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Hermann Schmidt and German 'proto-cybernetics'

Histories of cybernetics, at least those in the English language, concentrate almost exclusively on its origins in the USA and UK, associated primarily with Norbert Wiener and colleagues, and in particular with the series of Macy conferences from 1946 onwards. Independent work was, however, carried out elsewhere. In Germany, Hermann Schmidt introduced the notion of Allgemeine Regelungskunde *[general control theory] in the early 1940s, which bore many similarities to the almost exactly contemporary work of Wiener and colleagues. Schmidt's work was subsequently largely neglected during the rapid post-war dissemination of cybernetics ideas until it was, to a certain extent, rediscovered in Germany in the 1960s. There Schmidt is often credited, alongside Wiener, as one of the two 'fathers' of cybernetics. This article presents the nature and background of Schmidt's contributions and assesses their significance.*

In his recent *Key Thinkers* article on Wiener and Bateson, Ramage (2009) correctly notes that early cybernetics was 'largely an Anglo-American enterprise'. Not exclusively, however. In this paper I discuss early work carried out in Germany that is still largely unknown elsewhere. The central figure is Hermann Schmidt, who in the late 1930s and early 1940s led a group on control engineering convened by the *Verein Deutscher Ingenieure* – one of the two major German professional engineering bodies – and developed the notion, independently of Wiener, of what he called *Allgemeine Regelungskunde* [general control theory]. This was applicable, he claimed, not only to engineering but also to such areas as biology, physiology and economics. Like Wiener, Schmidt recognised that approaches developed in engineering could be applied to a range of systems involving control and communication. Unlike Wiener, he was not part of a scientific-technical milieu in which advanced mathematics was used to characterise information and communication in the Shannon sense. Nevertheless, for Schmidt the concepts of information flow and communication within a feedback loop – whether technological, biological or social – were paramount. Schmidt was not the only engineer contemporary of Wiener to start thinking in this broader manner; for a brief comparison of his work with that of some other engineers of the period in this area see Bissell (2010).

In contrast to the work of Wiener and colleagues in the USA and UK, the wartime activities of Schmidt and his group did not coalesce into the establishment of a new discipline. The reasons for this are complex, but include the differences between the wartime organisation of military research and development in Germany and the USA; the personal circumstances of Schmidt in the immediate post-war period; the absence in Schmidt's group of knowledge of the developments in communications engineering and information theory that had been taking place in the 1940s primarily in the USA; and the huge differences in the German and American post-war environments.

Cybernetics ideas in Germany before Schmidt

The notion that living organisms can be considered in some respects as machines has a long history, dating at least as far back as Descarte's *De Homine* (1643). Nearly two centuries later Charles Bell (1827) drew analogies between the biology of bones and internal organs on the one hand, and engineered structures and systems such as buildings, pumps and pipes on the other. Herbert Spencer (1862, 1864) considered the way organisms maintain dynamic equilibrium, drawing direct comparison with the steam engine, and also extended such ideas to the equilibrium of non-living systems in the natural world. In Germany, Eduard Pflüger (1877) addressed the importance of feedback, using the example of the control of the dilation of the pupil, in a paper whose very title, 'Teleological mechanics of living nature' anticipated the classic 'Behaviour, purpose and teleology' of Rosenblueth, Wiener and Bigelow (1943). According to Pflüger's 'law of teleological causality', the origin of a need in a living organism is also the origin of the means of satisfying the need. In the case of the pupil: 'the need here is for the correct degree of excitation of the optic nerve, in the way most suitable for acute perception. Thus the *excitation* of the optic nerve itself must control the width of the pupil' (Pflüger, 1877, p. 78, original emphasis).

The most significant 'proto-cybernetic' German work of the 19th century, however, was that of Felix Lincke (1840-1917), although his ideas were not taken up until much later, and then independently. Lincke was professor of mechanical engineering at Darmstadt Polytechnic, later to become the technical university: very little else is known about him. In a lecture published in 1879 he analysed mechanical regulation in general terms, and then applied his ideas to the human body. In a way very similar to later cybernetics and even mechatronics, Lincke distinguished between the *indicator* (specifying the value of the parameter to be controlled), the *modifier* (valve, etc), the *transmission* system (between indicator and modifier), and the *motor* (to supply power for the actuation). In the human body these functions were carried out by the eye, muscles and nervous system, for example. Information flow was thus a key factor, as was feedback:

> ... we observe the movement we have induced. In other words, the stimuli to the sensitive nerve endings resulting from the changes in our relationship to the external environment are transmitted to the brain by the sensory nerves and brought to consciousness. As we see, hear, feel, etc the motion caused by our 'machine' and the accompanying phenomena, we are in a position to bring our actions into harmony with our overall intention, as well as to modify or halt them in response to changes. [...] the activity we use to direct our human 'machine' towards its goal always derives from the difference between the will and the perceived or imagined reality – that is, the difference between the desired and actual result of the action (Lincke, 1879, quoted in Henn[1], 1969, p. 181).

By the 1920s a number of German zoologists and physiologists had taken up the study of biological control processes. Jacob von Uexküll (1864-1944) and Richard Wagner (1893-1970) both considered the rôle of feedback. Uexküll (1920a, 1921) used what we would now term signal flow diagrams to represent both internal feedback loops and the relationship of the organism with its environment, while Wagner (1925) explicitly discussed biological feedback systems and later claimed priority for certain cybernetics ideas (Aumann, 2009). Both authors also applied biological ideas to society. Uexküll (1920b) published a special supplement to the *Deutsche Rundschau* on *The Biology of the State*, in which he likened the state to an organism (or group of organisms) and considered analogies within the state to the 'nutrition', 'physiology', 'diseases', 'parasites', and so on of an organism. Wagner was the anonymous author of a short 1932 publication entitled *Unemployment and deflation in the body economic from the point of view of biological laws*, in which he proposed solutions to the economic crisis based on biological metaphors including feedback (Dittmann, 2009). Finally it is worth noting the work of Viktor van Weizsäcker, who in 1940 published his *Gestaltkreis* theory, a development of gestalt psychology which takes into account continual re-patterning of biological responses through experience.

While interesting from a historical point of view, this early German work did not significantly influence the development of cybernetic ideas in the German-speaking area, and did not become widely known until well after the Second World War.

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[1] All translations from German are by the author.

Schmidt and *Allgemeine Regelungskunde*

Hermann Schmidt (1894-1968) was a physicist by training, gaining a first degree and a PhD from the University of Göttingen. In 1929 he obtained his *Habilitation*, the higher degree required to teach at a German university, from Aachen Technical University. Between 1923 and 1931 he published over twenty papers in the highly specialised field of pyrometry. He joined the German patent office in 1930, where he was responsible for the field of control systems for technical processes, and from then on his publications were almost entirely devoted to control, regulation and the social impact of technology. In 1935 he began also to lecture at Berlin Technical University as *Privatdozent*, first on physics and later on control theory, obtaining a more formal academic title (*außerplanmäßige Professor*) a few years later. He began to realise the generic nature of control engineering and its applicability to non-technical areas, and in 1939 (following his own suggestion) he was asked to chair a new control engineering committee of the VDI *Verein Deutscher Ingenieure*. Under his leadership the committee took a broad approach, working with electrical engineers, physiologists and others, and promulgating these ideas in lectures and publications. He was appointed to probably the first full chair in control engineering in Berlin towards the end of the war.

As early as October 1940, the committee organised a conference entitled 'Regulation as a basic technical and biological problem'. It included papers on flight control, the inner ear, blood circulation and precision engineering. Schmidt himself gave a wide-ranging introductory address subsequently published, as were the other papers, in the VDI's journal (Schmidt, 1941a). In this address, entitled 'Control engineering: the technical task and its economic, socio-political and cultural implications' Schmidt looked at a range of applications of the emerging discipline.

Negative feedback is at the core of control engineering, and together with communication / information is a founding concept of cybernetics. The general notion is that the actual value of some variable is compared with the desired one, and a suitable control action is undertaken to drive the actual value towards what is required. Negative feedback is thus at the heart of all goal-seeking and homeostatic behaviour, and is found in almost every modern engineered device of sufficient complexity: from electronic circuits, through the DVD drive, the automobile and chemical plant, to missile control or global telecommunications networks.

Schmidt realised this universal character of feedback, and began his paper with a comprehensive list of contemporary applications of control theory: the control of variables in electrical engineering (voltage, current, frequency, ...); process control (pressure, temperature, level, acidity, humidity, and so on); mechanical engineering (autopilots, ship stabilisation, hydraulic turbines, textile production, cinema projectors, searchlights, gun control); and biology (temperature, blood pressure, pulse rate, movement and posture, metabolism). To Schmidt, the importance of the commonality of this range of phenomena cannot be over-emphasised:

> If we are convinced that technical and non-technical feedback systems are closely related, these relationships are not to be distinguished by their specific forms in anatomy or technology, but rather in their analogous modes of operation – that is, the control dynamics. Even in engineering applications, very different controller designs can result in very similar control dynamics; while very similar controller structures can bring about quite different behaviours. The state, too, can be viewed schematically in some of its activities as the regulator of free forces, for example by the setting of prices in a controlled economy, which eliminates the fluctuations caused by supply and demand through the intervention of the state (Schmidt, 1941a, p.82).

The greater part of the published version of this paper is a technical review of feedback control, giving a generalised description of a control loop and its dynamic characteristics, including implications for stability (although without reference to the most recent contemporary work on the latter, which was just beginning to be better known in practical engineering circles). Schmidt emphasised the need particularly for mechanical and electrical engineers engaged in control applications to come to a common understanding, by means of the 'translation' from the one domain into the other[2]:

> [The translation] of a mechanical control loop into an electrical oscillatory circuit is a way in which the mechanical controller can be made more accessible to the electrical engineer. Similarly, electrical engineering, particularly the damping of electrical oscillations [...] can be of use for the mechanical control loop. By means of such electro-mechanical translations the design work of control engineering can be assisted; a mechanical controller translated into an electrical one can be something new and an enrichment of the state of the art, easily found through the rules of translation. The usefulness of the electro-mechanical analogy has been demonstrated particularly by the translation of the theory of the feedback amplifier as the electrical analogy of the mechanical control loop (p. 87).

The paper goes on to outline the work of the VDI committee. The various requirements for effective automatic control systems are considered in some detail, with a number of recommendations where further development is needed. The importance of the quality of measurement is stressed, so that accurate information can be collected and processed in the control system. Perhaps the most striking aspect of the paper, however, is to be found in the concluding sections, where Schmidt turns his attention to economic, social, cultural and political implications, expressing his clear world-view in language coloured by National Socialist ideology:

> In numerous cases humans are already unable to equal even partially the fulfilment of tasks that can be fully achieved by a control system. [...] If an economy is born of technology, then of control engineering is born a controlled economy that alone is in a position to serve the new German economic area in its entirety.
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> [...]
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> The machine created the social question of the European nations; control engineering solves it. There are two solutions: to remain behind with craft and hand tools, which leave the subject spiritually unscathed [...] or to push on, with every application of vigour and creative intellect, to the solution of the technical problem by automation, liberating the subject from technical operations. [...] In the midst of experiencing the genesis of the Greater German social state, and certain of the future, the engineer's support for and development of control engineering is therefore also a socio-political task of the greatest responsibility.
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> [...]
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> The perfection of the technical world through control engineering, and thus the removal of the human element from technical operations, which is so important economically and socio-politically, is also crucial from a cultural-political point of view. [...] It is the engineer who has [...] transported the entire nation into a new, technological world. With the continuing, creative transformation of the natural into the technical, the engineer has an

[2] Even after the war, engineers from different branches of the profession found great difficulty in learning the new common language of control engineering, as discussed in Bissell (1994).

> increased responsibility to re-orient the outlook of those who have been shifted into his world (p. 88).

In 1941, Schmidt drew heavily on this paper in a memorandum (*Denkschrift*) to the VDI Chair. He called for the establishment of an Institute of Control Engineering to study application areas in industry, the military, biology and society, with the aim – in what became a famous aphorism modelled on Galileo's alleged remark about measurement – 'to control everything that is controllable, and to render controllable that which cannot yet be controlled' (Schmidt, 1941b, p.12). His notion of *Allgemeine Regelungskunde* was applicable, he reiterated, not only to engineering but also to such areas as biology, physiology and economics.

The memorandum is structured into five sections. The first, entitled 'The importance of control engineering', reviews the trans-disciplinary nature of the technology, stressing the need for a unified approach. Control is portrayed as the culmination of technical progress from simple tools, through powered machinery, to automation. Biological phenomena such as the maintenance of temperature, blood pressure, pulse rate and so on are strongly emphasised and the point made that:

> The diversity of variables and systems to be controlled, the variety of controller designs and the disjointed nature of control theories, should not blind us to the fact that the overall task is always the same, and that it is necessary to develop a general theory of control which unites all the individual applications (p. 6).

Furthermore:

> General control theory is thus not only a matter concerning engineers from the broadest range of disciplines, it is also something that extends beyond engineering to physiology. For the physiologist is forced, in a sense, to resort to simplified schemes or models for the investigation of organic regulation processes. He finds such simplified schemes in regulation technology in a great variety of forms, as if ready made for his use (p. 8).

The second section on 'The use of control engineering' is essentially excerpted from Schmidt's earlier conference paper, calling attention to the technical requirements for effective control systems, but moving on to economic, military and social policy implications as indicated above. The remaining three short sections spell out the teaching and research duties of the proposed interdisciplinary Institute, its establishment within higher education, and the rôle of the VDI committee, in collaboration with the other major (electrical) engineering professional body, the VDE, as a link between industry and the new Institute.

After some negotiations, a chair in control engineering was finally established in Berlin in late 1944, and Schmidt was appointed – briefly – to the position. His wide-ranging approach to control ideas certainly anticipated many of the cybernetics ideas championed by Wiener after the war (Dittmann & Ségal, 1997; Dittmann, 1999-2000; Fasol, 2001, 2002), but there is no direct line from his promotion of *Allgemeine Regelungslehre* during the 1940s and the later, post-Wiener cybernetics as it developed in either West or East Germany.

The VDI committee reported regularly during the war and in 1944 issued its final report (VDI, 1944). A large part of this addressed the unifying concepts of feedback control, and the need for a common terminology. The 63-page report later formed the basis of German standards in the field. It is quite a remarkable document, since it includes virtually no reference to the wartime environment during which it was written. None of the application areas mentioned relate to specific military technology, nor to the development of high-performance gun-control servos that were so crucial to the emergence of classical control theory in the USA and the UK. Control ideas *were* being applied in Germany, however, particularly for flight control of aircraft and missiles.

The immediate post-war period

Schmidt spent the first six post-war years in East Germany, being required by the Soviet occupying powers to work on control projects there. His papers in the archives of the Berlin University of Technology include over 1400 pages of manuscript material from the late 1940s, apparently drafts in preparation for a book on control theory he was to deliver to the Russians (Fasol, 2002). On his return to the West, he seems to have encountered difficulties re-integrating into the new academic environment. Dittman (1999-2000, p. 145) refers to possible problems with Schmidt's Nazi party past, but also to 'professional animosities between him and Walter Kucharski, Professor of Mechanical Engineering [and Rector 1946-7]', while Aumann (2009, p.112) points to his having been 'embroiled in the NS-system' and thus refused university employment immediately after the war. In any event, Schmidt appears to have become a party member in a rather passive way, simply through having taken part in a scientific meeting in 1939 when he was enrolled retrospectively from 1 May 1938 (Dittmann & Ségal, 1997, p. 557); he was formally 'denazified' in 1948 without penalty. It is worth remarking here that there is no simple causal link between the post-war fortunes of German scientists and the extent to which they had been involved in the Nazi regime. Some active former party and even SS members quickly took up successful careers again, while other scientists who had been only passive or peripheral participants found it difficult to regain their former status. Schmidt was reappointed to full Professor in Berlin in 1954, but whatever the reasons, his cybernetic ideas were not immediately accepted by colleagues. Fasol (2001, p. 141) notes that even up to his retirement he occupied a Chair without a formal Faculty attachment, and that Schmidt himself rather bitterly remarked upon the desire of the individual faculties to concentrate on their own specialist control applications, rather than adopting the general, trans-disciplinary, approach that he had advocated since 1940.

Immediately after the war engineering bodies in many countries addressed issues of technology and society that had been thrown into relief by the technological nature of the hostilities. The early 1950s saw a number of VDI conferences on such themes, in part at least to counter public antipathy towards technology. A meeting in Kassel in 1950 considered 'The responsibility of the engineer', followed by 'Mankind and work in the age of technology' in Marburg in 1950. The third in the series, held in Tübingen in March 1953, took as its theme 'The transformation of mankind through technology'. By now the Cold War had set in, and an address in Tübingen by Bundesminister and VDI President Schuberth contrasted the East ('men as robots and soulless cogs') with the 'general well-being and personal freedom' of the West – even using the term 'European Commonwealth'. Schmidt gave a talk which again stressed the universality of feedback, and was followed by Wagner on biological control systems – both led to lively discussion and argument (Kraemer, 1953). VDI meetings on similar themes were to be held every two years for the remainder of the 1950s.

By this time the cybernetics developments in the USA and UK had become more widely known in Germany – although Wiener's seminal 1948 book was not translated into German until 1963, almost a decade after the translation in 1952 of his *Human Use of Human Beings* (Wiener, 1950) aimed at a less specialised audience. VDI conferences of a more technical nature also extended to what we might call cybernetic themes. In April 1954 there was a two-day meeting on biological control mechanisms in Darmstadt (Mittelstaedt, 1956) and in March 1955 a similar one in Essen on the links between processes in economics and those in engineering (Geyer & Oppelt, 1957). One of Schmidt's colleagues from the VDI wartime committee, Winfried Oppelt, gave introductory talks at both events setting the scene for the ways in which control engineering ideas could contribute to an understanding of biological and economic systems repectively.

Schmidt himself took little part subsequently in cybernetics research – or indeed developments in the narrower field of control engineering itself – although he was active in German professional bodies relating to both cybernetics and social aspects of technology. For the next decade or so he combined teaching conventional control engineering with more general speaking and writing on cybernetic topics and the implications of his ideas for anthropology, ethics, philosophy, and technology in society. In 1963 he was approached by the new Federal German cybernetics research programme, but declined to participate while the programme concentrated on experimental research, rather than developing his much wider notion of the field (Aumann, 2009, pp. 112-13).

Discussion

There is no doubt that Schmidt clearly recognised the essential features of what came to be called cybernetics, in particular the crucial nature of feedback in a wide variety of technical and non-technical systems, treated in a holistic fashion; and the general significance of communication and information in such systems. Nevertheless, although a number of later commentators have stressed that Schmidt, like Wiener, set information alongside matter and energy as a fundamental quantity in our dealings with the world (for example, Frank, 1994), he made this much less explicit than the American cybernetics movement. In contrast to the wartime environment in which Wiener and others were working in the United States, there was little concerted military research and development in Germany to enable in particular the achievements of communications engineers to be translated (to use Schmidt's expression) into general feedback applications (Bissell, 2009). Where Schmidt used mathematical models, these were limited to traditional ones based on differential equations, rather than the powerful new models based on frequency representations and an analysis of information content of messages that had been developed by communications and radio engineers in Britain and the USA. Formal models of information and information flow were lacking. Neither was there anything in Germany (nor anywhere else, for that matter) immediately after the war to compare with the enormous resources devoted in the United States to promulgate the results of wartime research (publications, conferences, research programmes, etc) and to ensure US technological supremacy in the post-war period.

Schmidt's enforced stay in the Soviet zone until the early 1950s, together with personal reasons such as academic disputation and his Nazi party membership, meant that he was unable easily to become part of the post-war German academic community. Although Schmidt had no great involvement with the Nazi regime, the fact that his wartime writings – while essentially quite apolitical for the time – were coloured by Nazi terminology and ethos, may also have been problematic. Furthermore, Schmidt published only two significant specialised papers on control engineering after the war in the period up to his reappointment to his Chair in 1954. Indeed, according to Helmar Frank (a major German contributor to cybernetics in aesthetics, psychology and teaching), writing in the introduction to an article by Schmidt on language and mathematics dating from the early 1930s but not published until 1987: 'Anyone who came into academic contact with Hermann Schmidt knows how difficult he found it to consider a manuscript finished and permit publication'. In fact, Schmidt became increasingly concerned with issues of *Mensch und Technik* (which might be paraphrased somewhat inaccurately and ahistorically as 'technology and society'), and most of his publications in the 1950s and 1960s were in this area.

Schmidt's general approach to *Mensch und Technik* was a highly technocratic and utopian one, influenced by the very problems in Weimar Germany that had brought Hitler into power. Technocratic thought goes back at least to Francis Bacon and Saint-Simon, but the modern technocratic movement – essentially the idea that society is best managed by technical experts, rather than politicians or free-market capitalists – can be said to have originated in the USA in the 1930s (Akin, 1977; Fischer, 1990). It found eager supporters in Germany (and elsewhere in Europe), both at the end of the Weimar Republic and at the beginning of the Third Reich (Willeke, 1995; Renneberg & Walker, 1994). Although some advocates of technocracy tried to adapt the American model to the requirements of Third Reich autarchy, as a formal movement it was short-lived in Germany, with both the journal *Technokratie* and the German Technocratic Society (closely linked to the Nazi party, but soon falling out of favour) coming to an end in 1936. The ideas lived on, however, in the attitudes of many individual German scientists and engineers. Schmidt, for example, saw control engineering as a major part of the way that technology would solve many of society's ills. Influenced by the philosopher Arnold Gehlen[3], who viewed human beings as having inherent flaws that could be overcome only by means of social and cultural developments and institutions, Schmidt viewed technology as playing a vital rôle in the perfection of human society (Dittmann, 1999-2000).

Although Schmidt made no specific reference to Taylorism in his early writings, his depiction of the factory worker as the 'slave of the machine', and his conviction that his *allgemeine Regelungskunde* would bring about a liberation of humankind, clearly places him amongst the critics of hard-line scientific management – although rooted in a quintessentially German humanist tradition, rather than, say, a Marxist critique. Indeed, Schmidt's vision – shared by some other early cyberneticists – has much in common with more recent utopian advocates of the benefits of the 'information revolution' and the 'knowledge economy' (Harris, 2006). Interestingly, like some of the enthusiasts for the latter, Schmidt saw the new technology, in his case automation and control, as marking a distinct break with the past and a perfection or completion (*Vollendung*) of technological progress. While his writings now seem excessively naive and utopian, and some of the German cultural background for modern readers borders on mysticism and National Socialist ideology, his emphasis on the link between the natural and engineered worlds, and the social responsibility of engineers, finds at least some resonance today. For Schmidt, the engineer must appreciate that

> his technological world is no wall separating him from nature, but a bridge upon which nature and intellect [*Geist*] meet, a world in which nature and intellect have joined forces through the work of our hands – a world, like that of language, that we have set between us and nature through our own creative power, and a world that is thus much closer to us than unspoiled nature (Schmidt, 1941a, p.88).

In his Tübingen paper he again stresses the need for active, self-aware, engagement with technology:

> We consider this to be the decisive question of the present time: whether the technological world possesses a potential for changing the intellectual and moral [*geistig-sittlich*] self-awareness of the individual person, or whether it is simply a more primitive expression of our collective humanity, without intellectual and moral potential [...], which must be protected from degeneration and directed towards our material well-being (Schmidt, 1954, p.118).

An interesting point that emerges from Schmidt's more general writing on technology and society is that the agonising over the ills and benefits of technology is by no means new. As the vanquished in

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[3] Gehlen was one of the speakers at the 1953 Tübingen conference mentioned above. For an introduction to his philosophical thought see *Man: his Nature and Place in the World* (1940, thoroughly revised in 1950). Gehlen was following an earlier German tradition dating back at least to Kapp (1877) of viewing technologies as 'projections' of human organs, and his approach influenced later German philosophers including Habermas (1969).

1945, German intellectuals were perhaps more inclined to be concerned about the issues than were the victors. Certainly there seems to have been more soul searching in the German professional engineering societies than in the British and American ones.

Cybernetics as a discipline has had an interesting history: at different times and in different places both hailed as a panacea and dismissed as bourgeois nonsense (Gerovich, 2002; Dittmann & Seising, 2007). Cybernetics took off in the Federal Republic of Germany in the 1960s, at which time Schmidt was sometimes hailed as a pioneer of similar standing to Wiener; see, for example, the introductory chapter in Frank (1962). Schmidt's 1941 *Denkschrift* was reprinted in 1961, and he wrote a number of general articles over the following years; a bibliography can be found in Dittmann & Segal (1997). Recent commentators have been more circumspect, warning against attributing excessive significance to his work, and noting that histories of the forerunners of cybernetics are often as much about constructing national intellectual identities as about tracing lines of development (Aumann, 2009). An interesting little book that lends some weight to this argument is *Grundfragen der Kybernetik* (Haseloff, 1967), based on a series of talks broadcast by RIAS (*Rundfunk im amerikanischen Sektor*). The first four chapters are each entitled 'The origin and rise of cybernetics'; significantly, Wiener's thoughts on this topic are followed immediately by those of Wagner, Schmidt, and Konrad Züse (who had built an electromechanical computer in Germany during the war).

At least one German critic, however, has detected a rather wider import to Schmidt's ideas compared with the early Wiener (Fassler, 1999). One major difference in the thinking of the two is certainly their approach to the rôle of the human: where Wiener was at pains always to distinguish between the human and the machine, Schmidt tended to emphasise the human together with the machine as the overall system. Indeed, in his concept of the *objektivierte Handlungskreise* (the incorporation of technology into the human behavioural circle) it is tempting to see a step towards the later cyborg approach, although without the social critique of either some mid-20th century cultural critics or more recent theorists of technology and society (Franklin, 2002).

The precise differences between the early thinking of Schmidt and Wiener are not the major issue here, however, nor are we primarily concerned with the extent of Schmidt's influence, or lack of it, on subsequent developments in cybernetics. Rather, the work of Schmidt is of interest, for a number of reasons, to anyone concerned with information, communication and society. First, it is a fascinating story in its own right in this core area of twentieth century technology. Second, it reminds us that technological developments are deeply intertwined with the cultural history of people and places. And, finally, it sensitises us to the anglocentric nature of many accounts of technological developments during a period in which the hegemony of the English language became established in many disciplines, and the United States emerged as uncontested technological superpower.

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