THE EDUCATION OF ENGINEERS IN RUSSIA

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Report of a lecture delivered to the Royal Central Asian Society on Wednesday, May 9, 1956, Group-Captain H. St. Clair Smallwood, O.B.E., in the chair.

The Chairman: It is my very pleasant duty to introduce the lecturer, Mr. Goodlet, who has many distinctions. Firstly, he had the unusual fate to be born in St. Petersburg as it then was, the Petrograd of today. He knew Russia in his youth. He returned to Russia in 1955. Meanwhile, he was trained with Vickers and Metropolitan Vickers and later became engineer in charge of the Million Volt Research Laboratory of the Metropolitan Vickers Electricity Co. Then he became Professor of Electrical Engineering at Birmingham University and afterwards Professor of Electrical Engineering at Cape Town University and Dean of the Faculty of Engineering there. In 1952 he was Chairman of the Naval Education Advisory Committee at the Admiralty. Until recently he was deputy chief engineer, Atomic Energy Research Establishment, Harwell. He is now chief engineer and a director of the Brush Electrical Engineering Company, Ltd. Mr. Goodlet has also been responsible for various technical publications. We are extraordinarily fortunate in having such an authoritative and distinguished person with us, and evidence for that is shown by the fact that there are present many distinguished members of the engineering profession.

Mr. Goodlet then delivered his lecture as follows:

I WOULD, first, like to express my appreciation of being asked to address this distinguished Society. Secondly, I must explain that I was born in Russia; I learned my arithmetic in German; my algebra in Russian and my calculus in English. I left Russia in 1918 and, as the Chairman has told you, returned there in November, 1955, as one of eight members of a British Atomic Energy team, the Russians having invited us to go and see what they were doing. After thirty-seven years out of Russia I found myself in Moscow. Our team had a very full programme. I was taken with two others to the N. E. Baumann Technical Institute where we spent an afternoon. My sole qualification for talking about Russian education is therefore a good deal of family background and a quick visit to one particular institution. The actual factual information I collected during the course of my visit in 1955 was published in a two-page article in *Engineering* on February 10, 1956. Therefore I am not now going to repeat all the detailed figures and so on, but endeavour to give you something of the background of Russian technical education as I took it up and pieced it together from my historical and general background.

I would like to suggest that our profession of Engineering has two distinct traditions—engineering as an empirical craft and engineering as a science. The science as distinct from the craft of engineering was cradled in eighteenth-century France. The first trained professional engineers were the officers of the Corps du Genie formed by Marshal Vauban. Engineering science was first taught in the military schools of France founded in 1720 and the first treatise on Engineering Science was Commandant Belidor's "La Science des Ingenieurs" published in 1729. The Ecole des Ponts et Chaussées was founded in 1747, and by the time of the revolution

two traditions had been firmly established in France: *First*, that the engineer was an officer rather than a workman; *Second*, that the engineer received a scientific education.

This was the system which produced the engineer officer Charles Augustin Coulomb, whose pioneer work on friction, on earth pressure, on torsion and on electricity and magnetism endures to this day.

In the year 1793 the French military schools were disbanded as both pupils and teachers were suspected of counter-revolutionary tendencies. In the same year Gaspard Monge, Professor of Mathematics of the Ecole de Marine, proposed to the new Government that an engineering school of a new type be organized to replace all those which had existed under the old regime. This proposal was approved and instruction in the new school began in 1794. In 1795, the school was given its present name—L'Ecole Polytechnique.

The system of instruction in the new school, planned by Monge, differed substantially from earlier practice. In the old schools the design of each type of structure had been treated as a separate and distinct problem. If some special bit of mathematical or scientific knowledge was needed, it was taught as part of the design process.

In the new school it was assumed that the different branches of engineering required the same preparation in the general subjects—mathematics, mechanics, physics and chemistry. It was also assumed that a student well grounded in these fundamental sciences would find it easy to acquire the specialized knowledge pertaining to any particular branch of engineering. In accordance with this conception the first two years of the course were devoted exclusively to the fundamental sciences, while engineering was studied in condensed form only in the third year. Later on the engineering courses were discontinued and the Ecole Polytechnique became a school for fundamental science only, training in engineering being given subsequently in the resurrected monotechnic schools—the Ecole des Ponts et Chaussees, the Ecole de Mines, etc.

The Ecole Polytechnique was exceptionally fortunate in its initial teaching staff and evolved methods of instruction, including laboratory work, that were revolutionary for the time.

The Paris Ecole Polytechnique set the pattern for the engineering schools of continental Europe which has endured to the present day. Polytechnics were founded in Vienna in 1815; in Karlsruhe in 1825; in Munich in 1827; in Dresden in 1828; in Hanover in 1831, and so on. However, since no special engineering schools were in existence the Germans reverted to the original plan of two years' general study followed by two years' study of some special branch of engineering *taken in the same school.*

This meant the addition of several specialized engineering departments to the original scientific corpus of the Polytechnic.

I will now pass on to developments in Russia. It is a mistake to imagine that medieval Russian technology was primitive. The work of the Russian armourers was always of high quality, being influenced by Swedish, Byzantine and Mongol techniques. In the year 1586 the gun founder Andrei Chohov cast in Moscow a bronze cannon of 89 cm. bore and 534 cm. long, weighing over 40 tons, which can be seen in the Kremlin

today. The corps of Streltzy or Musketeers, suppressed by Peter the Great at the end of the seventeenth century, were well equipped with fire arms made in their own armouries.

Peter the Great reorganized the whole machinery of the Russian State and founded a salaried civil service having a prescribed rank structure. He paid great attention to problems of supply and organized the work of mines, metal production gun-founding, gunpowder manufacture and musket production to a definite pattern. The technologists working in these places were state servants holding ranks equated with those of the army and civil service. The standard of attainment in many of these places was high. For example, the first steam engine to work in Russia was built between 1760 and 1763 by Ivan Polzunov in a metallurgical works near Lake Baikal.

Polzunov was born in Siberia, educated in a military school there and trained as an ironmaster at the works in Zlatoust. He visited Europe only once, quite late in life. When he had reached a rank equivalent to Army Captain he read Leopold's book on the Steam Engine and asked permission to build one. He got this permission from St. Petersburg, 3,000 miles away, within eighteen months—our own Ministry of Supply took much longer to make up their minds about Whittle's jet engine! This engine had two cylinders and was used for working the blast furnace bellows. An amusing sidelight on working conditions is a station order in Polzunov's biography saying that pupil engineers were not to wear their swords in the workshops. Evidently the French tradition that an engineer is a member of the officer clan rather than the working class was established in Russia quite early.

The Organization of Science in Russia goes back to 1725, the founding date of the St. Petersburg Academy of Sciences. It is worth noting that the mathematician Euler was a member of this body from 1727 onwards and spent a total of thirty-one years working in St. Petersburg, where he wrote the first treatise on Mechanics in which the calculus was applied to moving bodies.

The first technical school in Russia was the St. Petersburg Naval Academy, founded in 1715. This was followed by the Engineer School in 1719 and the Artillery School in 1722. Two schools of hydraulic engineering were founded in 1767 and 1768 in connection with canal projects, while the year 1773 saw the foundation of the St. Petersburg School of Mines—the first higher technical institute in the country.

A significant advance was made in 1809 when the Institute of Ways of Communication was founded as a school for training civil engineers.

The first director of the Institute was the French engineer Betancourt who, being a graduate of L'Ecole Polytechnique, modelled the Institute on the same plan. The St. Petersburg Technological Institute was founded twenty years later.

I myself received my early education in pre-revolutionary Russia. I was therefore very interested in everything I saw when I visited Moscow last November and managed to have included in my programme a visit to a school training mechanical engineers. I have recorded my impressions in an article published in *Engineering*, but I will summarize them again.

First, the Russians train their Civil, Mechanical and Electrical Engineers in separate schools. The total duration of the course of instruction is about 4,870 hours, spread over five and a half years. For comparison the usual three-year engineering course at a British university totals some 2,500 hours, but from a rather higher entry standard.

The general plan is that all students take the same courses in the first three years, have some common courses in the fourth year, and during the fifth and sixth years concentrate in some specialized branch of mechanical engineering; the last half year is spent on a design project in that branch. A list of some of the specializations available is given in my paper.

This list shows that the degree of specialization required of a Russian engineer is much greater than would be regarded as proper at any British University. It should, however, be noted that these twenty-three specializations are achieved by a longer period of study and does not imply that insufficient time is spent on teaching fundamentals. The common courses taken by all students occupy some two-thirds of the total teaching time, and the time spent on basic subjects is as great as in British University Courses.

I have no reason to think that the Russian graduate engineer is less well grounded in fundamentals than our men. I am quite certain that he gets a better grounding in engineering drawing, design and manufacturing technology and is therefore useful to his employer with less further training than our men need. Finally, he makes a pretty thorough study of some particular branch of mechanical engineering. Once admission is gained to an Institute of Higher Learning, a University or Monotechnical Institute, the entrant is exempt from military service—that is to say, two years. There is no military service for those who take higher education.

This curriculum with its heavy lecture load is obviously designed to cater for the large number of average men who can be turned into useful engineers by good teaching. The man with research ability has to pursue his particular bent *after* going through the mill—or study science at a university.

The Russians aim at teaching everyone to be useful.

I would like now to draw some comparisons and conclusions. If it has to be admitted that engineering science was cradled in France it is equally true that craft engineering was cradled in England. The early British engineers were mostly rough, untutored and self-taught workmen, but nevertheless they led the world for 150 years.

We can be proud of this and we are perhaps justified in concluding that when scientific knowledge in a particular field is inadequate and imperfect, practical experience and the intuition of genius are dominating factors.

On the other hand we would be wise to distinguish between Civil and Mechanical engineering, in which the untutored intellect can comprehend a good deal, and Electrical, Chemical and Nuclear Engineering which stem from scientific research and are incomprehensible without a good scientific background. We would do well to remember that at no period have British engineers led the world in these more scientific branches of engineering.

The weakness of British engineers on the theoretical side was noted by

the ex-millwright Sir William Fairbairn after the Paris exhibition of 1855 who then wrote:

"I firmly believe from what I have seen that the French and Germans are ahead of us in technical knowledge of the principles of the higher branches of the industrial art; and I think this arises from the greater facilities afforded by the Institutions of those countries for instruction in chemical and mechanical science."

I have not gone into the history of engineering educations in Britain very thoroughly, but I think I am correct in saying that there was no school of engineering in existence until 1796. In that year an institution for the instruction of artisans—the Anderson College in Glasgow—began to offer lectures on natural philosophy and chemistry. In 1799 George Birkbeck began to lecture there on mechanics and applied science, and after a time Mechanics Institutes were founded in other cities. Some of these institutes later became the nucleus of a provincial university.

It is, I think, therefore correct to say that whereas the continental tradition is to create an officer class of engineers well grounded in fundamental science and instructed in the practice of some branch of engineering, the characteristic British tradition is rather to teach artisans a little mathematics, geometry and science to help them better their station in life. This difference in outlook has survived to the present day.

At the present time we in the United Kingdom are producing two different kinds of engineer—the University Graduate and the man with a Higher National Certificate.

The University Graduate gets a fairly adequate three years' course on the applications of mathematics and science to engineering problems. It is, however, generally admitted that he leaves the university weak on drawing, design and workshop technology and, unless his subsequent practical training is unusually good, he often remains weak in these fields. He gets very little instruction in the practice of any particular branch of engineering—it is, for example, not possible anywhere in England to get hundreds of hours of teaching on, say, Boiler Engineering or Electric Traction, as in the case of Russia.

The philosophy underlying the British University Engineering Course is, in fact, that of the founders of the Ecole Polytechnique—that is, that anyone well grounded in fundamental science will find it easy to acquire the specialized knowledge pertaining to any particular branch of engineering, so that instruction in engineering proper is almost unnecessary.

My own opinion is that this philosophy is incorrect, and I would point out that it was in fact abandoned quite early on the Continent, where it is well established that instruction in some branch of engineering must follow instruction in principles and fundamentals.

Manufacture is the Aim

I would in particular plead for much more teaching of drawing and machine design. In mechanical engineering in particular the nub of the matter is the conversion of ideas into sound designs and designs into hardware. Until this process is completed, the best ideas are only hot air and waste paper.

The conversion of ideas into designs requires much more than knowledge of engineering science; it needs the ability to produce good drawings and a wide acquaintance with design precedents which are the well-tried solutions devised to meet similar problems in the past. The designer must also know a lot about materials and shop processes, otherwise his designs will be awkward to make. The final stage of converting design into hardware demands a wide knowledge of materials, processes and machine tools and, last but not least, the ability to organize and administer large works. Quite a lot of this knowledge can be taught.

I must insist that engineering has no meaning without a useful end product. It would be a great mistake to regard the corpus of knowledge required for machine design and manufacture as some kind of narrow specialization. It is, on the contrary, basic to our mechanical civilization and extremely general since it enables its possessor to participate with almost equal facility in any branch of mechanical engineering.

Specialization begins when some other kind of knowledge—*e.g.*, thermodynamics—has to be added to the basic disciplines of machine design. The principles of manufacture remain much the same irrespective of what is made; even watch making and turbine manufacture have many principles in common.

The proposition that every mechanical engineer should be well grounded in the basic arts of mechanical design and processes of manufacture will be hard to refute. Let us turn to the question of how this knowledge can best be acquired—by "picking it up" or by being taught?

The writer's opinion is that picking knowledge up by experience unaided by teaching is not a good way of learning an unfamiliar subject. Most people would agree that medical men at least should not be trained that way. One spends too much time deciding what is relevant and what is not and in repeating other people's mistakes. In actual fact the graduate apprentice in a works learns by being told as well as by seeing and doing. The draughtsmen and craftsmen he works with are his teachers—unpaid and unco-ordinated; the knowledge he acquires is unsystematic. Might not results be rather better if graduates were given some systematic instruction in machine design and manufacturing processes? And if so, should this instruction be given in the teaching institution before graduates or in a works afterwards?

The practice in Europe, especially in Germany, Switzerland and Russia, is to give pretty thorough instruction in the teaching institutions. When the writer was in Moscow recently he discovered that the syllabus laid down for Russian undergraduate mechanical engineers included the following:

Subject	*Hours of Instruction*
Engineering Geometry	90
Drawing and Machine Drawing	188
Details of Machines	215
Technology of Metals	182
Metallurgy and Heat Treatment	96
Interchangeable Manufacture	48
	819

This time is additional to that spent in instructional workshops.

Besides this general training, some 1,000 hours is spent in studying in detail the problems of some *one* branch of mechanical engineering; for example—Boiler engineering Optical-mechanical instruments; Foundry design and management; Turbine engineering; Compressor engineering and so on; and also twenty weeks doing a design project related to that branch. One cannot help feeling that the Russian graduate mechanical engineer probably starts his career with as good a knowledge of fundamentals and with greater capacity to be useful than many of our men.

The writer's guess is that the Russian graduate may well be as useful after one year in industry as our men are after two or three. If this guess is accepted the picture is as follows:

Years.	*Age at Entry.*	*Military Service.*	*Period to Graduation.*	*Further training in Works.*	*Age at which fully trained.*
Russian:	17 plus	Nil.	5½	1	24
British:	18 plus	2	3	2	25 plus

Needless to say instruction at the required level can only be given if there are professors and departments covering each one of the subjects listed and maintaining close consulting connections with the appropriate works and industries. These necessary conditions do appear to obtain in the Russian monotechnics; in England a single Professor of Mechanical Engineering is expected to look after everything.

How in fact do our mechanical engineering graduates learn the practical side of their profession? After an initial period in the shops those few who wish to specialize in works management may be made foremen's or planning officer's assistants and so be introduced to all the troubles of the shops. Design is taught by giving the man a board and a problem and tearing up his first half-dozen solutions. The man who after this still wishes to be a designer will probably be a good one, but some will undoubtedly become disheartened. Recently one or two large concerns have started advanced engineering courses for their graduate apprentices, but most of the instruction seems to be concerned with recent advances in engineering science rather than bread-and-butter design and manufacture —which is, of course, very difficult to teach.

The Higher National Certificate man gets his theoretical knowledge by part-time study during an apprenticeship. The Higher National Certificate courses are neither as long, as stiff, or as wide as degree courses, and the theoretical knowledge of the Higher National Certificate man is often very superficial. On the other hand, his outlook is practical, and he often has drawing office as well as workshop experience by the time he qualifies. He also does know something about the practice of the particular branch of mechanical engineering which concerns his firm.

For these reasons many firms find Higher National Certificate men more useful than University Graduates.

The Government White Paper

The recent Government White Paper proposes to increase the national output of this kind of man and to give him a better education. This is to be done by starting sandwich courses lasting four to five years from O.N.C./G.C.E. level and involving alternate periods of theoretical education in a technical college and specially designed practical training in industry.

These proposals must be welcomed because they represent something which can be achieved in a reasonable time, building on what already exists. On the other hand, five years divided between Technical College and Works is at best only just equivalent to three years at a University and two years at a Works, and neither alternative in my opinion reaches the level of the five-and-a-half-year Russian courses. For this reason I would say that the Government proposals are "too little and too late." We are chasing our problems of technological parity from behind instead of boldly jumping ahead of them.

In conclusion I think we should remember that no system of education can teach all the knowledge that the recipient will need in forty years of professional life, and that we should therefore not be too depressed about our imperfection. The real job in education is to stimulate our students so that they go on learning for themselves all their lives—and our British system has not done this job too badly.

What impressed me very much in Russia was the high standard of machine drawing, a standard better than we had in Cape Town University. The students produce beautiful drawings; also they work out in considerable detail how things will be made. For example, in the drawings for a motor-cycle the transmission from the engine to the driving wheel was shown, and the student had also not only worked out all the technical details of the design, but what kind of machines, lathes and so on should be used in the making of the motor-cycle. All sections of the work were laid down in the drawing. That would not be done in Cape Town or in any English university I know of.

Insistence on workshop technology is a strong point in the Russian engineering course. After all, the workshop is the home of the proletariat who occupy such a strong position in the Russian hierarchy. Everything to do with the workshop is put on a pedestal. I think the Russians score by insistence on good fundamentals, which we do also; then on good drawing and workshop technology, which is done very sketchily here in England; finally, there is in Russia specialization in one branch of engineering, which cannot be got here.

I came away from my visit to the Moscow Higher Technical Institute with a large collection of books. There is a friendly atmosphere; all concerned are glad to see visitors from abroad and they are most helpful. We collected a large amount of information. I would say that at the present time the Russians must be turning out of the engineering schools between 50,000 and 60,000 engineers of various kinds per annum, all of whom would, I believe, have been through the five-and-a-half years' course. The latest figure I have for English production of engineers is between 3,000

and 4,000 in 1954. In addition to the Institutes of Higher Learning the Russians have the technicums which are, I think, producing as many technicians as do the technical schools.

I believe there is in Russia a very well-developed system of correspondence schools. I did not visit any of them but collected a large amount of literature. The whole standard of text-book production in Russia is very good, and the text-books are always bought up. They get out of print very quickly.

From what I have told you you will, I think, see that there is very good foundation laid in Russia of higher technical education, going back to L'Ecole Polytechnique of one hundred years ago. This nucleus existed before the Revolution. From 1922 onwards the Russians have been trying to double technical education every five years. I believe they now have thirty-five years of very solid experience and are turning out excellent engineers. I do not think one should underrate Russian technical education. I hope, in fact, that we shall get going in this country something which is equal to it.

Asked at what age trainees went through the technical high schools in Russia,

Mr. GOODLET replied: They enter at seventeen plus, about a year earlier than our young men, but they have not done calculus while at school, so that I reckon they are a year behind our students. Taking seventeen plus as the starting age for training and adding five-and-a-half years, that will bring the trainee's age to about twenty-four before his training is completed. These trainees do not do military service. Our young men enter at eighteen years of age and are probably a year ahead in their school work; they do military service for a period of two years; they get a three-year university course and finish at about the same age as the Russians; because the latter get a good deal of their drawing, design and so on at the schools; they probably pick up the workshop end more quickly.

Asked if he could give any information on Russian methods of teaching the technique of engineering design apart from the basic subjects underlying it,

Mr. GOODLET replied: The Russians have Professors of Machine Tools, Professors of the Technology of Machine Construction, Professors of Horology, Professors of Transport Machines, Professors of Hoisting and Conveying Machinery, etc. Each of these is a specialist whose business is to study one branch of machinery and act as consultant in that field, and he therefore does not consider things not obviously necessary for the job with which he is concerned. Secondly, there are consulting sections. It was explained to me very carefully that the Russian system of education not only comes under the Ministry of Education but also has a tie-up with the various Ministries—the Ministry of Electric Power, the Ministry of Machine Production, and so on; in fact, there are sixty Ministries in the Russian set-up and all have scientists and research workers attached to them. Some have educational sides as well. The Ministry of Heavy Machine Production would have factories which would probably rely on the M.V.T.U. staff for consultation.

Asked whether the professors undertook any research work,

Mr. GOODLET replied: Research does go on in the M.V.T.U., where there are 10,500 students, 700 members of the staff, and 200 people working on various research problems. My impression was that at teaching institutions they do much research, though most research is done in special research institutes which do not teach.

Colonel G. ROUTH: I have been told by a friend who knows Russia fairly well and who recently conducted Malenkov round when in this country, that the senior engineers, a very good lot of men, are rather bored with the Central Government and its tyranny and restriction; that the possible change in Russia which would come about, perhaps not soon but in time, would be some sort of managerial revolution in which all the trained personnel who know all about how things are done will get on top of the Government and get certain things altered. Did the lecturer notice any such tendency when recently in Russia?

Mr. GOODLET: I had not time to do so. I also met Malenkov when in this country. I thought him an extremely bright and intelligent man. I believe he had a technical education, possibly in a technicum. He certainly asked some very pertinent questions.

Major E. AINGER: Are the students all Russian or of various nationalities?

Mr. GOODLET: I do not really know. Entry is a result of passing an entrance examination, and about one-third of those who apply are taken. I do not think in Russia they take in all the odd nationalities; in Siberia, where there are large technical schools, they probably take more. It is easier to get into the Faculties if one does not want to be a white-collared designer.

Asked whether the Moscow and the Petrograd institutes worked to a higher standard than the Siberian schools,

Mr. GOODLET replied: I imagine so.

Asked what proportion of the 4,800 odd hours spent in specialized study were devoted to the teaching of mathematics,

Mr. GOODLET replied that he had not a time-table handy, but he thought, from memory, between 400 and 500 hours.

The CHAIRMAN: When I was in Moscow twenty-five years ago all mechanical apparatus was in bad repair: lifts in hotels would not work, and one heard of all sorts of breakdowns of farm machinery and so on. Certainly twenty years ago mechanical apparatus generally in Russia seemed to be in a very poor state. Has there been a terrific upsurge of instruction and improvement of knowledge?

Mr. GOODLET: I think it is true that at one time mechanical apparatus in Russia was in a bad way. The Russians have been turning peasants into workmen, and that is why they concentrated on teaching workshop technique in the technical schools. In addition to turning out engineers they also have to produce craftsmen. I have no doubt that twenty years ago the craft position in Russia was very poor indeed. There is still a good deal of shoddy stuff round about Russia. For instance, in a number of the high-grade research institutes I visited the doors did not fit; faulty timber is used and it warps. Sanitary arrangements are very primitive. Much of this

is accounted for by the fact that the Russians are choosey as to what they spend money on. Important projects have a large amount of money voted to them. Unless something is important enough to appear in some plan it is neglected and falls to pieces.

Asked if in the industrial areas of Russia there was any part-time education and, if so, up to what standard,

Mr. GOODLET replied: I am certain there is part-time education. There are the correspondence schools which cater for the people. Secondly, a lot of the Faculties have evening departments; thirdly, I believe there are works schools in large factories, some of which are affiliated to training centres which probably give specific training. There is very good vocational guidance, in the form of a number of books describing various careers—choice of careers for young people. When any particular industry is short of labour there are booklets issued setting out the attractions of that particular industry.

Asked if he could give any comparison between Western Germany and Russia,

Mr. GOODLET said: I have not been in Western Germany since 1945. I knew Western Germany schools fairly well in the late 1920s, and would say that work done in three that I knew was as good as anything I saw in Russia. Whether that is so today, I do not know. I think the German and Russian education stems from the same Paris Ecole Polytechnique as I have described, with the same duration of courses.

Asked if students could choose the branch into which they wished to go,

Mr. GOODLET replied: Entry is by competitive examination, but a winner of a gold medal at school can get admission to an institute without examination. Students receive grants which vary between 300 and 600 roubles a month. An artisan receives 900 roubles per month, so the student gets one-third or two-thirds an artisan's wage. Students live in hostels or at home. I do not think they pay the full amount the hostels cost. I gather that students are turned out if they fail twice in an examination. The examinations, as far as I could judge, do not make the same call on the scholar as does the Cambridge tripos. That does not imply that Russian engineers are inferior. There are a very large percentage of women in training.

Asked what was the Russian attitude towards sandwich courses—six months in industry and six months in college—becoming more into vogue in Great Britain,

Mr. GOODLET replied: I do not think the Russians have considered such courses. In many ways they are still living in Victorian days. All the standards of behaviour, good manners and so on are pre-World War I; they have always had a five-year course and do not think anything less always had this educational system of technical schools, though there has been a slight alteration in that there are now monotechnic instead of polytechnic schools. The Russians have an old-fashioned respect for learning; they have always had a five-year course and do not think anything less would be sufficiently good. They have technicums for training technicians as foremen and so on.

Mr. J. H. W. TURNER: One of the great difficulties in Great Britain in obtaining more engineers arises from competing demands from other

sources. If we succeed in bringing more young men into engineering, then some other profession or industry will go correspondingly short. In Russia is engineering being given priority above all other subjects or with their huge population can the Russians produce large numbers of engineers and still meet all the other requirements for trained workers?

Mr. GOODLET: The Russian population is four times that of Britain. The Russians turn out ten times as many engineers and must be producing two-and-a-half times as many per head of population in comparison with Britain. The Russians design the engineering courses to make the best possible use of men of average ability. The average man gets a better grounding in Russia than he does here. The percentage of bright young people in Russia and in the English population is probably the same content. I cannot believe that their ability content is two-and-a-half-times as great as ours. About two-thirds of the students in the Institute of Higher Learning are studying some kind of applied science, technology or engineering; in England the proportion is about one-third. In Russia everybody wants to be an engineer. The brake is not put on by direction but by propaganda.

I came to the conclusion that the scientist in Russia occupies the same position as a film star does. There is glamour about being a scientist or an engineer which does not apply in Britain. These people live extremely well. In Moscow an artisan's wage is about 900 roubles a month. In Central Asia he would receive twice that amount. An engineer leaving a university to take his first job receives approximately the equivalent of 2,000 roubles a month; ordinary engineers earn between 2,000 and 4,000 roubles a month. Professors in the teaching institutes reveive 6,000 roubles a month. Very eminent men are paid a separate rate. Fellows of the Russian equivalent to the Royal Society receive a pension of 5,000 roubles a month instead of having to pay a subscription to the Society. Many of the higher office holders are supplied with cars and chauffeurs. Russian scientists are really very well looked after, and that is something to be borne in mind when wanting to become a scientist.

Asked was it not unwise for Russia to be turning out such a large number of engineers,

Mr. GOODLET said: We could use the number very well in Britain. Every engineering industry here is short of such staff. We plan a job, the material arrives, but often the staff is not there to cope with what has to be done, often quickly. The Russians, when they make a plan, look after the personnel end as well as the finance and bricks and mortar. Engineering can be an extremely dull subject; some make it so, but it need not be. If I were founding a technological university in England, I would go back into history and say that whereas medieval universities took as their thesis the relation between God and man, and man and man, and founded Faculties of Theology and Law, a modern engineering university might take as its slogan "Man in relation to his Means of Subsistence and Natural Resources." I would have a Faculty of Geography to deal with rainfall and crops; a Faculty of Economics; a Faculty of Transport dealing with communications all over the world; there would have to be a Faculty of History to tell of what happened in the past; also a Faculty

of Law. If one takes a broad view, it will be realized that engineering covers everything except Theology. It has different approaches. I think the Russians are half-way there. I said all this five years ago in a valedictory address on the occasion of leaving Cape Town. But nothing on those lines is being done in England yet.

The CHAIRMAN: I am sure we have all enjoyed the lecture and discussion. My only duty now is to thank Mr. Goodlet for coming and giving us such an extraordinarily interesting talk. It is always a great treat to listen to a complete master of his subject. We certainly have had that treat and also that privilege today. On your behalf I thank Mr. Goodlet very much indeed for his talk. (*Applause.*)