German technical associations between science, industry, and the state, 1860-1914

Lundgreen, Peter

GERMAN TECHNICAL ASSOCIATIONS BETWEEN SCIENCE, INDUSTRY, AND THE STATE, 1860 - 1914+

Peter Lundgreen

The first section provides an analytical scheme for the study of technical associations. Their interests and activities are classified according to four major areas: professional interests; economic interests; regulation of technical standards; production and diffusion of knowledge.

Sections 2 and 3 analyse in more detail two of these areas. "Regulation of technical standards" deals with the technical associations as they were involved in matters of safety control, testing of materials, and standardization. "Promotion of research" considers the technical associations as they took part in the production of knowledge. They did so by formulating problems and by organizing research.

1. Overview

It is during the 19th century that associations are to be found as a typical form of social organization throughout European bourgeois societies. Associations both grew by membership and by fields of interests being covered. Amongst them the realm of science and technology is included, and it is this part of the history of associations to which I want to draw attention. More specifically, three technical associations will be studied out of some 180 which were founded between 1815 and 1930: (1)

- the German Engineering Association (VDI) of 1856;
- the German Metallurgical Engineering Association (VDEh) of 1860;
- the German Electrical Engineering Association (VDE) of 1893.(2)

The selection is intended to neglect associations like those of the physicists (1845) and the chemists (1867) which are held to have been strongly academically oriented. My present interest, by contrast, is to study another type of "technical-scientific association" which mainly recruited its members from the world of industry. In other words, we are dealing with technicians, engineers and scientists who usually (and to an increasing degree) have undergone a form of higher education (presumably at a German Technical University). After graduation many of them entered positions within industry ranging from workmaster to chief executive (technical director), or from shopkeeper to entrepreneur. Others flocked to the technical branches of the civil service, or to teaching positions.(2)Since there were special - and more prestigious - associations for technical bureaucrats, it is safe to think of the great Engineering Asso-

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ciations mentioned above as being clearly dominated, at least quantitatively, by the industrial engineers. By 1914, the Metallurgical and Electrical Engineering Associations had some 5.000 members alike, whereas the more general German Engineering Association could boast of more than 25.000 members.

Under these conditions some interesting questions can be raised with respect to the standing of the technical associations:

- In cases of conflicts between technical expertise (professional orientation) and economic constraints (occupational or institutional orientation), how did the associations vote or mediate?

- In cases where technical knowledge was lacking for given problems, how did the associations encourage the production and diffusion of knowledge?

- In cases technical standards, both internal and external to the enterprise, how did the associations participate in the decision making?

- In cases of adapting technical training to changing "requirements", how did the associations go into the lobby?

These and similar questions indicate that technical associations acted within a field which is influenced by three different "powers":

- Science, or the world of academia, directs the professional orientation of the engineers. Their social status is partly measured in terms of their education. As technical experts, engineers look out for realization of their ideas. At the same time, they look for further and better knowledge, whether it be produced at the institutions of their former training or elsewhere.

- Industry bases production technologies on the contemporary state of knowledge, and this includes hiring engineers. But additional considerations, above all economic ones, limit the range of potential technical realizations. Moreover, entrepreneurs may try to exploit the benefits of technical innovations formerly introduced or advanced by some engineers.

- The state plays a third part in this game, at least where a strong bureaucratic tradition prevails. On the one hand, the system of higher education is strongly influenced by the state, and if engineers have an interest in their academic credentials they address the government. On the other hand, technical legislation impinges upon technical and economic interests both of industrialists and of engineers. Matters such as safety control and standards of quality are obvious examples of compromises to be sought between the "public" concern (safeguarded by a benevolent bureaucracy), between the existing technical solutions (offered by the self-confident engineers), and between the demand for reasonable "private" profits (put forward by the employers and accepted by the general consent to a market economy).

If we reverse the perspective and turn from science, industry and the state - the three "powers" constituting our triangular field - to the technical associations as agents within this field, it is possible to discern four major areas of associational activities:

(1) Promotion of professional interests

In this area we can trace the concern of the associations with questions of educational reform, especially with the "appropriate" relationship between academic credentials and access to specific jobs. One of the main targets, for a long time, has been the opening of civil service careers to technically trained academics.(3) Furthermore, the legal standing of employed engineers in terms of social security legislation, or the equal footing with higher civil servants, are closely connected with the educational policy of the associations and hence part of their promoting professional interests.

(2) Promotion of economic interests

Technicians are interested to protect intellectual property, and their associations kept themselves occupied over decades with patent legislation. A recent study suggests that in this respect technicians lost out to the stronger position of the entrepreneurs when the German patent law of 1877 was enacted.(4) In spite of this instance the technical associations are believed to have backed industry whenever an issue of business legislation raised controversy. In other words, the well-being of industry seems to have been part of the technicians' general concern with the promotion of engineering for the benefit of the German fatherland. (5)

Figure 1 about here

(3) Regulation of technical standards

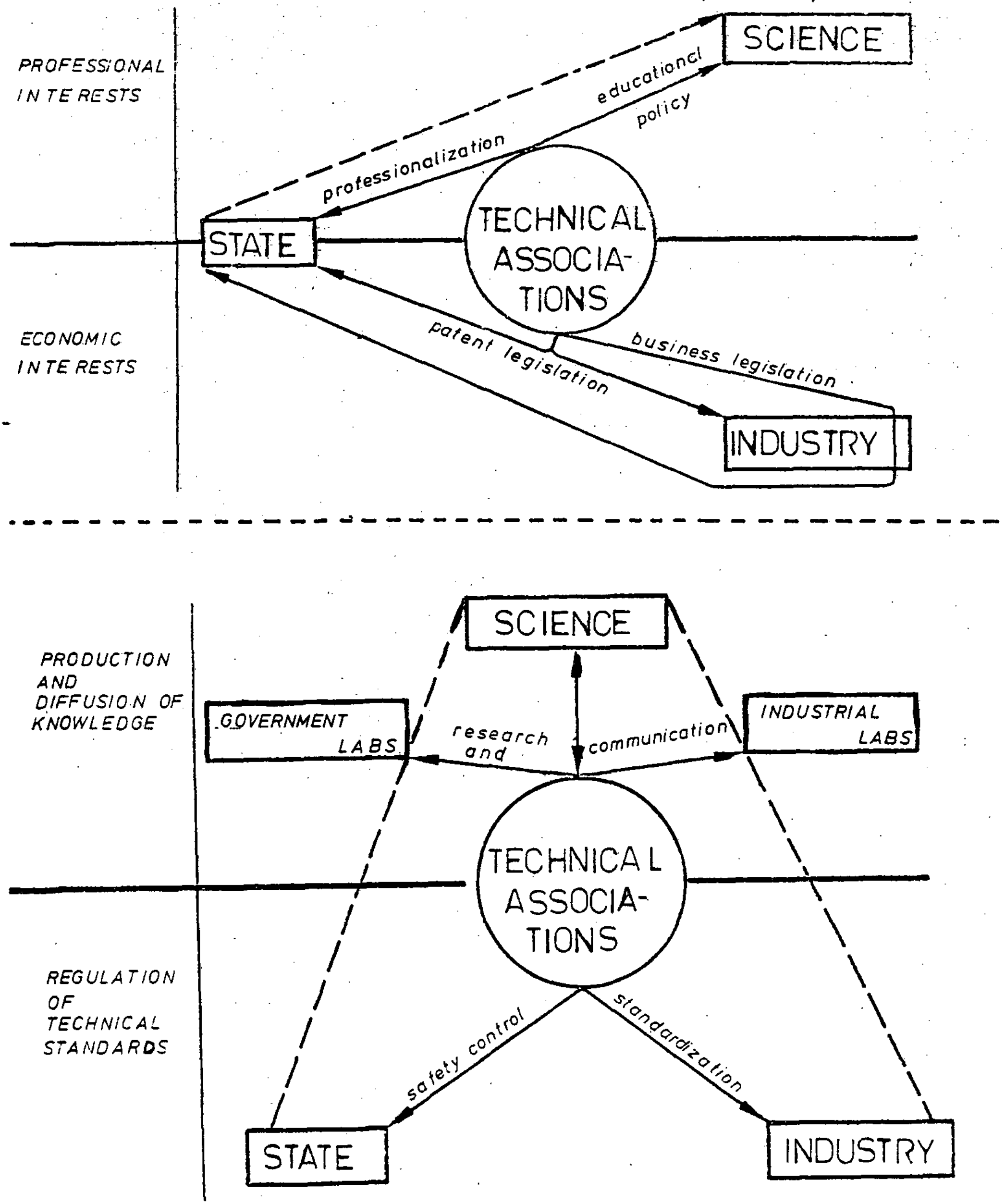
If economic production is based on industrial technologies, the need for regulation of technical standards arises in several aspects such as safety control, testing of materials, standardization of products, the terms of delivery, and measurement procedures. Technicians have a strong and genuine interest to participate both in the formulation of the standards and in their execution or supervision. As technical experts they claim priority for their competence, and they tend to strive for a kind of professional autonomy in matters of technical legislation.

(4) Production and diffusion of knowledge

One of the main purposes of any association is to serve as a platform for communication. In this respect, the technical associations did everything to maximize the exchange of personal experiences gained at the individual places of work. Such a transfer of knowledge was organized between the members and for the members: meetings of the board and of special committees; publication of journal and of other periodicals; organization of training courses. In addition, the associations stepped also into the field of production of knowledge. This they did as technical experts who had much closer contact to practical problems of technology than any academic could ever have.

In general terms, it makes sense to conceive the technical associations as being an interest group which is interacting with "science", "industry", and the "state" in a multifunctional and overlapping fashion. The remaining parts of this paper try to elaborate on this

FIGURE 1: Technical Associations between Science, Industry and the State



interaction in more detail. This will be done, by way of examples, for two areas of associational activities: the regulation of technical standards; and the promotion of research.

2. Regulation of technical standards

One important field calling for the regulation of technical standards is safety control, and a classical example thereof has been the supervision of steam engines. (6) In highly bureaucratized countries like the German states it was the government which started out to regulate safety. But as soon as the technical associations came into being, we observe a twofold competition until the state concedes its monopoly and grants a new one to the associations.

The first controversy applies to the personnel involved in supervision. In this respect, associations advocated the admission of the supervisory engineer employed by so-called "technical supervisory associations" which were to be financed by voluntary membership of the owners of steam engines. The Prussian state, which hitherto had managed the supervision by relying on his technical civil servants, agreed in 1872 to admit supervisory engineers as an alternative to his own services. During the following decades the supervisory associations succeeded, however, to enlarge their competencies, and in 1900 the dual system of supervision was given up in favour of a new monopoly. Henceforth everybody in need of supervisory services had to employ the technical supervisory associations.

The gradual replacement of the state by the technical supervisory associations, or of the technical civil servant by the supervisory engineer, coincides with a second controversy: Who is competent to formulate the technical standards according to which the supervisory personnel has to inspect and evaluate the steam engines? In the beginning of the 19th century, Prussian civil servants issued regulations for the quality of materials and for the construction of boilers. Examples are the formulas of 1831 and 1838 regulating the strength (thickness) of the sides of the boiler. Associations such as the VDI and the VDEh attacked this sort of petty regulation by proving its inefficiency. Consequently, the government retreated from regulating the ways and means of construction, but limited supervision to a pressure test of the final product. The ongoing occurence of boiler explosions, however, forced the technical associations to reconsider their policy. They established a special committee which included also representatives of the metallurgical and plate producing industries as well as of the boiler industry. The committee formulated two basic sets of regulations which were endorsed by the technical associations:

(a) Principles for the testing of materials used for the construction of boilers (Würzburg norms, 1881);

(b) Basic conditions and formulas for the calculation of plate strength for new boilers (Hamburg norms, 1885).

It is obvious that the technical associations returned to a policy of minutely regulating the ways and means of construction. This policy was bound to raise controversy as long as the state relied on its own technical civil servants in the process of technical legislation. The conflict was solved in 1908 when the state officially recognized the "Approved Regulations of Science and Technical Practice". Thereby, the task of formulating technical regulations was practically monopolized and yet kept flexible: A standing "committee for boiler norms", with an overlapping majority of engineers, served as a body of autonomous selfgovernment in matters of safety control.

A similar pattern of interplay between technical associations and government is to be found with respect to the supervision of electrical installations. (7) Here it is the German Electrical Engineering Association (VDE) which is outstanding in its activity to establish various special committees and to issue a host of regulations (Fig. 2). Examples are:

1895: Regulations for the construction and operation of high-voltage installations;

1901: Regulations for the safety of tramways;

1902: Regulations for the construction and testing of installation materials;

1910: Principles for the certification of electricity meters;

1913: Principles for the construction of telecommunications.

In the case of electrical engineering as a modern and unfamiliar technology, the state was willing right from the beginning to back by public decree the technical standards when they were formulated by the Electrical Engineering Association. Consequently, the "safety committee" of the VDE gained a position similar to that of the "committee for boiler norms" mentioned above.

A closer study of safety control as an aspect both of economic history and the history of technology might reveal more conflicts between technical expertise and economic constraints than can hitherto be recognized. On hypothetical grounds it is only too plausible to think of massive interests entering the decision making. Glimpses of such considerations are to be gained if one looks into testing of materials, a matter closely related to safety control. The rapid expansion of the railway network after 1850, and the replacement of wrought iron or puddled steel by the Bessemer and Siemens-Martin steel after 1870 set the stage for a controversy about standardization of quality. On the one hand, the largest consumers of steel, the railway companies, formed the Association of German Railway Administrations (1846). In 1876, the Technical Committee of the association demanded severe, public control of quality which would lead to a classification of iron and steel according to the testing results of the tensile strength. On the other hand, the steel producers organized themselves in the Association of Iron- and Steel Industrialists and kept close contact with the German Metallurgical Engineering Association. Both associations challenged the demands of the consumers as too rigid and pleaded for alternative testing procedures including crash or breaking tests. (8)

This instance is interesting because it reveals that technical expertise does not lead by itself to an undisputed solution of a given problem. Rather it is intertwined with non-technical considerations which differ according to the interests involved. In the case of steel production the government facilitated a compromise when it had taken over the railways and had begun to run public labs for the testing of materials.

Economic interests are supposedly even more involved, if the standardization of products is followed up. Unfortunately, no study has yet been made, to my knowledge, which investigates considerations of business benefits and losses behind the history of standardization. Therefore, it is only on the surface that we can grasp the standardization of products and the role played by the technical associations in this respect. The common procedure has been, as in the case of safety control, to set up a special committee charged to formulate regulations. In many instances, several associations sent their representatives to this committee, and so did the relevant industrial branches and, occasionally, the government. Once the regulations were accepted by the annual meeting of the leading associations, such as the VDI, they gained a semi-public recognition and were widely accepted. Examples from the metal industries include the following ones: (9)

1881: German norm book of profiles for rolled iron;

1882: Norm for cast-iron sleeves and flanges;

1886: Normal terms of delivery for iron constructional parts for bridges and overground-building.

The introduction of a unified and metrically based system of threads for screws kept the technical associations busy after 1875, and the issue was finally settled only in 1898 on an international level.(10) Standardization was even more frequent in application to the electrical industries, and one would be curious to know whether the outstanding weight of a few very large firms directed this process. Again we can only observe the same pattern of decision making, with committees of the Electrical Engineering Association as the platform, and tell the results (cf. Fig. 2): (11)

1895: Norms concerning the strenght of screws for fuses, switches, instruments, etc.;

1895: Norms for fuses, for circuitbreakers, for the strenght of cable;

1897: Terms of delivery for bulbs;

1908: Norms for the labelling of terminals at engines, starters for cooking and heating appliances.

In the last instance it is explicitly stated that this standardization did enhance the degree of exchangeability between products of different origin. It seems safe to think of external economies as a factor of "technical progress", and the technical associations served both the interests of consumers and of producers when they worked for "standardization".

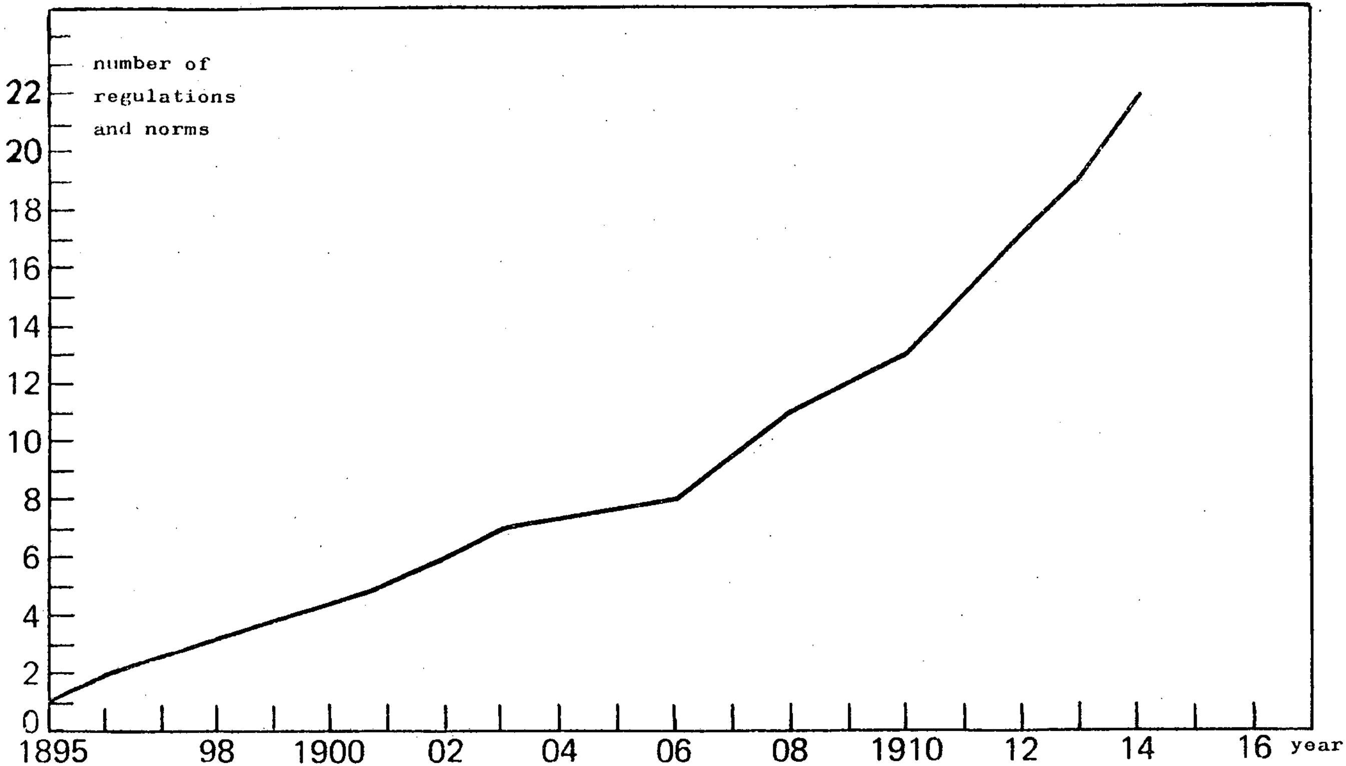


FIGURE 2: Regulations and Norms issued by the VDE, 1895-1914
(based on evidence cited in footnotes 7, 11, 13)

A final area which should be mentioned in this context is the standardization of measurement. If one aimed at comparable safety or efficiency or quality, a common frame of reference was needed. The technical associations linked up with scientists of the established research institutions. Again, special committees worked for a clarification of the relevant problems. On the one hand, norms were formulated which regulated testing procedures for comparing the power of steam engines, of gas engines and of electric engines. (12) On the other hand, the definition and realization of various units of measurement were discussed and eventually decided upon by appropriate committees. (13) It is easy to infer that this kind of regulation of technical standards bears a close relation to another field of associational activities, which is dealt with in the final section of this paper.

3. Promotion of research

In formal terms, the standard procedure of the committees appointed by technical associations can be labelled "problem formulation". That is to say, experts tried to confront given problems with the best relevant knowledge at hand, whether it be practical experience or academic science. The formal result of such a confrontation would be, first, a clear and distinct formulation of the problem, and secondly, a clarification whether a solution to the problem did exist or had to be sought. In other words, technical associations could barely avoid embarking upon the production of new knowledge, if only by enticing research into directions indicated by an ongoing problem formulation. Theoretically, therefore, technical associations should have served as important links between industry and science.

Practically, they did so in various ways and to a differing degree of intensity and success. (14) As far as the modes of directing research are concerned, two different ones can be distinguished. A traditional form was to announce a competition by advertising a prize essay, when the problem had been formulated. It can be shown, that this kind of encouragement of research did not yield satisfactory results. (15) Apparently, to rely on the individual researcher's means of research did not suffice any more. Another way, therefore, was to address existing research establishements or to plead for the foundation of new ones. It is in this area where we find our technical associations actively engaged, albeit characteristic differences between themselves prevailed.

In the field of iron and steel production the beginnings of experiments called for by the Metallurgical Engineering Association date back to the 1860s. The initiating engineers first thought of the ironworks as the appropriate places to carry out experiments. But they soon found out that secret-mongering on behalf of the industrialists severely limited the exchange of practical experience amongst engineers, let alone the undisguised and openly accessible production of knowledge. So they turned to the idea of establishing an industrial lab above the level of individual and privately owned plants, and they asked for the financial aid by the interested industrialists. Again the engeneers got disappointed, however, and it took almost four decades before the iron industry changed its mind.

Only after the turn of the century did the industrialists of this branch donate money for new metallurgical institutes at two Technical Universities (Aachen and Breslau), and somewhat later they joined forces to establish the Institute for Iron Research within the Kaiser-Wilhelm-Gesellschaft (1917).

Between the 1860s and the beginning of the 20th century, whatever there was of metallurgical research being done inside the plants was narrowly geared to greater efficiency. Judged by the Metallurgical Engineering Association, this outlook of industrial research led to an otherwise unnecessary neglect of material testing. It was government labs which took the lead in this field after the 1880s. Furthermore, the chemical committee of the association was strongly influenced by the chief chemists of the big iron-works, and the committee was mainly concerned with finding out standard and efficient devices for the chemical analysis of known processes. (16)

A rather different picture can be drawn with respect to electrical engineering. Apparently less hampered by secretmongering, the relevant association had little difficulty in promoting research whenever the necessity arose and a problem had been formulated. In doing so, the association collaborated both with private enterprise and government labs. Institutions which carried out experiments include the Munich electric power stations, the Prussian Office of Material Testing, the Imperial Administration of Telegraphy, and the famous Imperial Physico-Technical Institute. In many instances, the problem was formulated by a VDE committee; the experiments were undertaken by the institutions just mentioned; and private industry financed the whole matter, sometimes assisted by associational means. (17)

Still another pattern can be discerned, if the largest technical association, the German Engineering Association (VDI), is studied. Not being confined to any kind of specialized engineering applicable to a certain industrial branch, the VDI was mainly interested in general aspects of engineering basic to various applications. Above all, this meant a strong interest in power engines, especially in the steam engine which continuously needed improvement. As has already been shown, this interest is clearly linked with the regulation of safety control. Bearing this in mind it is somewhat curious to find out that the VDI bothered seriously about unduly neglected issues of research only after the late 1880s.

When the Imperial Physico-Technical Institute (PTR) had been founded in 1887, the VDI expected it to take into account the "wishes and demands of engineers" when embarking upon research projects. Some years later the VDI had already turned sceptical in this respect, but made another try. A special committee undertook an inquiry by soliciting every district branch of the association to name technical problems in urgent need of being studied. Out of the many answers a catalogue of problems was formulated and handed over to the PTR, which, in turn, felt unable to comply with such a major demand. Consequently, the VDI decided not to pin its hopes on the PTR any longer but to take experimenting into his own hands. (18) First of all, obviously, one had to look for an institutional alternative. In 1894, the VDI strongly advocated that laboratories be established at the Technical Universities. German governments were quick in responding, and within years a new institutional infrastructure for technical research was at hand. Secondly, this research

Table 1: Experiments promoted by the VDI, 1900-1914 (based on the evidence cited in footnote 19)

fields of research	number of experiments	expenditures (RM)	expenditures per experiment (RM)	number of years for all experiments	number of years per experiment	expenditures per experiment and year (RM)
1. testing of materials						
- by breaking strenght	3	6000	2000	6	2.0	1000
- by tensile strenght	11	52600	4781	38	3.4	1406
- other	5	23000	4600	17	3.4	1352
2. measurement						
- of power	5	13700	2740	13	2.6	1053
- other	5	15000	3000	10	2.0	1500
- new instruments	2	3500	1750	3	1.5	1166
3. power engineering						
- steam engine	10	38700	3870	56	5.6	691
- thermodynamics	9	56800	6311	30	3.3	1912
- hydrodynamics	7	23200	3314	18	2.5	1325
- aeronautics	1	35000	35000	4	4.0	8750
4. metallurgy and metal processing	9	54900	6100	23	2.5	2440
5. electrical engineering and chemistry	6	25000	4166	17	2.8	1487
total	73	347400	4758	235	3.2	1486

potential was heavily employed and supported on behalf of the VDI: by the formulation of technical problems; by subsidizing expensive experiments; and by publishing the results. For the management of this business the VDI constituted, in 1899, a standing Technical Committee (later called Scientific Advisory Board) which screened research proposals and allotted money. The members of this committee were affiliated to institutions of academic science, of big industry and of the technical civil service. Again, we see the technical association "between" science, industry, and the state.

During the period from 1900 to 1914 some 70 experiments were promoted by the VDI (Table 1) (19) A majority of them had been applied for from outside. But a considerable number of experiments was initiated by members of the committee, and many experiments were even carried out by committee members themselves, such as professors C. von Bach (Stuttgart) and C. von Linde (Munich). Thematically, most experiments belonged to the areas of power engineering and testing of materials. In terms of time and money per experiment, the range appears relatively narrow on the average. Institutionally, the experiments were mainly carried out at the Technical Universities, but also at some government labs.

It must have given satisfaction to the VDI, when the prestigious PTR, in 1913, turned to the leading technical association asking for scientific collaboration. The VDI decided to invite two PTR representatives to participate at the meetings of the VDI Scientific Advisory Board. (20) A "hybrid community" of scientists, industrialists and administrators was increasingly becoming institutionalized, and the technical associations clearly played a leading part in this process.

FOOTNOTES

1 Boeck, C.: Die technisch-wissenschaftliche Vereine, Berlin 1930.

2 The main sources are:
VDI: Peters, Th.: Geschichte des Vereins deutscher Ingenieure, Berlin 1912.
VDEh: Däbritz, W./Dickmann, H.: 75 Jahre Verein Deutscher Eisenhüttenleute. In: Stahl und Eisen 55 (1935), pp. 1253-1440.
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3 Manegold, K.-H.: Universität, Technische Hochschule und Industrie, Berlin 197o.
Lundgreen, P.: Techniker in Preußen während der frühen Industrialisierung. Berlin 1975; Scholl, L.U.: Ingenieure in der Frühindustrialisierung, Göttingen 1978.

4 Heggen, A.: Erfindungsschutz und Industrialisierung in Preußen 1793-1877, Göttingen 1977.

5 Hortleder, G.: Das Gesellschaftsbild des Ingenieurs. Frankfurt/M. 197o.

6 Sonnenberg, S.: Hundert Jahre Sicherheit. Beiträge zur technischen und administrativen Entwicklung des Dampfkesselwesens in Deutschland 181o bis 191o. Düsseldorf 1968.

7 VDE 1893-1918, pp. 20-23, 54-55, 60-62; Peters, op.cit., pp. 70, 108, 112, 126.

8 Däbritz/Dickmann, op.cit., pp. 1334-1335.

9 Däbritz/Dickmann, op.cit., pp. 1282, 13333-1334; Peters, op.cit., pp. 32, 36, 47, 116.

10 Peters, op.cit., pp. 25ff., 61ff., 73ff., 82, 90ff., 53ff.

11 VDE 1893-1918, pp. 19, 51.

12 Peters, op.cit., pp. 44ff., 93ff., 109, 115, 124, 132; VDE 1893-1918, p. 39.

13 VDE 1893-1918, pp. 45-46; Görges, H.: 50 Jahre Elektrotechnischer Verein 1879-1929. Berlin 1929, pp. 68-69; Naglo, E.: Die ersten 25 Jahre des Elektrotechnischen Vereins. Berlin 1904, pp. 80ff.

14 For a more detailed account cf. Lundgreen, P.: Forschungsförderung durch technisch-wissenschaftliche Vereine, 1860-1914. In: Wissenschaft und Gesellschaft. Studien zur Geschichte der TH/TU Berlin 1879-1929, ed. by R. Rürup, Berlin 1979.

15 Evidence can be found in Peters, op.cit., pp. 49, 51, 59, 62, 68, 74, 77, 87, 91, 102, 119; Däbritz/Dickmann, op.cit., pp. 1270-1271; Naglo, op.cit., pp. 137ff.

16 Däbritz/Dickmann, op.cit., 1266, 1270ff., 1284f., 1287f., 1344ff., 1317, 1325ff., 1339ff., 1344ff., 1378ff., 1383, 1385ff., 1429ff. For a general account cf. Troitzsch, U.: Innovation, Organisation und Wissenschaft beim Aufbau von Hüttenwerken im Ruhrgebiet, 1850-1870. Dortmund 1977, pp. 35ff.

17 Naglo, op.cit., pp. 58ff., 76ff.; VDE 1893-1918, pp. 18, 35, 37, 41f., 46f.

18 Peters, op.cit., pp. 49, 57, 60f., 71, 73, 76 .

19 The proceedings of the Technical Committee are documented in the Zeitschrift des Vereins deutscher Ingenieure, 43 (1899) - 58 (1914)

20 Zeitschrift des Vereins deutscher Ingenieure 57 (1913), p.399.