

MINUTES OF PROCEEDINGS  
OF THE  
Punjab Engineering Congress,

LAHORE,

1931.

VOLUME XIX.

EDITED BY  
MEMBERS OF THE COUNCIL.

Lahore:

PRINTED AT "THE CIVIL AND MILITARY GAZETTE," PRESS

1931.

*The Punjab Engineering Congress as a body does not hold itself responsible for the opinions expressed in this volume.*

---

To ensure the punctual delivery of Proceedings of the Congress and of other communications it is essential that every change of address should be notified, without delay to:—

The Hony. Secretary,  
Punjab Engineering Congress,  
P. W. D. Secretariat,  
Lahore.

# Punjab Engineering Congress

(ESTABLISHED 1912.)

(REGISTERED 1922.)

---

## OFFICE BEARERS AND COUNCIL

(1931-32.)

### PRESIDENT :

JOSEPH BENJAMIN GEORGE SMITH, C.I.E.

### VICE-PRESIDENTS :

RAI BAHADUR LALA WAZIR CHAND CHOPRA, M. I. C. E., M. I. E.,  
(Ind.) F. R. S. A.

RAI BAHADUR DEWAN AMAR NATH NANDA, B. A., M. I. E. (Ind.)

### OTHER MEMBERS OF COUNCIL :

LT.-COL. WILLIAM MACRAE, R. E.

KHAN BAHADUR SHAIKH ABDUR RAHMAN, A. M. I. E. (Ind.)

ALLAN NELSON McINNES ROBERTSON, B. A., B. E.

RAI BAHADUR BAWA NATHA SINGH.

ARTHUR RALPH ASTBURY, C. I. E., M. Inst. C. E.

RAI BAHADUR LALA MAKHAN LAL.

RAI BAHADUR LALA MANGAL SEN DHODY.

RAI BAHADUR LALA AMBIKA PRASAD VARMA.

### EX-OFFICIO MEMBERS :

JOHN HINTON FLETCHER, M. C. *Honorary Secretary*

RAI BAHADUR DEWAN AMAR NATH NANDA, B. A., M. I. E. (Ind.)

DAVID ARNOLD HOWELL, Assoc. M. Inst. C. E., *Honorary Treasurer,*  
*Honorary Business*

KHAN SAHIB MIAN IQBAL HUSSAIN, B. Sc. (Glas.), *Honorary*  
*Auditor.*



FAREDUN CURSETJI PAVRY,  
*President, 1930-31.*

## CONTENTS,

---

|  | Page.      |
|--|------------|
| <b>Address of Mr. F. C. Pavry, President</b>   | .. i       |
| <b>His Excellency Sir Geoffrey Fitzhervey de Montmorency,<br/>K.C.S.I., K.C.I.E., K.C.V.O., C.B.E., Speech</b>                                       | .. vii     |
| <b>Materials and construction of trunk and distribution pipe-<br/>lines for Water-supply, using metal pipes, by D. A.<br/>Howell, paper No. 143</b>  | .. .. 1    |
| Discussion on ditto  | .. .. 40a  |
| <b>Recent Practice in Girder Erection on the North Western<br/>Railway, by Major C. F. Carson, M.C., R.E., paper No. 144.</b>                        | 41         |
| Discussion on ditto  | .. .. 64a  |
| <b>Construction of a Railway Bridge over the River Indus at<br/>Kalabagh, by W. D. McD. Cruickshank, paper No. 145</b>                               | .. 65      |
| Discussion on ditto  | .. .. 104a |
| <b>Theoretical Design of a new type of Outlet for Irrigation<br/>Channels, by K. R. Sharma, paper No. 146</b>  | .. .. 105  |
| Discussion on ditto  | .. .. 113a |
| <b>Damaged Falls on Khadir Branch, of the Pakpattan Canal,<br/>by E. L. Prothero, paper No. 147</b>  | .. .. 115  |
| Discussion on ditto  | .. .. 122a |
| <b>Underpinning Satghara Rest House, by K. R. Sharma,<br/>paper No. 148</b>  | .. .. 123  |
| Discussion on ditto  | .. .. 133a |
| <b>Methods of Calculation and Analysis of Structures em-<br/>ployed on the North Western Railway, by Rai Bahadur<br/>P. L. Dhawan, paper No. 149</b> | .. .. 135  |
| Discussion on ditto  | .. .. 152a |

## ADDRESS

OF

MR. F. C. PAVRY, F.C.H., C.I.E.,

PRESIDENT.

### **Your Excellency and Gentlemen,**

It is my privilege to welcome, on your behalf, to open this Congress, His Excellency the Governor of the Punjab. In view of the importance of our activities to the welfare of the Province in so many directions it is natural that His Excellency should take a keen interest in our affairs; but our grateful thanks are due to him for the practical manner in which he shows that interest by honouring us with his presence at these meetings.

We welcome also the Hon'ble Revenue Member and the Hon'ble Ministers for Education, Local-Self Government and Agriculture, of the Punjab and the other distinguished visitors who have done us the honour of being present here to-day.

In the address which it is customary for the President of the Congress to deliver on this occasion, I propose to confine myself to matters connected with railway engineering and general railway working with which I am naturally familiar. I am full conscious of the magnitude and technical interest of the beneficent and vitally important work being carried out in this Province in connection with the development of Irrigation, Roads and Hydro-electric resources, but I leave these matters to those more competent to deal with them. I content myself with reviewing briefly some of the major activities and problems of the North Western Railway during the past seven years.

1. In 1921, the working of the State-owned Railways in India was reviewed by a committee presided over by Sir William Acworth and in the light of this committee's report the Railway Board was re-organized and strengthened in 1923-24. Arrangements were also made to find the necessary funds for making the existing lines a more efficient instrument of transportation and for launching an extensive programme of new constructions—arrangements which, however, have had to be modified during the last three years. Under the stimulus of a reconstituted Railway Board and of more stable financial arrangements, the first four years of the period under review were notable for intensive activity on the North Western Railway, as also on other Railways, in re-habilitating the existing property after the lean years of the War, in overhauling the methods of administration, operation, maintenance and public service and in pushing forward new productive lines.

2. In 1924, the administrative machine was re-modelled and adjusted to the requirements of such a large and rapidly expanding railway according to modern ideas. At Headquarters, the separate offices of the various Heads of Departments, working more or less in water-tight

compartments, were amalgamated into one central office. The duties of some of the Departmental Heads were re-distributed. The Chief operating Superintendent took over from the Traffic Manager and the Loco Superintendent all duties connected with the movement of traffic including charge of all rolling stock, except when under repairs in the Mechanical Workshops. The Chief Commercial Manager took over the remaining duties from the Traffic Manager ; and the Chief Mechanical Engineer took over the remaining duties from the Loco Superintendent. The Departmental Heads now function as staff officers to the Agent and direct the work of their respective Branches in his name. The 12 districts with their executive officers of the various departments, working with separate offices and largely in watertight compartments, were replaced by seven Divisions—each Division being administered by a Divisional Superintendent ranking as a Deputy Agent, assisted by executive officers of the various Branches, working in a central Divisional office. Matters connected with staff—totalling some 120,000 men—which were previously dealt with by the respective Departmental Heads and executive officers, were transferred to the care of a separate branch called the Personal Branch, both at Headquarters and in the Divisions. Experience of its working shows that the re-organization has made for simplicity, for uniformity and for more rapid and efficient despatch of business.

3. All the factors involved in economical and efficient operation and maintenance are continuously and critically examined by means of modern statistical methods, and a separate Statistical Branch has been established at the office of the Railway Board as well as on individual Railways.

4. Special attention is being given to methods of selection of probationers for employment in the lower grades, of training them in Railway schools for the various posts, of training those already in employment for higher posts and giving them refresher courses to keep them abreast with modern development. A Staff College for officers of all State Railways was opened at Dehra Dun in 1930, and the Area School at Lyallpur for subordinates of the North Western Railway was transferred to Lahore in 1929 and accommodated in more suitable buildings with more adequate equipment.

5. Of the improvements in fixed transport machinery, I will refer to only a few of the major ones on the broad gauge which may interest the Congress :—

- (a) Traffic or train control has been established over some 3,000 route miles out of a total of some 6,000 miles. By means of a special telephone system this method permits of the entire traffic or train movements in a Division or in an area being controlled from a central office in direct telephonic communication with the Divisional Superintendent. This method permits of substantial speeding up of train movements and of quicker and better distribution of rolling stock to meet public requirements.

- (b) Electric block instruments for double line, or token instruments for single line, have been installed on some 1300 route miles. These instruments permit of safer and quicker train movements than the paper line clear system which they replace.
- (c) A number of station yards, large and small, have been enlarged or altered so as to permit of longer goods trains being run, of quicker train movements or of quicker handling and sorting of goods wagons. In a number of yards the mere substitution of the modern method of shunting over a hump for the older method of shunting on the level has substantially increased the capacity and efficiency of the yard. For instance, at Lahore, the number of wagons which can be dealt with in the sorting yards during a month increased from 25,000 to 40,000, and the speed of handling them increased from 10 to 30 wagons per shunting engine hour.

6. Another important factor which will substantially increase operating efficiency is the gradual replacement of existing engines by new and more powerful engines embodying the latest improvements in design. On the main through routes, from Peshawar to Karachi, and from Lahore to Delhi, the present passenger engines, with axle-load of 16.5 tons, are being replaced by engines with axle-load of 20 tons, and with tractive effort and horse power 40 and 60 per cent. respectively in excess of those of the most powerful existing engines. At ordinary passenger speeds up the various grades, these heavier engines can haul about 40 to 50 per cent. greater load than the older engines, and thus permit of reduction in number of train miles. On the heavily graded sections, from Peshawar to Lalamusa, from Karachi to Kotri, and from Sibi to Chaman, the present goods engines with axle-load of 16.5 tons will be replaced by engines with axle-load of 22.5 tons and with tractive effort and horse power 50 and 90 per cent. respectively in excess of those of the most powerful present engines. At present goods train speeds up the various grades, these heavier engines can haul about 50 to 60 per cent greater load, or alternatively, can haul the existing loads at substantially higher speeds than the most powerful older engine. On secondary and branch lines, the existing passenger and goods engines are being replaced by new engines of considerably greater power though with no higher axle-load.

7. To enable these heavier engines to run on the various selected sections, the strength of track and bridges on such sections have been under careful investigation and strengthening or renewal of track bridges and girders has been in progress. Girders of the important bridges over the Indus at Attock, the Jhelum at Jhelum, the Chenab at Wazirabad and the Sutlej at Adamwahan have been strengthened or renewed. The various methods of erection employed at these bridges according to the necessity of each case are described in a Paper by Major Carson to be read at this session of the Congress. The entire main route from Peshawar to Karachi is now fit for these engines and they have started running on this route.



8. In connection with this intensive investigation a few technical details may be of interest to this Congress:—

- (a) Our old, somewhat hazy, ideas about the nature and intensity of stresses in the various elements of the track are now replaced by a simple but revolutionary theory, based on, and supported by, numerous experiments carried out in America. The theory assumes the whole of the track, including formation, ballast, sleepers and rails to be a homogeneous elastic structure, with a definite modulus of elasticity, determined experimentally for each class of track. It follows from this theory that the old assumption of deflection of the rail between the sleepers has to be superseded by the proved fact that the track as a whole deflects between the wheels further deductions from this theory are that rail stress under four wheeled carriage may be greater than that under a much heavier engine with closer spaced axles of the same individual weight ; and that additional sleepers do not appreciably reduce rail stress, although the pressure on ballast and foundation is approximately proportional to sleeper spacing.
- (b) Safety of foundations and masonry of bridges under the heavier engines is receiving special consideration. The oldest of these bridges were built some 70 years ago for possibly 12 ton axle-loads ; others for axle-loads up to 16 or 17 tons. It would be impracticable, financially and otherwise, to re-build all these bridges for the heavier axle-loads ; nor is it necessary to do so. Except under unusual conditions such as land slides, cloud bursts and hill torrents masonry structures do not normally collapse without giving adequate warning. What is being done, therefore is to survey the bridges carefully and renew or strengthen only where they show definite and substantial signs of incipient failure, or where area of foundation or section of masonry is exceptionally scanty. Those in which section of masonry is unduly scanty, or which show slight signs of failure, are carefully watched, and speed over them is restricted, if necessary. In this experimental method of dealing with a difficult problem we are fortified by the experience of many American Railways where axle-loads of 25 to 30 tons are running safely over bridges built for the original axle-loads of 12 to 15 tons. Theoretical analysis of some existing bridges, according to the usual methods, discloses much higher unit stresses in masonry and, particularly, in foundations than those normally adopted as working stresses in current practice. This has led to a more critical examination of our methods of analysis including assumption as regards external forces and unit working stresses. This matter has been dealt with in Mr. Dhawan's Paper which will be read at this Session of the Congress.

9. Expenditure on renewal or strengthening of track, girders and bridges to accommodate these heavy engines runs into several crores of rupees, and it may reasonably be asked whether the expenditure is justified financially or on other grounds. These heavier and more powerful engines, with their larger coal and water capacity, can haul greater loads at present speeds, or present loads at higher speeds with less frequent stops for coaling and watering. They can, therefore, move a given volume of traffic in a lesser number of trains or in lesser time; in other words, they will save engine and train miles or engine and train hours. These factors have a definite monetary value; and rough calculations show that the saving thus effected will cover the interest on the total capital expenditure. It remains to be seen whether this theoretical justification will be fully realised in practice. But there is no question that the heavier engines will give better service to the public from the point of view of quicker transit and greater certainty as regards running to scheduled time.

10. In 1926, a committee presided over by Sir Vincent Raven reviewed the working of workshops on India State Railways and recommended that, to secure efficiency and economy, work on the North Western Railway should be concentrated in a smaller number of well-equipped shops of modern design, and that modern scientific methods should be employed in their organisation and working. In the light of these recommendations the Locomotive and Carriage Shops at Karachi and the Locomotive, Carriage and Wagon Shops at Rawalpindi have been closed down and the bulk of the work concentrated at the already well laid out and adequately equipped shops at Moghalpura only a fifth of the loco repair work and a seventh of the carriage repair work being done in the existing shops at *Sukkur* and a quarter of the wagon repair work in the existing shops at Karachi. This was made possible by the improved output both as regards repairs and as regards manufacture of spare parts due to more scientific methods of organisation and production.

11. Statistical methods have been applied to the distribution and control of expenditure on repairs and maintenances of fixed structures. A suitable unit has been adopted for each class of structure, e.g., track mile for permanent way, 100 sq. ft. of floor area for buildings, etc., and the number of units for each class in the several divisions or sections have been ascertained. Past expenditure has been analysed to arrive at rates of expenditure per unit of each class on the several sections. The analysis disclosed wide variations in unit rates on certain sections which could not be explained on the basis of variation of conditions. More or less uniform unit rates, subject to variation according to variation in conditions, have now been adopted for the several sections. This method ensures better distribution of expenditure according to actual requirements and a more uniform standard of maintenance.

12. Local Advisory Committees consisting of non-officials representing various public interests, have been established on each Railway and a Central Advisory Committee advises the Railway Board. Their utility in bringing forward the point of view of the travelling public is undoubted, and they are doing very useful work. Under the stimulus of public

opinion, as voiced in the Legislatures, and by the Advisory Committees, a great deal has been done on the North Western Railway to meet the convenience of the travelling public—particularly that of the 3rd class passenger. Time does not permit of details being given, but efforts in two directions are worth noting. Tube wells have been installed at a large number of stations which supply pure drinking water, and practically all main line passenger trains and a number of stations are now fitted with electric lights.

13. The programme of new constructions, launched by the North Western Railway in 1926, has resulted so far in the construction and opening of 100 miles of broad-gauge "B" Class or secondary lines, 260 miles of broad-gauge "C" Class or light lines and 230 miles of narrow-gauge lines. The broad-gauge lines have been built at an average rate per mile of Rs. 1.1 lakhs for "B" Class and Rs. '64 lakhs for "C" Class. Considering the great rise in prices of labour and material since the War, these figures do not compare unfavourably with those of similar lines in similar country before the War. The construction of the "C" Class lines at this low figure has only been made possible by reduction in standard of structures and convenience to the point that a maximum of three trains a day each way can be run with axle-loads not greater than 16 tons and at speeds not exceeding 25 miles per hour. The Shahdara-Narowal and Sirhind-Rupar lines, opened respectively in 1926 and 1927, are already earning over 7 per cent. on the capital invested, and the Amritsar-Narowal line just under 3 per cent. ; but the remaining broad-gauge lines for which complete figures are available at present do not show signs of earning interest on capital in the immediate future. The programme includes the construction of new bridges over four of the Punjab rivers. The bridge over the Ravi at Narowal has been completed and opened. The bridge over the Jhelum near Khushab is due for completion this year; and bridges over the Chenab at Chiniot and over the Indus at Kalabagh are due to be completed next year. A Paper by Mr. Cruickshank on the construction of the Kalabagh Bridge is to be read at this session of the Congress.

Gentlemen, I will not detain you much longer, I trust that this brief survey of the activities of the North Western Railway during recent years will give you some idea of the manner in which this Railway is fulfilling its obligation of assisting in the well-being and advancement of this vigorous and progressive Province. I have only one more thing to say. The sands of my official life are fast running out ; and I would like to voice a hope in connection with the younger members of my profession. The face of India is rapidly changing, and increasing numbers of Indians are being called upon, and are forthcoming, to take an ever-increasing share in the multifarious activities of this Province. To my younger colleagues in the profession I would say this. In the years before you, as engineers and administrators may you build as well and truly, and as men may you deal by your fellow men as straightly as your predecessors have done before you and as your elders are endeavouring to do now !

I will now ask His Excellency the Governor to be pleased to declare the Congress open.

## SPEECH

BY

HIS EXCELLENCY SIR GEOFFREY FITZHERVEY  
DE MONTMORENCY, K.C.I.E., K.C.V.O., C.B.E.,  
GOVERNOR OF THE PUNJAB.

### **Members of the Engineering Congress and Gentlemen—**

No very considerable period has elapsed since I last had the privilege of addressing you, and I have been turning over in my mind on what topics of interest to you I can with any profit dwell to-day.

On the last occasion I acknowledged the many important contributions which various Engineering Services had made to the development of this province, and, in addition, I offered some observations on the everexpanding scope of engineering activity due to the great variety and complexity of calls, which higher standards of living and convenience and the spread of education among the public, bringing in its train new needs, are day by day making upon the experience, ingenuity and energy of Engineering Services.

There is a good deal more to be said on the subject ; but I feel that if I attempted to say it, my observations could hardly fail to echo a note of pessimism and despondency—for it is in the inevitableness of the present all-prevailing financial stringency that many projects of great public utility and technical interest must be deferred, and many investigations of the highest importance must be curtailed or suspended for some time to come ; but this depressing thought in its turn induces another line of thought, which can, in my view, be pursued with some advantage at a Congress of Engineers, representing many different administrations, departments and interests. This problem for want of a better name, I may describe as the possibility of a closer concatenation of engineering effort in the public interest.

Leaving aside engineering firms and engineering contractors with technical qualifications, the greater part of engineering in this country consists of departmental organizations for the purpose of planning and executing engineering works in the public interest. These different branches are separated from one another in different ways and work to a large extent in isolation from each other in departmental compartments without any formal bond, other than that individuals may set up by optional mutual consultation ; some of them, such as the North-Western Railway and Military Engineer Services, are definitely part of the activity of the Central Government : others are directly controlled by the Local Government and are independent of the Central Government, as, for

instance, the Irrigation Department, the Buildings and Roads Department, the Hydro-Electric Department and the Agricultural Engineering Department. Others are controlled by local bodies. From another aspect of view, there are also differences in kind in their classification. Some, such as the Railway Department, the Irrigation Department and the Hydro-Electric Department are commercial or quasi-commercial departments, and their operations have to be primarily conducted from this point of view. This does not apply to the Building and Roads Branch of the Public Works Department, though, of course, the latter department has to secure a return on the residential buildings it constructs, and would also ordinarily be clearly bound in matters, such as water supply installations, to design and execute a work within limits, which, with the application of ordinary charges for the service delivered, would be remunerative in return to the body paying for and maintaining the installation. Some forms of engineering activity, such as roads, while ministering to the welfare of the community as a whole, are definitely unremunerative to the administration, which constructs and maintains them, though they indirectly contribute to the profits of others, as for example, the case of feeder roads to railways.

Now, in all this departmental diversity there is from the point of view of the public one point of unity, and that is that the money which pays for the works comes out of the pocket of the tax-payer in the form of central or provincial or local fund taxation, whether direct or indirect or, in some instances, in the shape of payments for services rendered. It is a matter of indifference in the eyes of the man who pays into what particular purse or exchequer his money goes, or who executes the work; but it is of considerable importance to him that it should be expended by the conjoint effort of the organizations concerned, in the best and most economical manner; and it is in this connection that it becomes profitable to speculate on the possibility of the greater concatenation of engineering effort.

Please do not think that in anything I may say, I have a desire to be critical or carping. Far from it. I am fully aware that several of the points, on which I may touch, are fully in the minds of our engineers, and that they take the necessary measures in regard to them, and that as regards some of the others, constitutional difficulties and limitation of rules of finance, audit and accountancy create obstacles inherent in the system, which it is beyond their power to alter or remove. Nevertheless, the possibility merits exploration. I expect you all remember the well-known fulminations against inordinate departmental concentration of which the late Lord Curzon delivered himself. I need not quote the whole passage to you—a few words will suffice. "People sometimes ask what departmentalism is . . . . Departmentalism is not a moral delinquency. It is an intellectual hiatus—the absence of thought or apprehension of anything outside the purely departmental aspects of the matter under discussion." I am not for a moment inclined to paint the pre-occupation of departments with their own concerns in as

black colours as the great proconsul ; but I agree with him to this extent, that in all departments there must be a tendency to feel that the immediate and special point of view of the departmental need is the first and most obvious consideration in the foreground, with the result that a larger and wider interest may possibly remain unattended to in the background.

The points I have in mind are mainly financial, directly or indirectly, though there are cases also, where the consideration of the greater general efficiency and convenience comes in. Of course, finance is a primary consideration for every engineer ; economy in design and construction is among the ten commandments of engineering. Now, as regards finance, engineers in each department assuredly try to secure in making contracts or giving work orders that they obtain the necessary and right quality of work at the most reasonable cost possible ; but I ask myself the question, is it not a greater concatenation of effort possible, and will it not probably be fruitful ? It is a well-known fact that after the War costs of both material and labour rose : both have since fallen. It is fairly obvious that it is not sufficient for the Chief Engineer of one department, from time to time, to revise the schedules of rates which are to be the guide of his executive officers in these matters, for unless the heads of neighbouring departments act in a similar manner at the same time, the action by one alone is likely to be largely infructuous. In some cases, of course, as in the case of manufactured structural steel, the matter re-adjusts itself owing to the presence of many firms in a number of countries competing against each other for orders or contracts ; but this does not always happen : sometimes, for instance, there is a combine or ring of suppliers formed, such as the cement price ring, to prevent prices going down, to oppose which concerted counteraction by engineers is called for by various devices, such as a combined resolve to use other products in substitution or adopt alternative methods of construction. More particularly, this interconsultation and combination of engineers seems likely to prove of service to the financial interests of the public in the matter of labour or those work and material rates, into which the price of unskilled and temporary labour enters. Here close touch has to be maintained with economic factors : and it has, of course, to be remembered that a decline in the price of raw food-stuffs is not immediately followed by a corresponding fall in the price of labour, but that a lag usually occurs. It is always a moot point for interconsultation and decision in such cases as to when exactly, the lag has been made up and the psychological moment has arrived to make a common front to secure for the public the reduction in costs of work, which easier conditions of living and, consequently, lower wages of labour should bring ; and, in this instance, I think it is probably desirable for the heads of various engineering departments to be in much closer touch and to consult each other at more frequent intervals than has been the case in the past : or perhaps the result can to some extent be obtained by a periodical circulation of the revised rate schedules of various departments. Such co-ordinated action is likely to be particularly effective in times like the

present, where, owing to lack of funds, little new work is going on, there is more time to look round and the difficulty of securing a sufficient number of satisfactory contractors or amount of labour hardly exists. Other steps of interest in the same connexion are the publication of important contracts let and access to periodical reviews by the Chief Engineers of branches of the state of the commodity and labour markets.

Instances of another kind are where the needs and interests of different engineering works, which are being carried out in the same area, conflict with one another. A common case of this nature is the presence or the creation of a road, a canal and a railway in the same area, with a resulting conflict as regards crossings and direction. It may readily be admitted that each is pursuing a certain direction and has its public purpose to fulfil: each has to secure some fundamental requisite, as, for instance, progress along a certain level in the case of the canal, avoidance of an excessive curve in the case of the railway, convenience of crossing length and direction in the case of the road; and that these requisites are not easy to correlate. If it was a case of *tabula rasa*, there is no doubt that the matter should be settled by interconsultation, keeping in view, as the first consideration, the greatest economy and general convenience to the public to be served; but a too great tenacity to a departmental point of view may often lead in such cases to some sacrifice of economy on the projects as a whole through a tendency to force the weakest to go to the wall or to take a stand on possession being nine points in the law.

I can recollect a case, which is of some interest in this connection. Many years ago, I was entrusted with the task of revising the occupiers' rates on the Upper Bari Doab Canal, which entailed concentrated touring in the Gurdaspur, Amritsar and Lahore districts. The previous monsoon had been locally copious and late in its activity; and I found large areas had been flooded in the Gurdaspur and Amritsar districts, which even at Christmas time and after were still covered with water, and were not available for sowing crops. Though I enjoyed the duck shooting, I thought that the problem of the lack or obstruction of drainage for storm water called for some immediate solution, and I mentioned the matter to the Lieutenant-Governor of the time. He knew of the problem and authorised me to send for all the files belonging to different departments relating to the subject from the Punjab Secretariat, and to try to discover the best method to adopt to secure a remedy. A perusal of those documents showed that, while considerable ink had been expended by various departments in trying to fix the responsibility for improvement on some department other than their own, there had been no real joint effort at effective remedy. Some had blamed the conditions "on" the N. W. R., alleging too high embankments and insufficient waterways. Others put the Buildings and Roads Branch and the Grand Trunk Road in the dock. A gallows was erected for the Deputy Commissioner of Lahore, who had allowed cultivation in the flat lower reaches of the drainages. Everybody, except the Irrigation Department, was sure that that department was the villain of the piece; and even inside

that department itself, one division thought that if another division had taken some particular action, things would have been much better : and perhaps the strangest thing of all was that, when I showed a *precis* of the case to the head of the province, he came to the same conclusion as myself, namely, that they were all in a greater or lesser degree concerned, and that only joint action by all would effectively remedy the state of affairs. I mention this matter with all the more confidence, because the deficiencies have since, by mutual co-operation, been made good, and the shortcomings, if shortcomings there were, were those of persons, who have long ago been gathered to their forefathers.

It may be worth considering other means of pooling energies, with a view to the greatest economy in the public service. So far as engineering education in this country is concerned, on the whole, there appears to be no unnecessary overlapping ; but in the future, it will probably be wise to bear in mind that it may be better to have a few really good and well equipped Engineering Colleges and keep them up to date than to spread money over a number of courses and new institutions. There may be other methods of pooling with the same end in view, as for example, where one department keeps a workshop, which is only occasionally full of work and so is more of a convenience than an economic proposition. It may be possible, in such cases, to arrange with another department, the nature of whose activities requires the maintenance of a workshop working at continual pressure, so as to secure that the work of the former can ordinarily be taken up and executed by the latter. The entertainment of a single combined agency to dispose of stock belonging to different branches falls in somewhat the same category. Sharing of developed resources, such as quarries, may also offer some field for doubling up and avoiding duplication of overhead establishments. The occasional use by one department of special plant belonging to another department is also an instance in point. I know that such exchanges of services are hedged about, as between different departments, by difficulties of departmental charges ; but, after all, a system—even something as sacred as a system of finance and audit—is not a law of the Medes and Persians, which cannot be altered, and such systems can be re-examined, both from the commercial angle of view and considerations of general economy and the public service.

Pooling of information and results of research and enquiry is also, I conceive, of first importance. This is likely to be facilitated by easy access by the officers of a department to the library catalogues of another department and by the periodical printing up and recording of papers of special technical interest. I believe the engineers of this province are, at the moment, engaged on collating all the available experience in the Punjab as regards tube-wells : and no less than four departments—the North-Western Railway, the Public Health side of the Buildings and Roads Department, the well-boring side of the Agricultural Department and the Irrigation Department—have a considerable store of separately collected experience to add to a common fund of knowledge



in this kind of work ; and this sort of collection and condensation of results obtained by different agencies is naturally of very great value. Another aspect of the same matter is that each branch cannot, in the nature of things, be self-contained, and many branches are likely to welcome advice in certain directions from other branches equipped with specialised staff or special experience on particular lines—for instance, in the Punjab there may be branches which gladly at times seek the advice of the North-Western Railway Engineers in bridge building problems, of the Survey of India in precise surveying, or of the Architect's branch of the Buildings and Roads Department in questions pertaining to designs and lay-outs.

Though it has only been within my capacity to refer to some rather commonplace and obvious instances, where concatenation may prove of service in the general economic interest of the public, I trust I may have sown the seeds of thoughts among those better-equipped than myself to deal with the problem, which may bear useful fruit in due season. This Engineering Congress has always rightly been regarded as a great clearing house of ideas. It is a sort of exchange, at which all branches of engineering meet, and to which they each bring their stock of practical experience or the fruits of their research and enquiry ; and I can assure those gathered here that a wider public fully realises the spirit which underlies and animates these meetings, and the high value to be attached to the useful purpose which they fulfil, both from the point of view of the profession and of the public service.