions peculiar to themselves, but also of simulating nearly every disease known to modern neuro-pathology, as well as many of the so-called 'idiopathic' and 'functional' disorders." Yarrow has pointed out the possibility of confounding chronic carbon monoxid poisoning with various other conditions and intoxications. Among the sequelae of carbon monoxid poisoning are (according to Apfelbach) (1) pneumonia, (2) psychoses, (3) paralyses, (4) skin eruptions, and (5) gangrene. But there is no mention of the resulting eye lesions.

In the article upon Toxic Amblyopia in the American Encyclopedia of Ophthalmology, the classification of de Schweinitz is given, which puts carbon monoxid under Group II—"Drugs and chemical compounds which in full or toxic doses depress the cerebrospinal axis or the peripheral nerves." This paper states that: "Intoxication from poisonous combustion products, especially from carbon monoxid and carbon dioxid, as well as from hydrocarbons and other compounds in illuminating gas, is occasionally accompanied by ocular symptoms."

The following are some of the ocular sequelae of carbon monoxid poisoning that have been noted by different authors: H. Knapp; paralysis of several ocular muscles after exposure to the fumes of a stove. Illing; cases of homonymous hemianopsia. Emmert; case of paralysis of third nerve of left eye, associated with trigeminus and facial paralysis. Becker; cases of retinal hemorrhages and congestion of retinal veins. Henderson says: "In more severe cases the patients recover only with the loss, partial or complete, of vision, power of speech, or with some other nervous defect." Edsall says: "Ocular disorders are not very common; these may be partial or complete blindness of varying duration, with or without ophthalmoscopic changes, xanthopsia, nystagmus, and paralysis of the eye muscles, and there have been repeated instances of complete ophthalmoplegia with marked protrusion of the eyeballs." Apfelbach says: "Rare signs are nystagmus and strabismus...hemorrhages in the sclera and conjunctiva...and diplopia." de Schweinitz quotes Schmitz who describes the following results of carbon oxid: "Contraction of the visual fields, partial color blindness, venous hyperemia in the retina and contracted arteries." Many authors mention inequality of the pupils. McGurn gives a list of 105 varying pathologic conditions known to have been caused by carbon monoxid intoxication. Among them

are the following eye lesions: "Central and marginal scotomata of the optic discs"; "color blindness, transitory"; "diplopias"; "engorgement of retinal vessels"; "impairment of pupillary light reflexes"; "impairment of vision (toxic amblyopia)"; "irregular pupils"; "narrowing of the fields of vision"; "nystagmus"; "edema of optic discs"; "sectional blanching of optic discs"; "optic nerve atrophy (secondary)"; "unequal pupils." Nearly all of these conditions were "seen in cases of multiple sclerosis caused by chronic carbon monoxid inhalation in furnace gas."

There is a wide difference of opinion concerning the state in which carbon monoxid exists in the blood of those poisoned by it, and its mode of action upon the body tissues. Haldane, Henderson and others believe that it "acts as a poison solely by its ability to prevent the normal supply of oxygen from reaching the tissues, and thereby the normal metabolism of the body cells." Henderson says: "It resembles oxygen but the avidity with which it combines with hemoglobin is three hundred times greater than oxygen. It kills because it reduces the oxygen-carrying power of the blood and not because it forms a permanent compound with hemoglobin." He believes that access to fresh air causes a speedy disassociation of the carbon compound. On the other hand, many close observers feel that the compound is stable and that it has a direct action upon the delicate nerve structure of the body. Yarrow says: "Carbon monoxid, as is well known, forms a very stable combination (chemic) with hemoglobin, so that blood once impregnated with the deadly gas loses its power as an oxygen carrier to the tissues of the body." According to Rand, "If a considerable portion of the blood becomes saturated with this gas death is inevitable not by suffocation, as commonly imagined, but by carbon monoxid poisoning." McGurn says: "The writer wishes to express the opinion that CO is a chemical substance capable of a peculiar, selective affinity; that enters into a more or less fixed combination with the hemoglobin of undiluted blood and yet possesses a stronger avidity for certain nerve elements that are not found in other structures of the body; also that when carbon monoxid pervades the general circulation, it is *slowly liberated* from its hemoglobin combination and reabsorbed by receptive brain and nerve tissues so that irritative and permanent degenerative changes often result; and that when such irritations and degenerations of the central or peripheral nervous systems are once established, an infinitely small quantity of this gas (one to two hundred thousand) is capable of aggravating and hastening the retrogressive changes which it has already produced." Apfelbach says: "The CO rapidly united with the hemoglobin, replacing the oxygen and forming a very stable compound known as carboxy-hemoglobin."

Whatever the difference of opinion concerning the mode of action of this poison upon the central organs, all are agreed upon the very definite lesions that have been observed in fatal cases. Munroe says: "The effect is to produce intense congestion of vital organs, especially in the brain, usually accompanied by small hemorrhages." Apfelbach says: CO causes a rapid degeneration of various organs...Autopsy on cases from psychoses of CO gas shows a predilection for degenerations, thrombosis, encephalitis in the lenticular nucleus and optic thalamus. It is held that the encephalitis and hemorrhages, sometimes observed in gas autopsies, are due to the rapid fatty degeneration which occurs in the vessel walls." Concerning the changes in the nervous system in these cases, in addition to conditions already mentioned, Brown states that there were "hemorrhages in the pia of the brain and cord, bloodless patches with softening in the cord and fatty degeneration of the endothelium of the small vessels of the central nervous system, chromalytic and atrophic changes in the large motor cells of the cord." He assumes "an interference with the nutrition of the neurons which regulate the function of the nerves."

CASES

The following instance of the chronic carbon monoxid poisoning of an entire family is given in detail from the account that Mrs. H. wrote while the occurrences were fresh in her mind. This recital is of interest because it gives a very intelligent account of the physical and psychic effects of the gas, and also because the writer has been able to follow the case of one of the children, B., who as a result of this poisoning has suffered from the long continued effects of an optic neuritis.

"Near the end of October, 1912, our town house was burned. Therefore it became necessary for us to hire a furnished house for the winter. As it was November, most of the desirable ones were taken, and we had great difficulty in finding one with a sufficient number of bedrooms. Finally we succeeded in finding one vacant.

It was a large, rambling, high-studded house, built about 1870, and much out of repair. It had not been occupied by the owners for the past ten years, tho occasionally it had been rented for the winter. The house was situated on a sunny street, and altho the sun bathed the outside of the house, it rarely seemed to penetrate thru the tall and narrow windows. All the floors and stairways were heavily carpeted. Absolute silence reigned thru the house, not a foot-fall could be heard. There was no electricity, the house being lighted thruout by gas.

On November 15th we moved into the house. The children were not to come for a couple of days, until we had become somewhat settled. The second day we were in the house the furnace broke down, and new parts had to be made in Syracuse. It was a very old furnace, built thirty years or more ago, a combination of hot air and steam, with a boiler suspended over the fire. While waiting for the new boiler to be made, only part of the furnace could be used, not enough to heat the whole house, so we decided to have the children stay away for ten days longer.

G. and I had not been in the house more than a couple of days when we felt very depressed. The house was overpoweringly quiet. The servants walked about on thickly carpeted floors so quietly that I could not even hear them at their work.

One morning I heard footsteps in the room over my head. I hurried up the stairs. To my surprise the room was empty. I passed into the next room, and then into all the rooms on that floor, and then to the floor above, to find that I was the only person in that part of the house

After November 25th the furnace was temporarily repaired and we sent for the children. We felt more cheerful after they arrived, the house seemed less big and solitary. Many mornings, when going down stairs or thru the halls, I would notice an odor of gas. Upon investigating the different gas fixtures I would find them in proper condition.

I had not been in the house more than a couple of weeks when I began to have severe headaches and to feel weak and tired. I took iron pills three times a day and spent a couple of hours each afternoon in my room, lying down and resting, a rather discouraging process, as after resting my headache was always worse than it had been before.

It had always been G.'s habit at night before going to bed, to sit in the dining-room and eat some fruit. In this house when seated at night at the table with his back to the hall, he invariably felt as if someone was behind him, watching him He therefore turned his chair, to be able to watch what was going on in the hall

The children grew pale and listless and lost their appetites. The playroom at the top of the house they deserted. In spite of their rockinghorse and toys being there, they begged to be allowed to play and have their lessons in their bedroom.

I grew more tired and indifferent to everything, and also felt very cold in the evenings, and wore shawls and scarfs most of the time. The children seemed so poorly and I was so tired, I took them away the day after Christmas, for the holidays.

While we were away, G. was frequently disturbed at night. Several times he was awakened by a bell ringing, but on going to the front and back doors, he could find no one at either. Also several times he was awakened by what he

thought was the telephone bell. One night he was roused by hearing the fire department dashing up the street and coming to a stop nearby. He hurried to the window, and found the street quiet and deserted.

Soon after the New Year, the children replied; but as I grew more wide awake I realized that it could not be any one of the doors of the room as they were tightly closed. Another time, a little before daylight, I was awakened by heavy footsteps going down a staircase behind the wall at the head of my bed. Then a

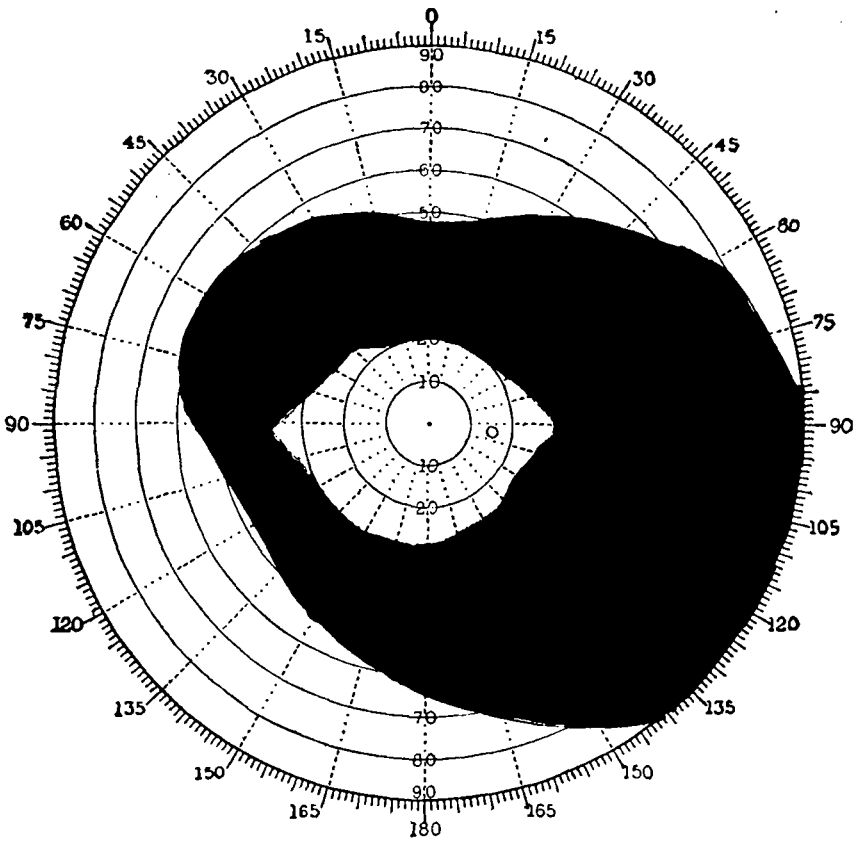

Fig. 1.—Form field of right eye, 1917, Jan. 5. Case 1.

and I, with the nurses, returned to the house. We all felt better for our change and returned quite glad to settle down again. Soon, however, the gloom of the house began to cast a shadow over us once more. The children grew paler and had heavy colds. When out of doors their colds grew less and they seemed better. My headaches returned, and I frequently felt as if a string had been tied tightly around my left arm. One night I was awakened by a heavy door slamming once, quite near me. It woke G., too, and he said to me, "What was that?" "Only the door of the room," I

number of crashes down stairs, as if several pots and pans had been hit together or against the kitchen stove. Soon I realized that there was no staircase behind the wall, only the thickly carpeted front stairs on which no footsteps could be heard. Also that it would be impossible, in my room, to hear any sounds from the kitchen, no matter how loud.

On one occasion, in the middle of the morning, as I passed from the drawing-room into the dining-room, I was surprised to see at the further end of the dining-room, coming towards me, a strange woman, dark haired and dressed

in black. As I walked steadily on into the dining-room to meet her, she disappeared, and in her place I saw a reflection of myself in the mirror, dressed in a light silk waist. I laughed at myself, and wondered how the lights and mirrors could have played me such a trick. This

And so on he talked, insisting that he had been called, and for me to explain who it had been.

The days went on, and the children grew paler and more listless. Some days, as their colds seemed worse, I kept them in bed. Then again, as there did not

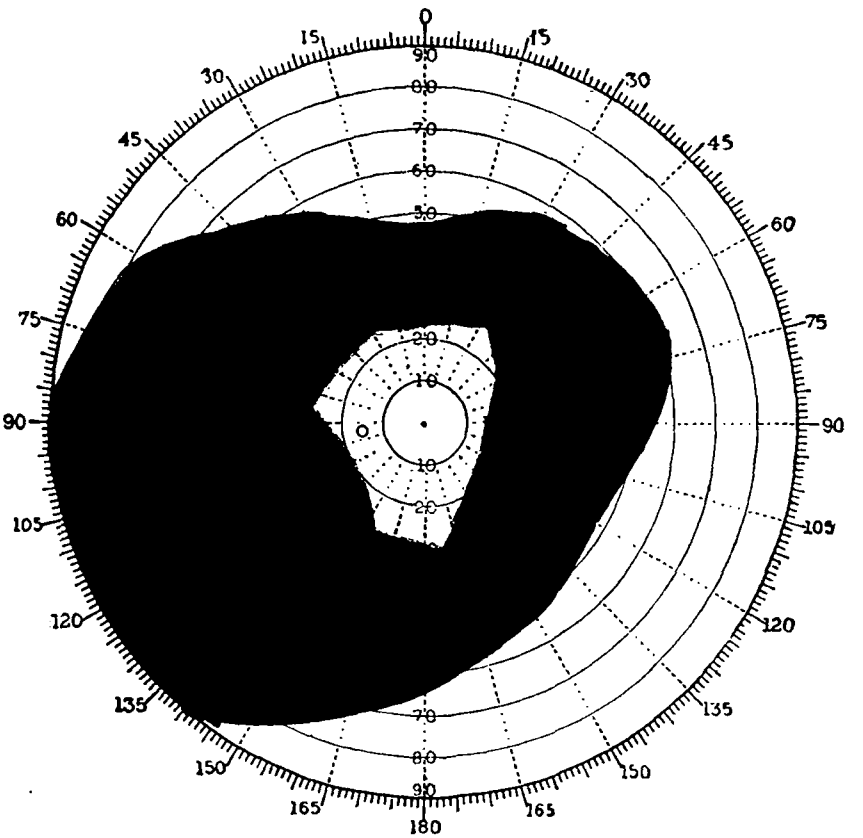

Fig. 2.—Form field of left eye, 1917, Jan. 5. Case 1.

happened three different times, always with the same surprise to me and the same relief when the vision turned into myself.

As I was dressing for breakfast one morning B. (four years old) came to my room and asked me why I had called him. I told him that I had not called him; that I had not been in his room. With big and startled eyes, he said, "Who was it then, that called me? Who made that pounding noise?" I told him it was undoubtedly the wind rattling his window. "No," he said, "it was not that, it was somebody that called me. Who was it?"

seem to be very much the matter with them and they appeared to be growing too fond of staying in bed, I made them get up and go for a walk in the sun. It was very hard to make them eat. B. would play vigorously for a little while, and then would lie, stretched out, limp and listless upon the floor, a toy in front of him clasped in his hand, his eyes glued upon it and yet apparently neither seeing nor thinking about it. About half an hour later, perhaps, he would suddenly get up and play again.

About this time my plants died. Some of them I had had for a number of years.

At this time I had a cold and cough, and ached all over as if I were going to have an attack of grip, but as I had no fever, I went about as usual. G. was not feeling at all well either. He had a great deal of pain at the back of his head and felt as if he was going to have typhoid fever for a second time. The servants, too, had grown pale, and moved about the house listlessly.

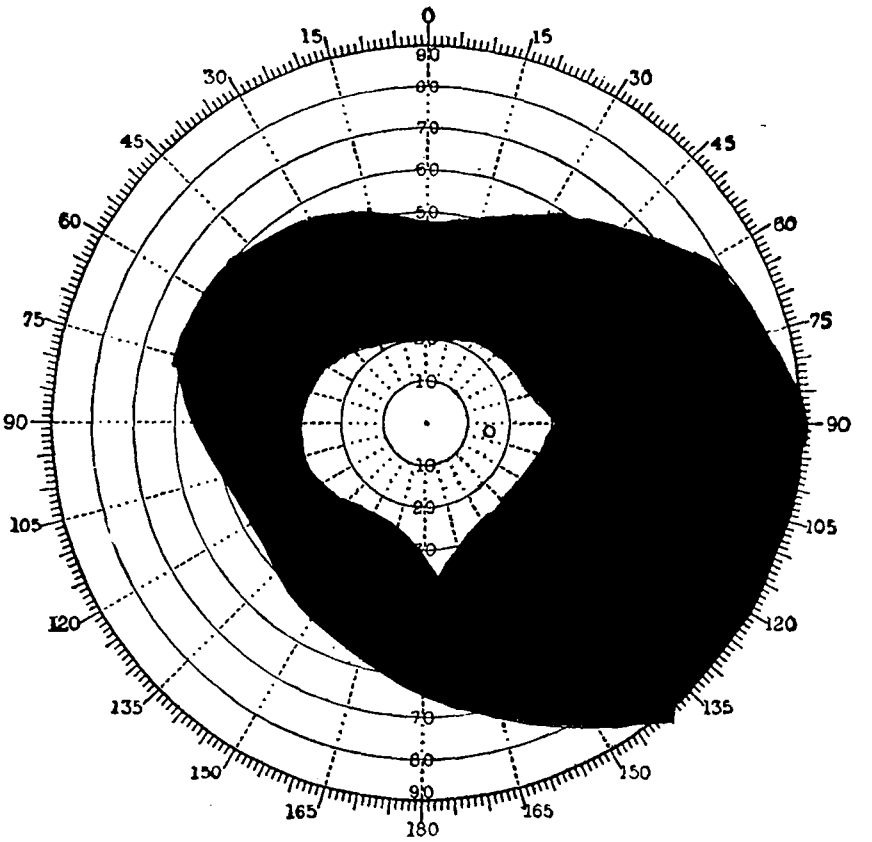

Fig. 3.—Case 1. Form field R. E., 1917, April 21.

On the night of January 15 we went to the opera. That night I had vague and strange dreams, which appeared to last for hours. When the morning came, I felt too tired and ill to get up. G. told me that in the middle of the night he woke up, feeling as if someone had grabbed him by the throat and was trying to strangle him. He sat up in bed and had a violent fit of coughing, which lasted about five minutes. His first thought had been that burglars were in the house, but as everything was quiet he instantly dismissed that idea. It then flashed across his mind that I had been playing a joke on him, but upon looking at me, he saw that I was in a heavy sleep, very much as if I had been drugged. Until we lived in this house, I had always been a light sleeper, waking at the slightest sound. In this house, however, nothing seemed to wake or disturb me. Quite the contrary with G., for in the past he had always slept heavily, never hearing a sound and nothing disturbed him. Now he was continually waking, answering the telephone and doorbell, which had never rung, and looking for burglars, who never materialized.

That morning after breakfast, as was my usual custom, I sent for the children's nurse, a Scotch woman who had lived with me for several years. She looked worn and pale, and when I asked how

the children had slept she burst out with, "It has been a most terrible night. This house is haunted."

I laughingly told her that that was the most ridiculous thing I had ever heard.

"I would have said the same thing three months ago," she answered, "but fat man touch me.' He was terrified. It took Fräulein and me until ten o'clock to calm him. He slept the rest of the night with me, in my room. Fräulein slept in B.'s bed, beside G. Jr., to protect him. G. Jr. did not wake up all night, but the muscles of his face kept twitch-

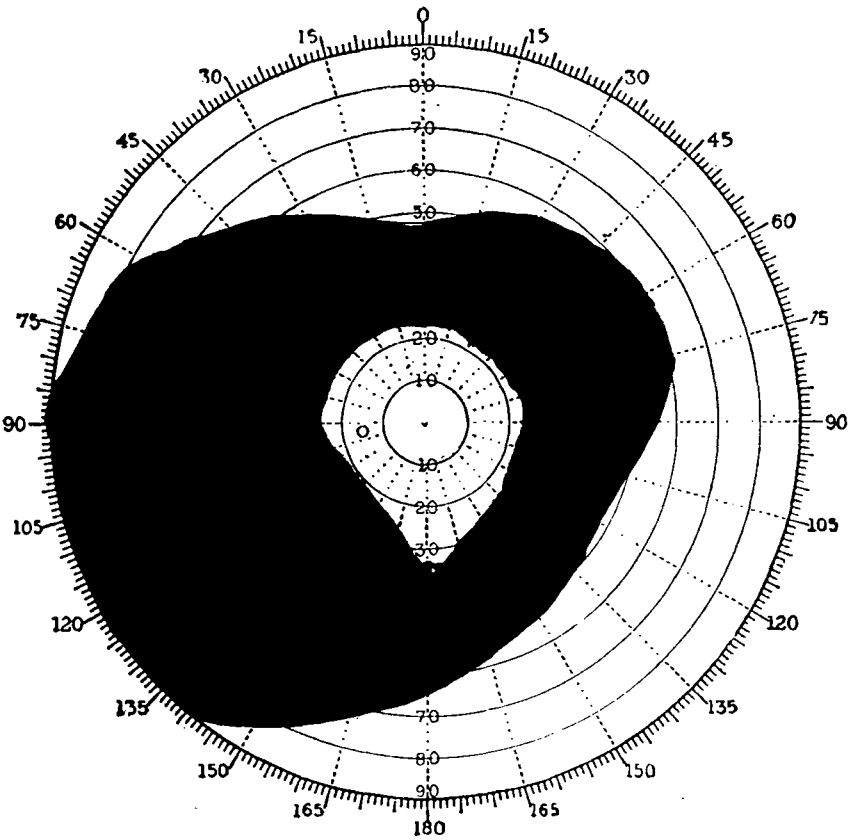

Fig. 4.—Case 1. Form field L. E., 1917, April 21.

I have had such experiences that I am now convinced of it, and everyone in the house has had experiences too." She said that after being in the house two or three days, things had begun to happen. She had not told me before, as she and the rest of the household had made up their minds that I ought not to be disturbed about it. "But last night," she continued, "when the children were attacked, it became my duty to let you know at once. While you were at the opera," she went on, "about half past eight, B. woke up and ran screaming thru the hall to my room, 'Don't let that big ing, as if someone was continually pinching him. In the morning when he woke, he said indignantly to Fräulein, 'Why have you been sitting on top of me.' and when she told him that she had not been sitting upon him, but had been in the bed next to him, he said, 'No, you have been sitting on top of me, and you were awfully heavy, too.'

"Often in the evening, after the children have gone to bed, never until after dark and the lights are lighted, Fräulein and I may be laughing and talking, when all of a sudden we hear the heavy tread of an old man walking slowly and stead-

ily along the hall on the floor above us. It has not been one of the servants, for I have often run up stairs to see, and I have found the whole upper story of the house in darkness, and empty. Sometimes as I walk along the hall I feel as if someone was following me, going to touch me. You cannot understand it if you have not experienced it, but it is real. Some nights after I have been in bed for a while, I have felt as if the bed clothes were jerked off me, and I have also felt as if I had been struck on the shoulder. One night I woke up and saw sitting on the foot of my bed a man and a woman. The woman was young, dark and slight, and wore a large picture hat. The man was older, smooth shaven and a little bald. I was paralyzed and could not move, when suddenly I felt a tap on my shoulder and I was able to sit up, and the man and the woman faded away. Sometimes, after I have gone to bed, the noises from the storeroom are tremendous. It does not happen every night; perhaps a week or ten days will pass, and then again it may be several nights in succession. Sometimes it sounds as if furniture was being piled against the door, as if china was being moved about, and occasionally a long and fearful sigh or wail."

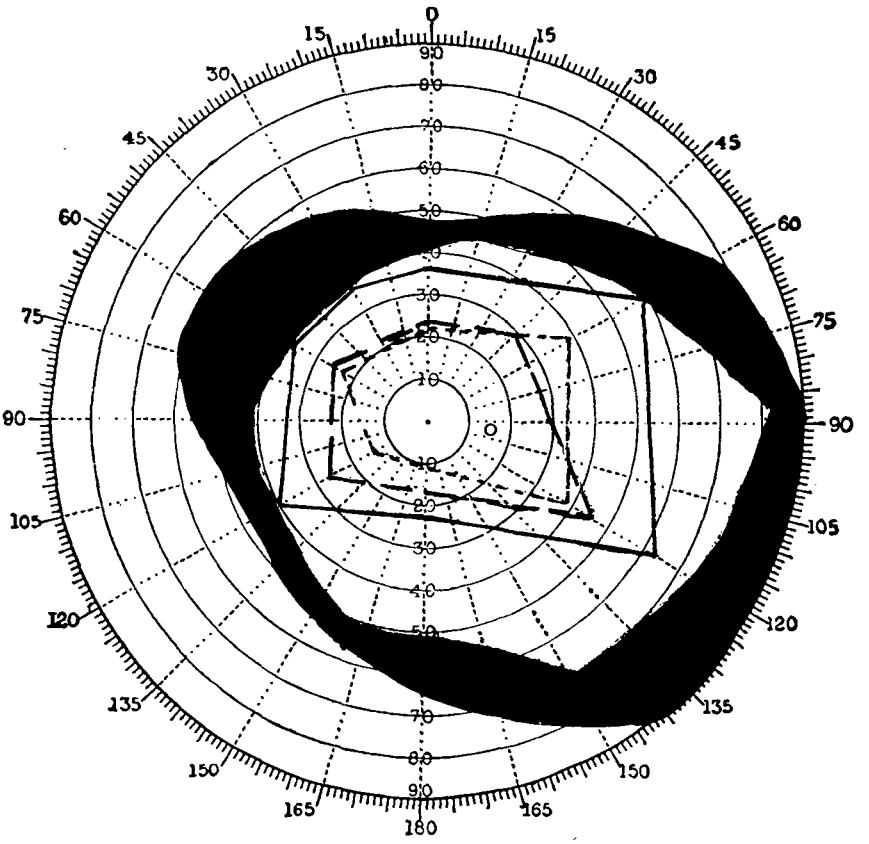

Fig. 5.—Case 1. Right fields, 1919, May 28. Form field, inner edge of black. Field for blue, continuous line. Field for red, line of long dashes. Field for green, short dashes.

The governess, Fräulein Y., then came to me. She also spoke of the heavy footsteps at night—like an old man in overshoes walking slowly along. She also heard the noise in the store-room, the moving and piling up of furniture. She slept in a big, four-post bed, with a canopy. One night, after she had been in bed a little while, she felt the bed shaken, and the canopy swayed. Thinking that a draught from the open windows might be causing the sensation, she

got up and closed them. She returned to bed, and after a short time the shaking of the bed was repeated. Again she got up, examined the room thoroly, but was unable to unearth anything.

I interviewed all the servants in turn. They all had heard at some time or other, tales, we nevertheless felt as if there was a serious aspect to it. Why had all the servants whom we had had for several years, gone practically mad all of a sudden? We began to trace back the history of the house. The last occupants we found had exactly the same experiences

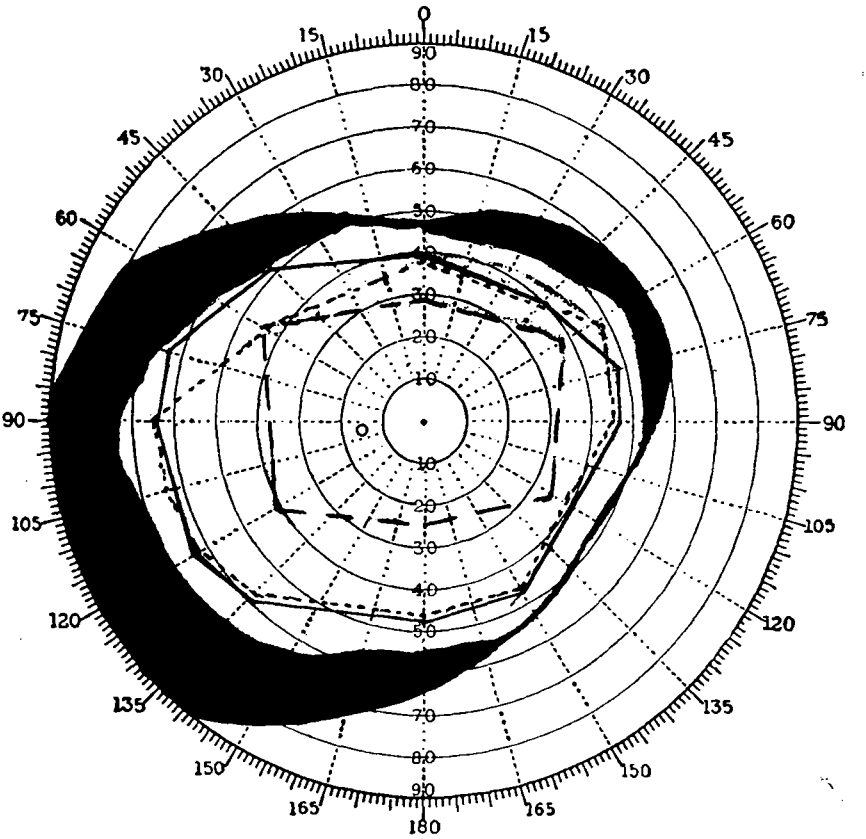

Fig. 6.—Case 1. Left fields, 1919, May 28. Form field, inner edge of black. Field for blue, continuous line. Field for red, line of long dashes. Field for green, short dashes.

the footsteps at night going slowly along the corridor outside of their rooms. Each one at first had thought it one of the others, and was surprised, after inquiring, to find none of them about. They all spoke of strange experiences after they had gone to bed; as if something crept around the bed and then over them, and then they were unable to move. Sometimes it lasted for a long time, sometimes shorter. Not every night, but perhaps every second or third night. It never happened to them all on the same night, but to one and then to another.

Much amused as we were by all these as ourselves, with the exception that they stated that some of them had seen creeping around their beds visions clad in purple and white. Going back still further, we learned that almost everyone had felt ill and had been under the doctor's care, altho nothing very definite had been found the matter with them.

Saturday morning, the eighteenth of January, G.'s brother told us that he thought we were all being poisoned; that several years before he had read an article which told how a whole family had been poisoned by water-gas and had had the most curious delusions and experi-

ences. He advised us to see Professor S. at once. As he was out of town, his assistant, Mr. S., came at once to our house. We told him how listless and ill the children appeared. He found one of them lying on the floor, and the other two in bed. We related the experiences of poisoned. He instantly ordered iron for them, and for the whole household. He also stated that none of us ought to stay in the house another night."

On January 5, 1917, when B. was eight years old (four years after he had been taken from the poisoned house), the

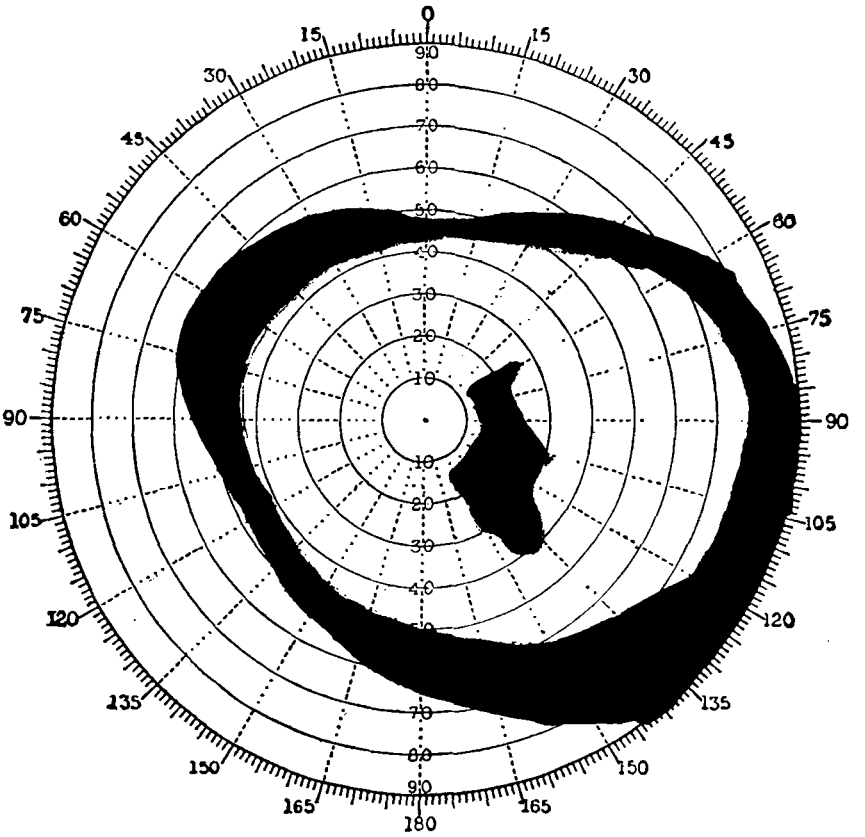

Fig. 7.—Case 1. R., 1920, March 22. Showing paracentral scotoma.

the children and servants, and told him about the plants. He examined the house thoroly from top to bottom and interviewed the servants. He found the furnace in a very bad condition, the combustion being imperfect, the fumes, instead of going up the chimney, were pouring gases of carbon monoxid into our rooms. He advised us not to let the children sleep in the house another night. If they did, he said we might find in the morning that some one of them would never wake again.

Early in the afternoon our physician arrived and examined the children and agreed with Mr. S. that they were being

writer examined the boy's eyes. His mother stated that of all the family he was the only one who seemed to have persistent symptoms following his exposure to the carbon monoxid fumes. In his case there had been some gastric disturbance and anemia. In addition, he did not do well in reading—miscalling letters—altho he was a very clever boy. His adenoids had been removed when he was three years old. Two operations on his tonsils had resulted in their removal. Tho he experienced numerous colds there had never been any recognizable sinus trouble. "About two years previously his eyes had been examined by Doc-

tor Proctor who had found a contraction of the visual fields." (In a recent personal communication Doctor Proctor says, at that time he had in mind hysteria as a cause of the eye trouble.)

Present condition: Externally the eyes were normal, pupillary reactions normal, motility and muscle balance good. The central vision was 20/20+ in each eye, accepting a cyl. +0.25 at 135° in the right and the same cylinder at 45° in the left eye. Visual fields much contracted (Figs. 1, 2). The fundus of each eye was practically normal. The discs, if departing at all from the normal, were a trifle hyperemic. The central color vision was very acute. On April 21, 1917, the patient's eyes were again examined. The tests were practically as at the last examination, three months and a half previous (Figs. 3 and 4).

On May 28, 1919, after a lapse of a little more than two years, his eyes were reexamined. At that time, his general physical condition was reported much better. R.E.V. = 20/40 with cyl. —0.50 at 45° = 20/30+. L.E.V. = 20/30; with cyl. —0.50 at 135° = 20/20+. Color vision still normal. Light sense seemingly a trifle diminished. Visual fields improved (Figs. 5 and 6 fields for form and colors).

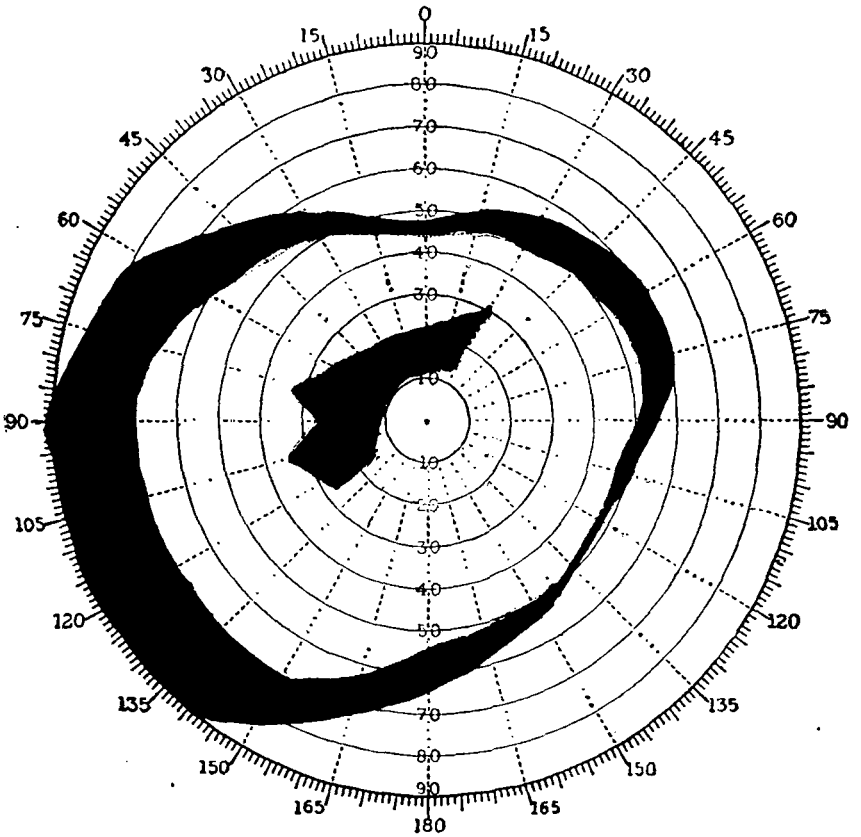

Fig. 8.—Case 1. 1920, March 22. L., showing paracentral scotoma.

On March 22, 1920, B. was again presented for examination. Mrs. H. reported that for the last month his sight had seemed more normal. He had become very fond of reading and voluntarily read a great deal. The central vision and color sense were unchanged since the last examination in May, 1919. The visual fields were much enlarged but there was a marked paracentral scotoma in each eye. Blind spots enlarged. (Figs. 7 and 8 show form fields with paracentral scotomas. Figs. 9 and 10 show enlarged blind spots.)

The patient when first seen by the writer seemed to be recovering from an interstitial inflammation of both optic nerves of the type described as perineuritis by Peter and others. As the ophthalmoscopic changes were negligible, the diagnosis had to depend upon the history of the case and upon the visual

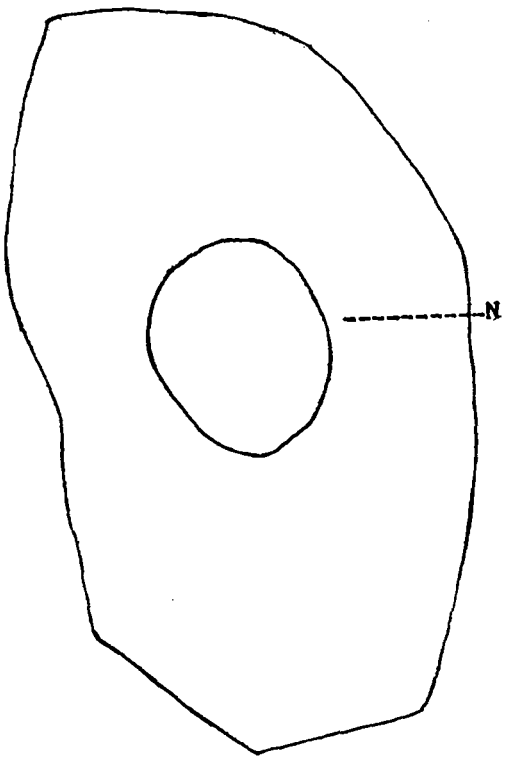

Fig. 9.—Case 1. March 22, 1920, showing enlargement of blind spot Right N. outline for normal blind spot.

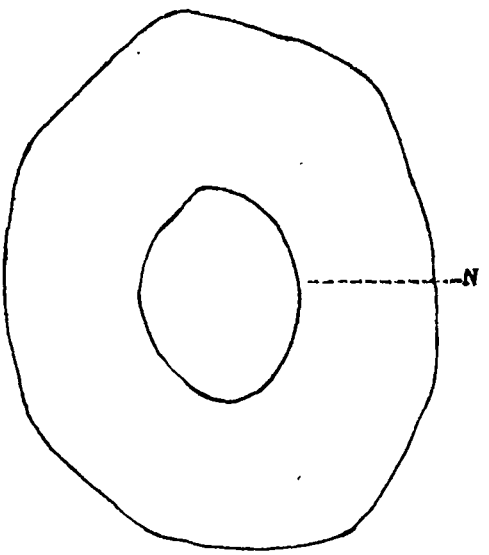

Fig. 10.—Case 1. March 22, 1920, showing enlargement of blind spot in Left. N. outline for normal blind spot.

fields. Nothing apart from the exposure to a poisonous gas could be found bearing a causal relation to the ocular disturbance. On October 1st of this year, Mrs. H. wrote concerning the lad: "He has developed a great taste for drawing and painting. I am sending a few samples of them, thinking they might interest you in regard to the development of his eyes."

The writer is indebted to Dr. J. W. Burke for the notes of the following case. The patient was first seen on September 11, 1920. J. E. B., 35 years of age, well nourished; never had a serious illness; family history good; habits good; used alcohol in moderation and smoked from ten to fifteen cigarettes a day. About May 1, 1920, used a gasoline torch in a closed room, to remove paint from a mantel piece. For about two hours afterwards felt very faint, dizzy and nauseated; did not vomit; had headache; and could not continue the work. These symptoms disappeared in a short time. But two days later, vision became very blurred. This seemed to disappear after lasting two days. On July 1st, he used the torch in the same way in the same room all day and half of the next day; had to stop work several times owing to a recurrence of the symptoms experienced in May. Two days later, the vision again became impaired, and it grew steadily worse for ten days. But since that time, there has been practically no further change in the vision. Patient was carefully questioned about the possibility of having used wood alcohol, quinin, or other toxic substances; but no evidence in regard to such use could be elicited. Had seen several oculists who had pronounced his trouble optic atrophy. R.E.V. = 13/200; L.E.V. = 20/200. Jaeger 14 with difficulty. R.E. pupil 3½ mm. and L.E. 4½ mm. in diameter; reactions present but sluggish. Color sense

very defective. Fields contracted (Fig. 5).

Patient was treated by subconjunctival injections of normal salt solution and increasing doses of strychnin. While under observation, the central vision remained practically the same, tho later, on September 21, there was a slight improvement in the visual fields (Fig. 12).

The neurologic report stated that, apart from the eye condition, there was

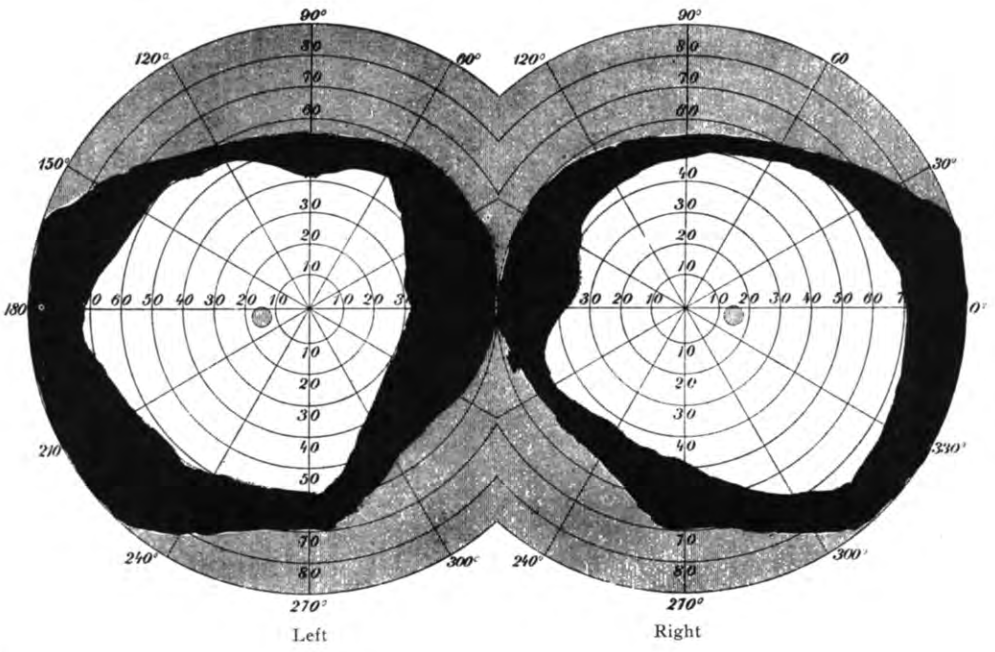

Fig. 11.—Case 2. Form fields, 1920, Sept. 11.

no evidence of an organic lesion of the central nervous system. There was, however, an absence of the achilles reflex as well as a distinct difference between the knee kick and the tendon reflexes of the upper extremities. The examination of the cerebrospinal fluid showed that the Wassermann reaction was negative, but that the protein content had been increased, and there were 20 cells per cu. mm. Examination of the blood negative in all particulars. X-ray of sinuses and sella turcica negative. Examination of feces negative. All other examinations made to discover a possible source of toxemia, were negative.

The exposure in modern life to the influence of carbon monoxid, introduces an additional cause of eye lesions. As carbon monoxide is present in all of the gases connected with domestic and industrial activities, it has possibly been responsible for certain obscure amblyopias that have been attributed to other often quoted chemical substances. And its causal relation may be obscured at times by some other very evident source of toxemia, such as septic tonsils, apical abscesses, syphilis, etc.

It is not of vital importance to the ophthalmologist whether carbon monoxid manifests its serious effects as a distinct chemic poison, or whether it deals destruction purely by its power of quickly depriving the blood of its essential oxygen-carrying power. But it seems to the writer, after much experience with pure oxygen want, artificially produced, that there is much truth in the two opposing theories. On the one hand, the physiologist sees the dramatic effect of carbon monoxid upon the person who takes one whiff of the concentrated gas and falls as if electrocuted; or he is interested in those cases which finally become unconscious after a longer exposure to fumes of lesser strength. Moreover, he

sees the results of experimentation in the laboratory, and he is quite rightly impressed by the effect of this gas upon the oxygenation of the blood. But he does not come in contact with the final consequences of the prolonged, but intermittent, exposures to infinitesimal doses of this gas—results which are of such interest to the clinician. In these cases, the symptoms run the gamut of clinical medicine.

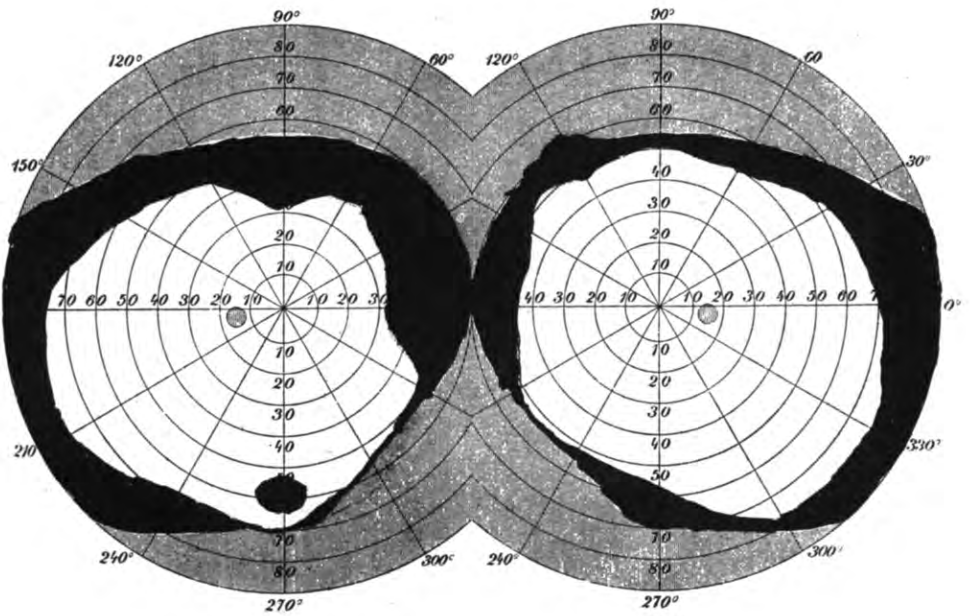

Fig. 12.—Case 2. Form fields, 1920, Sept. 21, showing some enlargement with scotoma in left.

The history of carbon monoxid convinces one that, apart from the effect upon the hemoglobin, it is chemically inert compared with the toxicity of other well-known chemic substances. However, one cannot but feel that after a prolonged attack upon the body tissues, it exerts a deleterious influence which is apart from its purely oxygen-depletion effect—tho the latter does sensitize the delicate structure of the central nervous system.

Carbon monoxid does not show any great predilection for exhibiting its toxic influence upon the optic nerve fibres as a whole, nor even upon the very sensitive papillo-macular bundle which is so markedly affected by alcohol, nicotine, etc. The ocular nerve lesions seem to be due to changes in the delicate structures of the nuclei of origin of these nerves.

However, thru its effect upon the sensitive fabric of the central nervous system, carbon monoxid does cause ocular paralyses, hemianopsias, disturbances of normal pupillary reactions, optic neuritis, and, actually, optic atrophy. Like pure asphyxiation, it is the source of great ocular congestion, and in this way it does cause subconjunctival and retinal hemorrhages; while in the milder cases of carbon monoxid poisoning congestion of the respective cerebral centres causes hallucinations of vision, hearing and touch.

The writer feels that the first case reported is one of optic neuritis due entirely to carbon monoxid poisoning. This seems to be a logical conclusion to draw from the history of the case, the great general disturbance, the very slow recovery, the elimination of every other toxic source, and the recognized susceptibility of children to this gas.

In the second case, carbon monoxid is the probable cause of the optic atrophy, by reason of the very clear history of

ocular and other disturbances that followed each exposure to its fumes, and the exclusion of all other toxic sources.

The treatment seems to resolve itself into remedies suggested by the symptoms, prophylaxis, hygiene, and the legislation that should follow the proper education of the public in regard to the insidious toxicity of this "Frankenstein" of advanced civilization.

BIBLIOGRAPHY

Friedrich, Martin, Dr. Poisoning by Carbon Monoxid. Cleveland Med. Jour., 1910, II, 420

Hall, A. J., Dr. Two cases of poisoning by coal gas from a "geyser," one of which ended fatally with mental symptoms. Lancet, 1910, I, 1467.

Tibbetts, T. M., Dr. Notes on cases of poisoning by carbon monoxid from an unusual source. Public Health, London, 1908-9, XXII, 426.

Reid, J., Dr. A case of poisoning by coal gas. Lancet, London, 1907, I, 1155.

Fleming, R A., Dr. Personal experience of poisoning by charcoal fumes. Edinburg Med. Journal, 1906, XX, 248.

Thompson, W. J., Dr. A case of carbon monoxid poisoning. Tr. Roy. Acad. Med., Ireland, 1904, XXIII, 376.

Ingram, P. C. P. A case of carbon monoxid poisoning. Lancet, London, 1905, II, 1894.

Buchanan, R. J. M. Note on poisoning by carbon monoxid. Liverpool Med.-Chir. J., 1904, XXIV, 271.

Yarrow, T. J., Dr. Chronic carbon monoxid poisoning and carbonyl-hemoglobinuria; the latter a hitherto undescribed condition. Reprint from Amer. Med., Phil., 1902.

Ringer, A. I., Dr. Studies on the effects of carbon monoxid poisoning. Proc. Soc. Exper. Biol. & Med., N. Y., 1908-9, VI, 68.

Banerjee, K. P. My story of a demon; carbon monoxid gas; my punishment for want of foresight. Indian Med. Gaz., Calcutta, 1902, XXXVII, 373.

Redmond, T. O'C. Carbon monoxid poisoning. Med. Press & Circ., London, 1902, LXIV, 261.

Wood, Casey A., Dr. Toxic Amblyopias. American Encyclopedia of Ophthalmology, XVI, 12719-12800.

Henderson, Yandell, Professor. Carbon monoxid poisoning. Jour. A. M. A., July 1, 1916, LXVII, 1-5, Aug. 19, 1916, LXVII, 580-583.

Ibid. How Much Gas Can You Breathe? Popular Science Monthly, Aug., 1920, Vol. 97, No. 2, 19-22.

McGurn, Wm. J., Dr. Chronic Carbon Monoxid Inhalation and Some of its Untoward Results. Boston Med. & Surg. Jour., Feb. 15, 1917, CLXXVI, No. 7, 231-235.

Apfelbach, G. L., Dr. Carbon Monoxid Poisoning. Diseases of Occupation and Vocational Hygiene. Kober and Hansen.

Massanek, Gabriel, Dr. Polyneuritis in Folge von CO Vergiftung. Pest. Med. Chir. Presse, Budapest, 1903, XXXIX, 965

Schaffer, Dr. Uder eine noch nichtbeschrieben Veränderung des Nervenmark. Centralbl. f. Nerven u. Psychiat., Berlin u. Leip., 1903, XXVI, 485.

Edsall, David L., Dr. Carbon Monoxid Poisoning. Osler's Modern Medicine, Vol. II, pp, 388-392.

O'Malley, Mary, Dr. A Psychosis Following Carbon Monoxid Poisoning with Complete Recovery. Am. J. Med. Soc., CXLV, 855.

Darling, H. C. R. Bath Heater Poisoning. Med. Jour. of. Australia. 1908, II, 181

Yarrow, T. J. Jr., Dr. Chronic Carbon Monoxid Poisoning with Report of an Illustrative Case. N. Y. Med. Jour., 1900, LXVI, 496.

Lind, C. J., Dr. Symptoms and Treatment of Coal Gas Asphyxiation. Nor. West Lancet, Minneapolis, 1902, XXII, 70.

Nasmith, G. G., Dr., and Harrison, F. C., Dr. Carbon Monoxid Poisoning. Jour. Exper. Med., Lancaster, Pa., 1910, XII, 282-287.

Hoke, E., Dr. Ueber die Aufnahme des Kohlenoxyde durch das Nervensystem. Arch. f. Expere. Path. u. Pharm., Leipzig, 1906, 7, LVI, 201-206.

Izard, L., Dr. Des troubles nerveux consecutifs aux intoxications oxycarbones. 8 Lyon, 1907.

Brown, Sanger, Dr. Psychoses Resulting from Coal Gas Asphyxiation. Jour., A. M. A. April 28, 1906, Chicago, XLVI, 1205.

Hamilton, Alice, M.D. Inorganic Poisons, other than Lead, in American Industries. Jour. of Industrial Hygiene, Vol I, No. 2, 89.

Van Slyke, Donald D., Dr., and Salvesen, Harold A., Dr., The Determination of Carbon Monoxid in Blood. Jour. Biol. Chem., Nov., 1919, 40, No. 1, 103-107.

Fieldner, A. C., Teague, M. C., and Yoe, J. H. Protection Afforded by Army Gas Masks against Various Industrial Gases. Jour. Indust. and Engin. Chem., July, 1919, II, No. 7, 622-623.

Lamb, Arthur B., Bray, William C., and Frazer, J. C. W. The Removal of Carbon Monoxid from Air. Jour. Indust. and Chem. Engin., March, 1920, 12, No. 3, 213-221.

Rutherford, W. J. Carbon Monoxid Poisoning in Warfare. Lancet, Jan. 24, 1920, 198, No. 5030, 184-188.

Balthazard, V. Present Ideas of Carbon Monoxid Poisoning. Bull. de l'Acad. de méd. April 8, 1919, 41, No. 14, 439-441.

Munroe, H. S. Physiological Effects Carbon Monoxid. Amer. Jour. Pharm., 1912. LXXXIV, 401-404.

Fuchs. Text Book of Ophthalmology. Edited by Duane, p. 754.

Norris and Oliver., Drs. Article upon The Toxic Amblyopias, by de Schweinitz. System of Diseases of the Eye, Vol. IV, p. 831.

Weeks, John E., Dr. Diseases of the Eye. p. 561.

Love, Edward G., Dr. Impurities in Gas. Vol. I, p. 360-365.

Hart, William F. Laws relating to Gas Companies in the District of Columbia.

Translation of List of Industrial Poisons by Dr. Wm. H. Rand, from list prepared by Prof. Dr. Th. Sommerfeld and Dr. R. Fisher, and Edited by Permanent Advisory Council of Hygiene of the International Association for Labor Legislation. Published in Bulletin No. 100, Bureau of Labor, Washington, D. C., 1912.