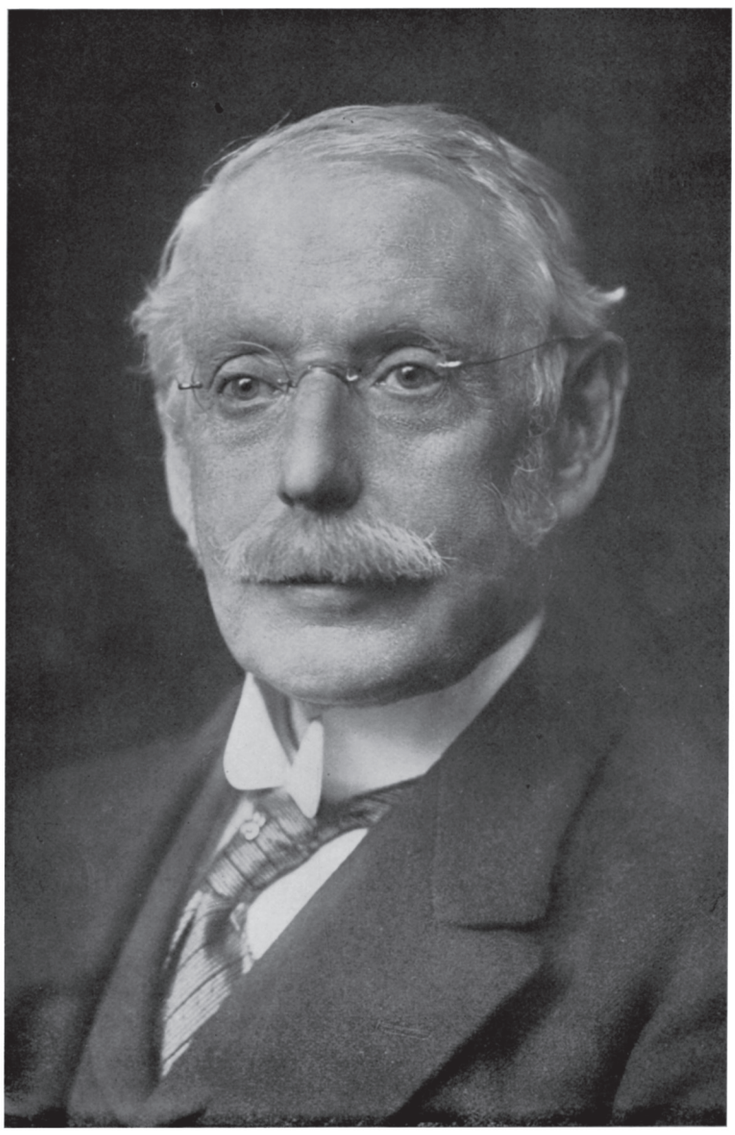
SCIENTIFIC PAPERS AND ADDRESSES OF THE HON. SIR CHARLES A. PARSONS

PLATE I



THE HON. SIR CHARLES ALGERNON PARSONS, O.M., K.C.B., F.R.S.

SCIENTIFIC PAPERS AND ADDRESSES
OF
THE HON.
SIR CHARLES A. PARSONS
O.M., K.C.B., F.R.S.

With a Memoir by
LORD RAYLEIGH
and Appendices

EDITED BY
THE HON. G. L. PARSONS

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NOTE BY THE EDITOR

There is given as an Appendix to this volume a complete list, as far as is known, of Sir Charles Parsons' papers from 1885 onwards. From this Collection a fair number of the papers have been omitted in order to avoid reduplication, and for the same reason, amongst others, parts of some of the papers have been left out. It has not been thought necessary to state in each paper where omissions occur, but where it seemed desirable the nature of the matter contained in the deleted part has been briefly indicated. Some repetition has been found unavoidable.

In only a few cases have papers of which Sir Charles Parsons was part author been included in this volume.

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PREFACE

Sir Charles Parsons, owing to the position which the steam turbine had taken in the world, was much sought after as a speaker or lecturer at public meetings. It cannot be said that he was a good speaker for he was always hampered by a diffidence, amounting almost to shyness, before an audience. But as the author of the greatest mechanical invention of the nineteenth century he was always welcomed and respected, and as he had often something new to reveal he was listened to with attention. Hence, willy-nilly, he was called upon to deliver a great many papers and lectures. At the express wish of Lady Parsons, a selection from these published writings has been made and is here presented.

The first part of the volume is devoted, principally, to papers and lectures dealing with the development and progress of the steam turbine. In making the selection repetition has been avoided as far as possible, and in consequence only a few of the papers are complete. In the second part three lectures on the famous research into the artificial manufacture of diamonds are reprinted in full. They give a complete record of a task which occupied Sir Charles, on and off, for many years.

A third part contains three appendices, of which the last is a list of all Sir Charles' published writings. The other two deal with subjects about which no written records of speeches or addresses remain, but which, nevertheless, it seemed proper to include in this volume. The first describes the Auxetophone, that wonderful air-valve-operated "loud-speaker" on which Sir Charles spent many laborious nights. The monograph was written by the late Mr A. Q. Carnegie to whose devotion, it might almost be said, the saving of the instrument from oblivion is due. This is not the place to speak of Mr Carnegie's attachment to Sir Charles throughout many years and the valuable part he played in the progress of the steam turbine, but it is fitting to express here profound regret that he died before this little tribute to his great master was in type. The second appendix deals with optical glass, the manufacture of which was kept alive in this country largely through Sir Charles' exertions. For the notes upon which it is based thanks must be given to Mr R. S. Campbell, Mr S. M. Morrison and Mr C. Young.

Finally, I desire to thank all the institutions and societies which have courteously permitted extracts to be made from their transactions; my cousin, Mr Arthur Parsons, for the help and advice he has given me throughout; and especially Mr Loughnan St L. Pendred, whose experience in the

preparation of text for the press and in the reading of proofs has greatly lightened the work of editing.

But I must not conclude without a final word. Lord Rayleigh has increased the value of this Collection incalculably by a delightful memoir which gives a real picture of Sir Charles as Engineer and Scientist, and also as one who loved the countryside and was the most courteous and kindly of hosts. The memoir was written by Lord Rayleigh at the wish of Lady Parsons, and one cannot but feel that she would have endorsed every word of it had she been spared to see it.

GEOFFRY L. PARSONS

FOREWORD

In offering this collection of papers of the late Honourable Sir Charles Parsons, it is with the hope of helping the interested reader to appreciate the genius, the perseverance, and the indomitable courage of Sir Charles. These were the qualities which carried him through the early days of difficulties and discouragement; through the days of hope and of bitter disappointment, such as when success seemed within grasp only to be foiled by the calamitous wrecks of the *Viper* and the *Cobra*; the bitter grief and sorrow brought him by these disasters; and, finally, to the days, in later years, of brilliant achievement and recognition.

It needed the collaboration of a great scientist to emphasise the distinguishing features in the work of a great engineer. To meet this need Lord Rayleigh generously undertook to write a preface to the papers of his old friend. A preface by so distinguished a scientist will add greatly to the interest of the papers.

Our thanks are also due to the Honourable G. L. Parsons who has undertaken the collecting and sorting of his uncle's papers, a task that entailed nice discrimination and sound judgment.

KATHARINE PARSONS

RAY DEMESNE
KIRKWHELPINGTON
NORTHUMBERLAND

10 *August* 1933

SOME PERSONAL REMINISCENCES OF SIR CHARLES PARSONS

By Lord Rayleigh

I am proud to have, by Lady Parsons' wish, the opportunity to write a few personal recollections and comments by way of preface to the collected writings of my great and lamented friend, Sir Charles Parsons.

For a connected account of his life, reference will naturally be made to the biography by Mr Rollo Appleyard,* who has admirably worked up the available material. There is, however, very little on record about Parsons' intimate life—in fact, he lacks a Boswell. I am far from pretending to fill the gap; yet, as I was better placed than most, it would be a pity to let slip the opportunity of recording such recollections as remain, notwithstanding that they are somewhat disconnected and only cover a small part of his life and activities. I shall supplement them with recollections by some others of his friends and fellow-workers.

The early struggles of Parsons' career were over at the time when I first got to know him, which was at a garden party at Sir George Darwin's house at Cambridge, when the British Association met there in 1904. He had come through into smooth water, but occasional remarks showed how much he had endured. Thus, apropos of the habit of smoking, he remarked how soothing he had found it at a time of acute financial anxiety. This referred, no doubt, to the litigation over his patents. He appreciated the sympathetic advice of his counsel, Fletcher Moulton,† at that time.

In his address to the Engineering Section of the British Association (1904), he says, "Even in our time I scarcely think that anyone would venture to describe the lot of the inventor as altogether a happy one," and no doubt he was speaking from experience. The young inventor in the commercial world is often regarded as a sort of revolutionary, who wishes to upset vested interests, and many people's hands will at first be against him. Like the political revolutionary, he is apt to be regarded as a dangerous nuisance before he succeeds, and only becomes a hero afterwards.

Parsons' problem had been in many respects one of peculiar difficulty. As Mr Turnbull has well remarked, the turbine was naturally best adapted for large sizes, but had necessarily to be developed through the small sizes, when the reciprocating engine already held the field and was very suitable.

* *Charles Parsons*, Constable, 1933.
† Afterwards Lord Moulton of Bank.

There can be little doubt that even among his friends many wise heads were shaken over his determination to pursue its development.

After the Cambridge meeting, I came across C. A. P. on several occasions and the friendship ripened. My first visit to him at Ray, his shooting lodge on the Northumberland Moors, about twenty miles north-west of Newcastle, must have been about 1910 or 1911. I came from the South and he intercepted me at Newcastle, where I had intended to change into the local train, welcomed me kindly, strapped my luggage on to the back of his car, and we motored out. The journey of some twenty miles was not without some psychological interest. Parsons was a severe critic of the drivers of cars that we passed, and called out his criticism in emphatic language. His voice, however, had not much carrying power, and this circumstance may not have been altogether unfortunate. People could not resent what they did not well hear, and if they attempted to reconstruct it for themselves they very likely thought that they had been deceived and that such strong words could not have come from one whose aspect was so mild and benevolent. Sometimes he expressed his protest by blowing his horn, and would continue to blow it for a long time afterwards, much to the surprise of the passers by, who had not seen the earlier phases of the incident.

Ray was at that time as now a house of moderate size and rather lonely situation, but possessing considerable charm and all the essentials of comfort. There was grouse shooting and trout fishing on the loch known as Sweethope, a place of some historic interest as the scene where the Northumbrian rebels of 1715 assembled and pledged their faith to one another. Parsons was fond of both kinds of sport, and he liked the fishing all the better in that he used a motor boat, which frequently refused to work, and gave him the congenial task of dealing with its deficiencies. In the motor boat there was always kept a jar of feathers, and when fishing was done these feathers were used to clean the sparking plug, an operation which was always performed several times during the afternoon.

His sanctum was not without character, and deserves description. There was a writing-table in the window and occasional letters were written there, but not very systematically and for the most part late at night. He never dictated letters. The house-maids were strictly forbidden to touch anything on his writing-table, though Lady Parsons sometimes came in and removed cigarette ends, burnt-out matches, and the like.

At one side of the room was a cage containing a large white cockatoo, and I, for one, must confess to having found its contributions—or rather, interruptions—to the conversation most inharmonious. But Parsons did not seem to be conscious of this. He would get up and placate it with soothing words and with sugar. The cockatoo went to London with him during the winter months.

On the central table was a litter of books and papers—perhaps a number of *Engineering* or *The Engineer*, another of the *Proceedings of the Royal Society*, a copy of the Apocrypha which (oddly enough) was a favourite study with him, and one or two novels, together with pipes and tobacco. *The Pickwick Papers* was a great favourite, and he read it repeatedly. So was P. G. Wodehouse. He liked reading detective stories and "shockers" but I do not think he troubled much to appraise their merits. There was nothing in the way of fixed bookshelves in the study, but a few books were carelessly thrust into a cupboard on one side of the fireplace. Among these were Smiles' *Lives of the Engineers*, some of Rudyard Kipling's works, and a few miscellaneous books on shooting and fishing, and others on scientific subjects.

I never saw anything like an adequate collection of books of reference in any of his houses or in his room at the Works, and I was never able to understand where he turned to for information. It may be suspected that when he wanted it, he simply directed some member of his staff to get it for him. At any rate, he never seemed to suffer from want of being properly informed about any subject which it concerned him to know. He got the necessary knowledge somehow.

To return, however, to the arrangement of his study. On the mantelpiece was a barograph, but the usual printed charts were lacking, and a piece of plain paper on which there were several previous traces would do duty instead. Beside it there lay for many years a unique tobacco pipe, with the bowl made from a stone with a hole in it, which had evidently been picked up. The stem was an ordinary one, introduced into a side hole in the bowl. The temperature in September at Ray, high up on the Northumberland fells, was rarely high enough to be comfortable without a study fire, even in the morning. But Parsons usually lighted it himself, and "drew" it up into a blaze by means of a sheet of newspaper held over the upper part of the opening. He never seemed to be bored with doing this—in fact, he apparently enjoyed it.

In one corner was a gorgeous casket* in which he had been presented with the freedom of the City of Newcastle, and over the mantelpiece was a painting by B. Gribble of the ornate ships of the Spanish Armada. Contrasting with the leisurely dignity of these were photographs of the *Turbinia* cutting her way through the water at full speed, which were hung on the walls. So also were photographs of cavitation produced in the experimental propeller tank at Wallsend, or, perhaps, in the small tank at Holeyn Hall.

If any serious engineering studies were made at Ray, this was not obvious. I never remember seeing a slide rule or a book of logarithms

* This however was later than the date of my first visit.

lying on C. A. P.'s table; and my impression is that he never used either, then or elsewhere, preferring to rely on the multiplication table. Nor, so far as I can recall, were there any engineering drawings or blue prints. Probably, however, he made rough calculations and sketches at home, and took them to the draughtsmen at the Works to be elaborated. On the other hand, mechanical models made of cardboard or paper with corks, cotton reels, knitting needles, wire, sealing wax and string were in evidence, and if a mechanical point were under discussion, he would insist on its being explored and any suggestion being put to the proof, as far as possible in this way. It was much more congenial to his habit of mind to test a question by experiment than by abstract reasoning or calculation.

The practice of making paper models of this kind goes back to very early days. A Cambridge contemporary who wishes to remain anonymous writes:

"He and I were fellow-oarsmen in the Lady Margaret 3rd boat in 1876, and in the first in 1878; it was the custom in those days during the period of training for the members of the crew to breakfast in each other's rooms on alternate mornings, and after breakfast in Parsons' rooms he said, 'Look here, you fellows, I have an engine here which is going to run twenty times faster than any engine to day.' 'Rot!' was the reply; however, on moving towards a side table in the room, there was a 'toy' paper engine into which Parsons blew and the wheels simply flew round, but to show further our contempt we put Parsons and his engine under the table."

On a small table in the study were laid out a few tools of the simple kind which may be bought at the humblest ironmonger's shop. There was no workshop at Ray. At Holeyn Hall, C. A. P.'s earlier home, there was one. I never saw it, but have been told that the lathe and tools were very much neglected, being allowed to get covered with rust from the acid fumes used in his experiments on diamonds.

I can recall many interesting conversations in this room at Ray. We discussed on one occasion the supposed secret possessed by the ancient Egyptians of hardening bronze to a cutting edge. Alan Campbell Swinton, who was present, mentioned a disagreeable legend that bronze swords were hardened by heating them red hot, and holding them against the back of a living slave; but Parsons brought the subject down to earth by remarking that when he spent a winter at Assouan in 1909 he had taken trouble to obtain specimens of ancient bronze chisels, and had found that they had nothing beyond the ordinary degree of hardness that can be attained by cold working.

Once, when he was alone with me and in a confidential mood, he spoke of the disaster of H.M.S. *Cobra*, one of the first destroyers to be fitted with turbine engines, which broke in half in a heavy sea on her voyage south

from the Tyne in 1901 under the command of a Naval officer but with some of Parsons' men on board. Parsons was emphatic that the turbine machinery was not in any way the cause of the disaster. His information was, that in the course of the voyage, the deck plates of the ship showed alarming signs of distress and that representations were made to the commanding officer, who declined to listen, as sailors are apt to do when landsmen try to interfere. "If I had been there," said C. A. P., "I would have raised a mutiny and brought her into port"; and his words carried conviction. He was no boaster. Another remark which he made apropos of difficult and dangerous situations should not be suppressed, though it runs counter to the cherished notions of many excellent people. It was that men who were occasionally given to drink had often proved the most helpful to him in emergency. This he connected with a certain recklessness of character which made them willing to take risks in order to save a situation.* "They don't care a damn" he said.

The way in which C. A. P. himself reacted to a difficult situation is well illustrated by a story told by Mr James Denny. "A preliminary trial trip of the *Viper* was made early in the day, and the bearing of the engineers was ominous. They differed with Mr Parsons as to the trial trip rate of wages, and, as the latter knew his own mind, the engineers walked off the ship. Everyone thought that the day's proceedings must end there and then, but Mr Parsons thought otherwise. He turned on his apprentices to do journeymen's work, picked up some men off the quay, borrowed some more from Messrs Hawthorn Leslie and Co., who had the contract for the hull and boilers, and made all into a scratch crew for the trial trip. Under these extraordinary circumstances the *Viper* ran her trial,† and on that day did the unparalleled speed of 37 knots. When Mr Parsons emerged from the engine room, dirty and warm, all crowded round him to congratulate him, but he took the whole thing as a matter of course."

The difficulties which had to be met in the development of high speed propellers were by no means limited to those which were inherent in the problem. Skilled workmen do not like experimental work. The men employed to file up the early high speed propellers felt much disgusted when they were brought back to the shop for alterations. They had a feeling at the back of their minds that their work was being wasted: it was generally agreed that a slow speed propeller was the thing for efficiency. The men may have known or guessed this, and they perhaps thought that Parsons was following a will-o'-the-wisp. Moreover, he was not always

* In these controversial matters, I merely repeat the substance of what Parsons said to me, without making any attempt to weigh what might be said against his view.

† I.e. actually the official Admiralty Trial.

reasonably patient with them when they were doing work to which they were not accustomed. Thus, I have it from Mr C. Turnbull, M.I.E.E., that when the rotor for the *Turbinia*, which was the first to have long blades, was under construction, the turner who was turning up the blades took too heavy a cut, and the blades were bent over. When Parsons came into the Works and saw what had happened, he boiled over, and dismissed the unfortunate workman on the spot. This was probably unjust, but it must be remembered that he was naturally temperamental, and that he was living and working at that time under conditions of great strain, financial and otherwise.

This incident brings to mind another of much later date when a workman whom he personally wanted early in the morning was not forthcoming. Parsons became more and more impatient, and when the man ultimately arrived half an hour late he said "You're fired" and would not hear a word in mitigation or excuse. However, a member of the engineering staff insisted on stating the man's case, which was that he had been sitting up all night with a sick wife. Parsons was filled with remorse, decreed that the man's wages were to be increased five shillings a week, and personally called at his home with presents of grapes and other delicacies suitable to an invalid.

I have been tempted to digress somewhat widely from the subject of my own intimate conversations with C. A. P. To return, he once said that the bow of the archer was an admirable contrivance from the point of view of mechanical design. The only part which moved rapidly was the string, which had a negligible mass. Thus little of the energy of the bent bow was wasted in giving velocity to the moving parts of the bow itself, and nearly all went to give velocity to the arrow.

Again, he spoke of his apprenticeship at Elswick and of the first Lord Armstrong, for whom he had a great admiration. Some trouble being experienced with a new device, Parsons asked the foreman of the shop what progress had been made. The answer was "That will soon be all right. He [Armstrong] is attending to that himself." It was not considered prudent, C. A. P. said, to disturb Armstrong when he was grappling with a difficulty. Anyone who was rash enough to do so was likely to regret it.

Mr Appleyard (p. 27) quotes a testimonial received by Parsons from W. G. Armstrong & Co. Nevertheless, it may be doubted whether he was fully appreciated there. His action in taking out a patent was strongly resented by one of the directors, who maintained that he had no right to use material and time belonging to the firm for developing an invention for himself. At that time the doctrine that all such inventions belong to a firm had not definitely crystallised out. The directors were not perhaps predisposed in Parsons' favour by his habit of experimenting with rockets,

which sometimes resulted in shattering explosions under the windows of their luncheon room.

I have heard him, too, on the subject of his auxetophone or "bellow-phone" as it was colloquially called, used for amplifying the sound of the violin or 'cello. He never made it very clear to me why this invention was dropped. In one mood he seemed to suggest that it was from opposition in the musical world, conceived in a narrow trade-union spirit with which he had no patience. At other times he seemed sympathetic to those who feared loss of employment by the introduction of this instrument, many of whom had written appealing letters to him. It may well be, however, that he was rather tired of negotiating about it, having bigger things on hand.

On another occasion, the Mediaeval Cathedrals regarded as engineering structures were discussed, and someone said that they were an instance of how little practical engineering construction was indebted to formal theory, for they were built before any such theory existed. "I quite agree," said Parsons; "theory is not used in doing the thing. That is put in afterwards to make it look pretty."

It was, in fact, very curious how little use he ever seemed to make of the formal mathematical training he had had at Cambridge. He had been 11th Wrangler in the Mathematical Tripos, and must be credited with having had at one time a thorough mathematical knowledge and facility in using it. At the time I knew him, however, he never allowed this to appear. I do not think that I ever saw him use any mathematical method more complex than the rule of three. If he was invited to listen to anything a little less simple, he always turned it off by saying that his mathematics were rusty. "That is analytical," he would say, "I like something geometrical. I never was very good at analysis and now I have forgotten what I once knew." It was difficult to feel sure how far this could be taken literally, but it is certain that he had no liking for symbolical methods of expression, and seldom, if ever, used them in his published papers. All his turbine calculations, he said, had been made in terms of successive small expansions only, and no use was made of integrated expressions for the work done by the expanding steam. He even affected to regard the use of atomic weights and molecular formulae to determine combining proportions, as a thing beyond his ken.

Later on in his life, he would simply hand a numerical problem to his staff to be dealt with. He took no interest in the mathematical reasoning used by them; he only wanted the result. I never heard him on the subject of entropy, but Lord Falmouth tells me that the mention of it used to fill him with a curious indignation. Apparently he regarded it as a useless mystification. However that may be, he did not object to his staff employing

it if they saw fit. Although Parsons did not make use of any formal methods of calculation, he seemed to have a kind of subconscious way of arriving at conclusions for which most people would have found such methods indispensable. Needless to say, he could not explain how he did it—but then he equally failed to explain with any lucidity things which, to the ordinary observer, were much less mysterious.

The Newtonian system of mechanics was, so to speak, part of his religion, and when Einstein and his followers proposed to modify it, Parsons was, I believe, torn by a painful embarrassment. On the one hand, he could not but see that the position of the relativity theory was very strong in that it had quantitatively predicted facts which observation confirmed. When this was pointed out, he did not seriously attempt to dispute it; but he showed that he was not happy in giving up the familiar mental images which he had made his own for others which seemed so vague and elusive. I think it was always a surprise to him that people whom he regarded as much more learned than himself, and who doubtless had academic knowledge which was outside his province, could by no means see with his own sure intuition the way through a mechanical difficulty, and the conditions of success in overcoming it.

The attempts at artificial production of diamonds occupied a large share, perhaps an unduly large share, of Parsons' life work. Contrary to what has sometimes been supposed, he took up this problem from a purely scientific standpoint, and not with a view to manufacturing diamond dust as an abrasive; though, in the event of success, this aspect must ultimately have received attention. His investigations on this subject range over more than thirty-five years, from 1888 onwards. The original idea of melting carbon under the highest temperature and pressure was thoroughly tried out and also the solidification under pressure of carbon dissolved in molten iron, no expense or effort being spared. Dr Stoney estimates that £30,000 was spent on these experiments. Parsons remarked to him, "We have now made a bit of money, and deserve to have some fun." The ultimate results, however, were wholly negative.

Parsons had, in no small degree, the traditional British quality of hating to be beaten, and in this instance it seemed to lead him too far. It was difficult to see much prospect of success in some of his later experiments, in which great trouble and expense were incurred to carry out elaborate furnace operations *in vacuo*. I believe this view was shared by several of his friends, myself among them, but if any of us ventured to press it on him he would only reply, "I think it ought to be tried." It was not perhaps surprising that he should rely on his own judgment rather than on the judgment of others. In his youth the prospect of constructing an economic rotatory engine was generally considered visionary. Innumerable

inventors had attempted it from the time of James Watt onwards; but in the face of all scepticism Parsons had shown the engineering world that he could succeed where others had failed. Parsons' persistence in the research on diamonds was no doubt encouraged by the reported positive results of Moissan and Crookes, which had long been generally accepted in this country. After Crookes' death some of his specimens came into Parsons' hands; he tested them, and came to the conclusion that they would not burn in oxygen and therefore could not be diamonds. So far as I am aware, this result has never been made public. He also explored the ground in Paris and tried to get on the track of Moissan's specimens: but he could not learn that any such had been preserved. He found moreover that some of Moissan's old colleagues did not feel any confidence in his results, though (one may suppose) they had for a time naturally shown some reticence on the subject.

During my visits to Ray, I often went with Parsons to his Works at Heaton and at Wallsend, and lunched with him and his staff at the former place. So far as I saw on the occasions of my visits, he did not work much in his own room there. This had a rather neglected aspect, and indeed, though he must have roughly sketched specifications of patents and written out the papers that were published by the various engineering and scientific societies, I never saw him doing it, nor got any insight into his methods of composition. He showed me the manuscript of his Presidential Address to the British Association (whether typed or not I do not remember) and asked for criticism. I pencilled what seemed to me slight verbal improvements in a few passages. These he professed to adopt; but I was amused to observe that when the address came out, the suggested alterations had been deleted and the original wording restored. This was an example of a trait in him that others have noticed. Lord Moulton, who had the greatest admiration for Parsons, remarked that he might seem to be impressed by what was said to him, but, often enough, quietly retained his original opinion.

Lady Parsons remembered once finding him in his own room at the Works reading the newspaper. This struck her as so unusual that she was moved to wonder what was wrong. It appeared that things had come to his notice which forced him to conclude that the organisation of the Works was seriously amiss, and he was painfully perplexed as to what to do about it. Reading the paper, one may suppose, served as a sort of mental anodyne, while the problem was being battled with subconsciously.

He once remarked to me—apropos not of any one in particular, but of the selection of his right-hand men generally—that it was hard to find anyone under 50 years old who was much good. It is fair to observe,

however, that he was over 70 himself at the time. At an earlier date he would perhaps have put the limit rather lower.

Parsons, like most inventors, was alive to the importance of secrecy in matters which were not protected by patents. In the early days, when he was interested in the manufacture of carbon incandescent lamps, a carbonaceous mixture containing sugar was in use for making the squirted filaments, and, for fear someone should taste it, and learn the secret, the bottle was labelled ARSENIC. The same spirit was observable at Heaton Works. Thus, when C. A. P. had shown me a wooden pattern of his latest design of propeller and explained his notions about it, he said, "It will not do to leave it about where everyone can see it," and, so saying, he hid it away behind the books in the bookcase.

Again, at my first visit, I was given to understand that no one was ever admitted into the department where searchlight mirrors were made, and when I inadvertently got too near the subject in conversation, I was gently warned off. At a later visit, this embargo was removed, and I was offered the opportunity of seeing everything. I gathered from the staff and from Parsons' manner that this was a high favour. The main secret has long since leaked out, that the mirrors were made from plate glass by softening it at a moderate heat and shaping it to a paraboloidal metallic former. It was then carefully annealed. The mirror thus made was ground and polished on a machine by a comparatively small tool, the surface of the glass itself serving as a guide. The general shape given in the moulding process was not seriously interfered with in the grinding and polishing. Parsons had recently examined the annealing process, and had determined by the permanent bending of a glass thread what was the temperature at which it became plastic. This investigation pleased him very much by its simplicity and showed the way to a considerable economy of fuel in the annealing process. To amuse visitors he liked to bring one of the largest (60-inch) mirrors out into the sunlight, and ignite a large piece of wood at the focus.

Parsons was a singularly modest man, and did not seem at all to realise his own standing in the world. I believe he appreciated the distinctions which were conferred upon him but did not draw the obvious inference, or at any rate did not keep it in mind. His want of self-assertion was at times almost comic. Thus, when he went to the International Astronomical Union at Rome in 1922, he failed to receive the customary invitations to the various receptions. He seemed to think that this was a sign that he was not appreciated, and was much hurt. He did not think proper to take any action, and returned home only to find the missing invitations awaiting him there! Again, he has been known to listen to a ship's engineer explaining the action of a steam turbine without giving the slightest hint that he had ever heard of such a thing before! In some people, silence under such

circumstances might have been taken as rather disagreeable and sardonic. In his case, it was simply an indication of a very retiring disposition. Nevertheless he was not always prepared to be silent when he did not agree. On one occasion he fell into conversation at the Northern Counties Club, at Newcastle, with a naval officer, the only other diner. "Who is that contradictious old gentleman?" the latter asked afterwards. "He seems to think he knows more about the engines of my ship than I do myself." It is a safe guess that he did know very much more.

C. A. P. was at times absent-minded in the affairs of everyday life. This was attributed by his friends and neighbours to his being absorbed in thought. In matter of dress he was as a rule fairly tidy, but with occasional lapses. Thus, invited to meet his Sovereign at a great house, he created some surprise by coming down to dinner without a tie: and other incidents of a similar kind could be recalled, if it were thought worth while. But one of the most amusing instances of his absent-mindedness was shown at the house of his neighbour Mr Joseph Straker. It was the custom of the house to collect scraps from the breakfast table, such as fragments of bacon, bones, leavings of bread, porridge, and the like, in a pie dish, and to cover it with milk and gravy for the dogs. C. A. P. came down late, after most of the other members of the party had finished, and the customary collection of scraps had been made. He was observed to go to the side table, help himself from the dog's dish, eat his way steadily through what he had taken and come back for more!

He had a strong dislike of adopting any contrivance from foreign engineering design. His staff were sometimes compelled to adopt unsatisfactory alternative expedients in order to fall in with this sentiment. He would be told that a foreign firm met the difficulty in such a way. "Very well, then," he would say, "let's do something different." This instinctive dislike of conventionality in the way of doing things was often to be seen. Lady Parsons remembered that their daughter, Miss Rachel Parsons, when about 15 years old brought home a mathematical problem which she had solved, but for which marks had been denied her, because the solution was not considered orthodox. C. A. P. followed her solution and approved it. He went on to complain that school teachers were always "down" on any originality of thought, and discouraged their pupils from wasting time on what they called "useless" experiments.

During the war I frequently sat with Parsons on committees at the Admiralty Board of Invention and Research and elsewhere. His want of readiness and lucidity of speech hampered his usefulness in this work, and often practically prevented his views from carrying their proper weight. He was painfully conscious of this, and was mortified by it. It was difficult or impossible to persuade him that others, who were more vocal

and made their views heard when his were practically a sealed book, did not mean him any injury. But these resentments did not last long and vanished like a puff of smoke if a friendly advance came from the other side.

Throughout his life it was very noticeable how much pleasure he took in "tinkering" and doing small mechanical repairs with his own hands. As the motor car developed from its early beginnings, his pleasure in using it seemed to diminish in the same ratio as the number of mechanical breakdowns which he was called on to deal with by the roadside. He was ready with expedients which to the ordinary motorist would seem fantastic. A fire was on occasion lit at the roadside, and a bent axle heated red hot, and hammered straight with a stone. Once in bitterly cold weather, the car refused to start, and no ordinary means were at hand for warming it. C. A. P. reflected, however, that man's animal economy provides periodical supplies of a warm fluid: and this source of heat was applied to the outside of the carburetter with good effect.

Again the Parsons family were to rendezvous with Mrs J. H. Cuthbert's* party for a picnic. They arrived behind time. Parsons' explanation to her was somewhat cryptic. He said: "The car would not go, and we had to undress the parlour maid." It appeared that a piece of steel spring was required to repair the distributor, and some mysterious intuition told C. A. P. that the fastening of the parlour maid's stays would afford what he wanted! She was accordingly sent upstairs to undress, and the stays were sacrificed. He often wanted to requisition Lady Parsons' engagement ring when he was at work on the diamond problem: but I believe that in this case his wishes did not prevail so easily.

At Ray, the house was lighted by a small direct-driven petrol motor set without accumulators. At times it gave trouble, and Parsons would get up from the dining-table in his dress clothes and go out to deal with it himself. One felt that an elderly man who would do this rather than order in candles was indeed a born mechanic. A machine which would not work seemed to be the thing of all others that stimulated him into activity. When he was no longer young, his friends would view with concern and disapprobation the energy he could put into "cranking up" a refractory motor car. He never seemed to take the slightest interest in, or care for, his own health; though if anyone about him either at home or at the Works was unwell, he was most solicitous that they should have the best advice.

He had a boyish pleasure in any experiment which ended in a big bang or flare up, such as firing a rifle bullet into a block of steel a few inches from the muzzle. He made many experiments of this kind in connection with the diamond problem. Once when something broke down

* Now Lady Rayleigh.

under extreme experimental conditions, I remember the characteristic words, "Well, we have the satisfaction of having bust it."

Going back to the time before I knew him, and when his own children and those of his friend and neighbour Mr Norman Cookson were in their 'teens, he was seen in his best and most genial mood when playing with them. He constructed model machines of original design for their amusement, and, I suspect, incidentally for his own. The helicopter illustrated in Mr Appleyard's book (p. 66) was one of these; and if the children mishandled or broke them it never ruffled him, any asperities in his character being for the time completely in abeyance. They were encouraged to come into his workshop at Holeyn and "help" him as they called it, when he was working at experiments on cavitation, the auxetophone, and so on.

There was a small trout stream close by, and he delighted in going there with them provided with spades and buckets. A bend of the stream would be dammed up; and short-circuited by a canal cut across. The trout would thus be stranded and captured. This, if not sportsmanlike in the most orthodox sense, was, to the children, the greatest fun that could be imagined.

It would be a mistake, however, to think that he did not appreciate orthodox sport. In his early days he appeared with the Tynedale hunt in surprisingly correct get-up—pink coat, top boots, and so on. Probably Lady Parsons' hand may be traced in this. He showed no lack of pluck in riding to hounds, though his horsemanship might be rudimentary. He was fond of entertaining his friends and neighbours for the shooting at Ray, and their enjoyment was his chief concern. A more unselfish host could not be imagined.

He liked occasional shooting as well or better than regular grouse drives. This recalls an amusing incident which I have from Lady Rayleigh. He went for a picnic to Sweethope on one occasion with a party of young people, and took a gun with him. A grouse was shot on the way across the heather. When they had arrived by the lake, and were about to lunch, someone said "I suppose if we were gipsies we should cook the grouse in clay and eat it, like they do the hedgehogs." The idea appealed to C. A. P. at once. A fire was lighted, and clay was ruthlessly dug out with a silver spoon, the only tool which was to hand. The grouse, feathers and all, was covered with a layer of butter, and an outer coating of clay, and put on to bake. After a due interval, the clay ball was opened and the grouse came away from the feathers. He ate his share of it with much contentment.

Parsons kept up his interest and enthusiasm to the end, though it seems that he was somewhat depressed to find that, as was inevitable in so large a concern, many of the problems at the Works had passed beyond his personal guidance and control. He was full of schemes for the improvement of large telescope mirrors, and, within a day or two of his death, had

dwelt on his hopes of "having a shot" at making the mirror of 200-inch diameter required by the American Committee. He had evidently no notion that the end was so near.

I bring these random recollections to an end with some regret that it has not proved possible to weave them into a more systematic narrative. It has been unavoidable to jump from one scene to another, with little continuity of time, place or subject. The purpose has been to bring before readers of this volume the personality of one of the greatest figures in the engineering world of his own or any other time. To read these recollections cannot, however, confer the great privilege which was enjoyed by those who knew him.

PART I