Innovation Without the Word:
William F. Ogburn's Contribution
to Technological Innovation Studies

Benoît Godin
385 rue Sherbrooke Est
Montreal, Quebec
Canada H2X 1E3
benoit.godin@ucs.inrs.ca

Project on the Intellectual History of Innovation
Working Paper No. 5
2010

Previous Papers in the Series:

1. B. Godin, *Innovation: the History of a Category*.
2. B. Godin, *In the Shadow of Schumpeter: W. Rupert Maclaurin and the Study of Technological Innovation*.
3. B. Godin, *The Linear Model of Innovation (II): Maurice Holland and the Research Cycle*.
4. B. Godin, *National Innovation System (II): Industrialists and the Origins of an Idea*.

Project on the Intellectual History of Innovation
385 rue Sherbrooke Est, Montreal, Quebec H2X 1E3
Telephone: (514) 499-4074 Facsimile: (514) 499-4065
www.csiic.ca

Abstract

The history of innovation as a category is dominated by economists and by the contribution of J. A. Schumpeter. This paper documents the contribution of a neglected but influential author, the American sociologist William F. Ogburn. Over a period of more than thirty years, Ogburn developed pioneering ideas on three dimensions of technological innovation: origins, diffusion, and effects. He also developed the first conceptual framework for innovation studies – based on the concept of cultural lags – which led to studying and forecasting the impacts of technological innovation on society. All in all, Ogburn has been as important to the sociology of technology as Robert K. Merton has been to the sociology of science and Schumpeter to the economics of technological innovation.

We are so obsessed with the delight and advantage of discovery of new things that we have no proportionate regard for the problems of arrangement and absorption of the things discovered.

J. Stamp (1937), *The Science of Social Adjustment*, London, Macmillan, p. 60.

Innovation Without the Word:
William F. Ogburn's Contribution
to Technological Innovation Studies

Introduction

In the last few years, papers have appeared that attempt to "map" the field of technological innovation studies and identify the classic authors behind current research. Such studies are definitely witness to the fact that this field is becoming mature enough to look back at its own scientific production. At the same time, they help to provide or to strengthen the identity of a community of scholars around key ideas and authors.

The danger is that such assessments may, unintended by their authors, function as promotional material for a particular vision of innovation. These studies rightly highlight the role of J. A. Schumpeter in innovation studies: a precursor (Martin, 2008), and an exception among economists (Fagerberg and Verspagen, 2009). Schumpeter is definitely a forerunner in the study of technological innovation. However, these studies also omit some influential authors. One is economic historian W. Rupert Maclaurin, a pioneer in the study of technological innovation in the 1940s, developing theories far more precise than Schumpeter's with regard to the process of technological innovation (Godin, 2008b). Maclaurin evidently deserves no mention despite the influence of his linear model of innovation on academic and policy circles in the following decades.

Another forgotten classic is American sociologist William F. Ogburn (1886-1959). Over more than thirty years, Ogburn studied technological innovation through its many effects on society, producing dozens of articles and books. Together with his colleague S. Colum Gilfillan, Ogburn was among the first academics to devote extensive and systematic studies to technological innovation. In fact, with regard to the study of innovation, the sociologists preceded the economists, who in recent years have chosen to concentrate on innovation defined as commercialized invention.

Born in Butler, Georgia, Ogburn received his PhD from Columbia University in 1912, taught in several of the social sciences – economics, political science, history and sociology – at various American universities between 1911 and 1927, among them Columbia University (1919-1927), then became professor of sociology at the University of Chicago until he retired in 1951. Ogburn held highly influential positions in the field of sociology. He was president of the American Statistical Association and editor of its journal for six years. He was also chairman of the Social Science Research Council, and the first president of the Society for the History of Technology (founded in 1959). Ogburn also served as consultant and expert to many US government commissions and agencies. To name but a few, he was chairman of the Census Advisory Committee for a number of years, he was director of President Hoover's Research Committee on Social Trends (1930-1933), which published the two-volume report on social indicators titled *Recent Social Trends* in 1933, and he served as research director for the National Resources Committee's exercise on technological forecasting, which produced *Technological Trends and National Policy* in 1937.

How could researchers miss such an important figure in their writings on the field and on the "history" of innovation studies? The reasons are many. The first may have to do with the methodology used. The studies are based on bibliometrics (a technique that catches only what one puts into it as input, and that is a poor substitute to more in-depth studies) and/or rely on surveys based on self-assessments by researchers (whose memory fails and whose knowledge is selective). The scope of these studies is policy, management and economics, with little or only residual interest in sociology. These studies are also mainly concerned with one type of innovation (technological), and only within organizational settings.

The second reason may be the relative absence of extensive studies on Ogburn. While papers on Schumpeter are published by the dozen every year, Ogburn still awaits an appropriate assessment of his huge output. Except for O. D. Duncan (1959), T. E. Huff (1973) and, to a lesser extent, R. Volti (2004), no serious study exists on Ogburn's life and works, although several sociologists have noted his contributions, for example in

handbooks, histories and encyclopedias of sociology, and many papers have discussed and criticized his concept of the cultural lag. [1] Furthermore, the few authors who over the last two decades have discussed Ogburn usually stop at the sociological literature – with references to the philosophy, the anthropology and the history of technology (for example Brannigan, 1981; McGee, 1995) – neglecting to document the conceptual link between Ogburn, economists and what some call the field of innovation studies.

Third, the neglect of Ogburn may be due to the absence in Ogburn's writings of the term innovation (see Appendix 1), a term that was just beginning to appear in the academic literature of the 20th century. However, as it would be a mistake to study an object or concept (innovation) in construction only through those who have used its (yet-to-come) name (as bibliometric studies that select their sample based on words do), it would also be a mistake if it is forgotten that an idea may exist before the word as such comes into use. Ogburn was getting into a new field of study with his own vocabulary, as every author of the time did. Certainly, it would be Whiggish history to suggest a linear progression from Ogburn to what came to be called innovation. However, it is a historical fact that later sociologists labeled Ogburn's object of study as innovation.

This paper aims to document Ogburn's contribution to the study of innovation. It looks at Ogburn's work from the perspective of what I call a comprehensive theory of innovation. A comprehensive theory of innovation addresses innovations in ideas, things and behaviours – not only technology – and covers three dimensions: 1) the origins or sources of invention and its development, 2) its diffusion and use, and 3) its effects or impacts. I examine and interpret Ogburn in light of his contribution to each of these three dimensions. No one has yet produced such a comprehensive theory, not even Schumpeter. However, such a framework allows one to identify the strengths and weaknesses in an author's theory.

[1] For some very brief biographical information and a list of Ogburn's publications, see Odum (1951), Duncan (1964) and Jaffe (1968). This represents almost the entire list.

The first section of this paper places the study of innovation in perspective, examining innovation as a factor in social change. The rest of the paper documents Ogburn's discussion and treatment of the above three dimensions of innovation: its origins, diffusion and effects. Some of Ogburn's ideas are well known and have been used, discussed and criticized widely, like that on the inevitability of invention (R. K. Merton). The next two sections of this paper briefly document two of these ideas: "culture" as a source of invention and cultural lags as a framework for the study of the diffusion of innovation. These sections also document Ogburn's use and adaptation of the psychological idea of *combination* to explain the source of invention, and discuss *social invention* as an aid – a necessary one – for the diffusion of technological invention. The last two sections each highlight rather neglected aspects of Ogburn's ideas and their contribution to a theory of innovation. The first is the study of the *social effects* of technology. Social effects is a much neglected aspect of current technological innovation studies. Ogburn's originality lies in a (sequential) model on which his whole theory of social effects is based. The model allows Ogburn to incorporate origins, diffusion and effects of invention into a single sequence. The final section looks at the policy relevance, or "appliedness" of Ogburn's work: forecasting the social impacts of technology. Again, forecasting is made possible precisely because of a systemic view of invention, as suggested in Ogburn's sequential model.

In this paper, I cite passages from Ogburn widely, for it is the language used that reveals an author's ideas and their development. I let the author speak for himself. This paper is in fact part of a larger project on the intellectual history of innovation. In this project, concepts, their context and their uses are fundamental entities since, as Q. Skinner has suggested on many occasions: "words are markers of the social understanding of the world, and the emergence of new words is a marker of changes in society's values" (Skinner, 1988). Ogburn's concern with the "use of technological invention" (as opposed to invention *per se*) is precisely what over time came to be labeled as technological innovation.

Change

Early writers on innovation during the sixteenth and seventeenth centuries were concerned with change as the antithesis of orthodoxy and authority (Godin, 2010). The introduction of change or novelty – in religion and politics – defined what innovation is; it had nothing to do with technology. At the time, the term innovation was pejorative, and would remain so until the late nineteenth or early twentieth century. Then, innovation acquired a positive association and change became a topic for study. Not surprisingly, in studying innovation, researchers turned to the concept of change: cultural change (anthropology), technological change (economics) and social change (sociology). In fact, no-one can study innovation who is not interested in change, since innovation is about bringing something new into the world: an idea, a behaviour (or action) or an object (Barnett, 1953).

Social change is precisely what Ogburn was interested in explaining: "why social changes occur, why certain conditions apparently resist change, how culture grows, how civilization has come to be what it is" (Ogburn, 1922b: v). To Ogburn, "invention is the evidence of change. If there are few inventions, there are few changes" (Ogburn and Nimkoff, 1940: 815).

In explaining change, Ogburn opposed evolutionary theories based either on biological explanations or on the development stages of culture. To Ogburn, social change cannot be comprehended using biological explanations. Such explanations, which were much in vogue at the time of Ogburn's 1922 publication *Social Change with Respect to Culture and Original Nature*, placed biology at the core of human "evolution". Culture was generally interpreted in terms of the biological factor: "It is quite generally assumed that the status of the culture of any people is an index of the stage of their inherent mental development as a race" (Ogburn, 1922b: 63). That culture grows, or accumulates, is rather "due to two features of the cultural process, one is the persistence of culture forms (tradition) and the other is the addition of new forms (invention)" (Ogburn, 1922b: 74).

To Ogburn, "biological changes are slow" (Ogburn, 1922b: 123): "Biological variations and transmissions of these variations occur through a slow process of heredity and selection, and through mutations whose frequency is not great" (Ogburn, 1922b: 123-130; see also Ogburn, 1938b). Consequently, as A. J. Jaffe put it, "the explanation of social change must be sought in culture rather than in the biological nature of man" (Jaffe, 1968: 278): "Within the last several hundred years the number and rate of cultural changes have been much greater than the number and rate of biological changes (…). At the present time, inventions are more frequent than mutations" (Ogburn, 1922b: 131). [2]

Ogburn also opposed the efforts of anthropologists and others to develop grand theories of change, or evolution by stages, *à la* Spencer. [3] To Ogburn, "attempts were made to establish the development of particular social institutions in successive stages, an evolutionary series, a particular stage necessarily preceding another (…). A half-century or more of investigations on such theories has yielded some results, but the achievements have not been up to the high hopes (…). The inevitable series of stages in the development of social institutions has not only not been proven but has been disproved" (Ogburn, 1922b: 57). To Ogburn, "the concept [social change] bears a certain relation to the somewhat earlier ones, social evolution and progress. Social evolution had come to be identified fairly closely with the dogma of inevitable successive stages of development based on biological determinants; and progress usually implied a faith in borrowed standards from current morals. The need for a term free from dogmatic or moral implications explains the present day preference for the expression social change (…)" (Ogburn, 1933-34: 330).

Rather than follow existing biological or anthropological theories, Ogburn concentrated on studying the mechanisms of change. To Ogburn, a central factor or mechanism of social change was technological invention, or "material culture" as he called it in 1922 following the usage of anthropologists, among them O. T. Mason and Clark Wissler. "The key to [social] change may be sought in invention, [namely] any new element in

[2] For an early criticism of Ogburn's view on biology and psychology and their contribution to culture, see Allport (1924).
[3] Inorganic, then organic, then superorganic. See Spencer (1877: chapter 1).

culture (…). To understand social change it is necessary to know how inventions are made and how they are diffused" (Ogburn, 1933-34: 331).

To Ogburn, "technology has possible contributions to sociology on a plane quite comparable with those of geography, biology, and psychology" (Ogburn, 1938b: 8). However, "there have been", Ogburn claimed, "no sociologists who based sociology on technology (…). The neglect of the consideration of technology by sociologists has resulted, it is thought, in a great loss in the development of sociology" (Ogburn, 1938b:1). [4]

To Ogburn, two forces were at work (Ogburn, 1922b). On one hand, invention (and its diffusion) is growing at an accelerated rate, as he would repeat all his life. On the other hand, inertia and resistance lead to delays or lags in adoption and adjustment of adaptive culture or social institutions. These reflections he first developed in *Social Change* in 1922. To Ogburn, "the environment of man may be said to consist of two parts", natural and social. The latter, often called culture (civilization refers to the late phase of culture, or modern culture), really includes two dimensions, the mental and the material. To Ogburn, "the use of material things is a very important part of the culture of any people" (Ogburn, 1922b: 4), but is not particularly emphasized in the usual definitions: "there is a tendency to think of culture as somewhat removed from material objects" (Ogburn, 1922b: 5). To Ogburn, culture is social heritage: "culture may be thought of as the accumulated products of human society, and includes the use of material objects as well as social institutions and social ways of doing things" (Ogburn, 1922b: 58; see also Ogburn, 1933-34: 332; Ogburn and Nimkoff, 1940: 794-795). [5] In this sense, Ogburn was relying here on discussions of the time as to what culture is, and opted for the anthropologists' definition of culture as the products of societies and the processes and social factors responsible for them (Wissler, 1916; Kroeber, 1918; see also Ellwood, 1918).

[4] On Ogburn's evaluation of the contribution of anthropology and economics to technological studies, see Ogburn (1937). On his evaluation of history and technology, see Ogburn (1942).

[5] In a later paper, Ogburn put material culture, or technology, on a par with the natural and social environments, namely as a third environment *per se* (Ogburn, 1956).

As already mentioned, to Ogburn culture grows by means of invention (and its diffusion). How then do inventions occur? Ogburn studied three factors (Ogburn, 1922b: 80f): 1) individuals (mental ability), 2) culture base (antecedents and achievements), and 3) "social attitude towards the new" (Ogburn, 1922b: 111). Ogburn would develop his views on these factors over the next three decades, as I discuss in this paper. He got deeper into many dimensions of this theory, first expounded in *Social Change*, in many subsequent papers (see, for example, Ogburn, 1933-34; Ogburn, 1938b), brought the major findings into his general sociology (Ogburn and Nimkoff, 1940) and applied it to government studies (US President's Research Committee on Social Trends, 1933; US National Resources Committee, 1937b). In summary: 1) he would downgrade the role of individuals as the source of invention; 2) he would argue rather for the social roots of invention; 3) he would suggest the concept of cultural lag to account for "why culture does not change" and to study the effects of invention.

Ogburn has often been accused of technological determinism. Indeed, we can find a great deal of evidence of such determinism in Ogburn's writing: "what you do is likely to be determined by technology" (Ogburn, 1938a: 2); social change is "caused" by inventions (Ogburn, 1936b: 2). However, this determinism is sometimes more nuanced: inventions are "one" of the greatest sources of change in social institutions (Ogburn, 1937b: 365); social problems are influenced "in part" by inventions (Ogburn, 1937a: 8).

Determinism is an easy accusation, but it deserves qualification. In fact, Ogburn's intent was, as he put it, "to trace out the processes of one factor, technology" because of its important role in social change (Ogburn, 1949c: 17), not to neglect other factors. In fact, and probably in reaction to the accusation of technological determinism, in the mid-1940s he started emphasizing that several other causes or factors exist – although he had also mentioned the fact regularly before that date. He also began to discuss explicitly how technology is not a matter of a dichotomy between inevitability and choice, but rather a continuum and a matter of probability. He felt that men have relative freedom of choice (Ogburn, 1949c: 17-19; Ogburn, Adams and Gilfillan, 1946: 72-75).

Against Great Men Theories

I have suggested that a comprehensive theory of innovation deals with at least three dimensions of invention: its source, its diffusion and its effects. To different degrees, Ogburn's theory addresses these three dimensions. This section is concerned with the origins and sources of innovation.

In a paper published in 1926 and titled *The Great Man versus Social Forces*, Ogburn suggested that the "role of technology in history is clouded by the devotion to heroes (…). We like our history to be in terms of the exploits of great men" (Ogburn, 1938a: 2; see also Ogburn, 1926: 38). To Ogburn, "the discovery of the calculus was not dependent upon Newton; for if Newton had died, it would have been discovered by Leibnitz. And we think that if neither Leibnitz nor Newton had lived, it would still have been discovered by some other mathematician" (Ogburn, 1926: 37).

Ogburn's colleague Gilfillan has held the same discourse (Gilfillan, 1927; 1935b). [6] He deplored the fact that "the very essence of invention is commonly misunderstood": "we are still in the antediluvian geologic age, holding a cataclysmic rather than evolutionary theory of the origin of things. The great inventions are supposed to have been made by certain great men, much as Adam was made and then leaned against a fence to dry, according to the song" (Gilfillan, 1935b: 3). To Gilfillan, the great man or genius as hero is a mythology for historical origin "to increase the cohesion of [a] group and its loyalty to its living leaders" (Gilfillan, 1935b: 77-78).

Certainly, to Ogburn (the making of) inventions depends on individuals, more particularly those people in the upper strata of the curve of mental ability in a population. To Ogburn, mental ability refers to learning and education not heredity. But the (material) culture has a good deal to do "with determining the nature of the particular inventions that are made" (Ogburn and Thomas, 1922a: 87). As evidence, Ogburn looked at the phenomenon of independent or duplicate inventions (and discoveries), a fact first

[6] A paper on Gilfillan's life and works would be invaluable, but none exists. Occasionally, I use some of Gilfillan's papers to complement Ogburn's arguments.

discussed during the patent controversy in nineteenth century Britain (Macleod, 2007: chapter 9), then by anthropologists like A. L. Kroeber (1917: 199f). In a paper published in 1922, the same year that *Social Change* appeared, Ogburn produced a list of 148 inventions, and determined that "many inventions have been made two or more times by different inventors, each working without knowledge of the other's research" (Ogburn and Thomas, 1922a: 83). Briefly stated, the "inevitability" of an invention is witness to how invention depends on the cultural factor, or preparation, and on cultural needs. [7] Ogburn concluded as follows: "Since the existing status of culture is so important a determinant of a succeeding culture, since culture is so highly variable, since inherited mental ability is so stable, we must conclude that the processes of cultural evolution are to be explained in cultural and social terms, that is, in terms of sociology and not in terms of biology and psychology" (Ogburn and Thomas, 1922a: 93).

What then is the role of the individual? Certainly, men and their inherited qualities and mental abilities greatly influence the times, but only through favourable social conditions (Ogburn, 1926: 40), that is, through cultural materials and social valuations. He states: "Great men thus appear as media" (Ogburn, 1926: 41). Men are a medium in social change (Ogburn, 1926: 43). Great men are the product of their times, and they in turn influence their times (Ogburn, 1926: 42). "The production of great men and their influence are strongly conditioned and determined by the particular existing stage of historical development. The great man and his work appear therefore as only a step in a process, largely dependent upon other factors" (Ogburn, 1926: 43).

What are the implications for understanding the nature of invention? McGee (1995) has documented the difficulty that Ogburn and several contemporary sociologists had in establishing a consistent sociology of invention that was culturally constructed and without reference to the role of the human mind. McGee looked at Ogburn as he wrestled with this intellectual challenge through the 1920s and 30s, and showed that neither he nor the others sociologists were able to escape their contradictions. As a result, I suggest, there is no theory or study of the act or activity of invention in Ogburn's work. Ogburn

[7] The concept of independent invention has been widely used and criticized since Ogburn, particularly for methodological reasons. On Ogburn's awareness of the limitations, see Ogburn and Thomas, 1922: 93.

takes invention for granted. The *lacunae* would be filled by psychologists, economic historians and sociologists of technology in later years. What Ogburn offered was an alternative to great men theories in the form of principles (and laws) yet to be tested empirically, which Gilfillan would do (Gilfillan, 1935a). To Ogburn, invention is an evolutionary process of combination/accumulation in the following senses.

One of Ogburn's recurrent findings was the exponential growth of invention, an influential idea indeed. [8] In 1922, he called the growth of inventions, or the curve that represents them, a compound interest law, as an analogy to capital: "with compound interest the interest is not spent but is added to the principal and the succeeding sizes of the growing principal mean a larger amount of interest" (Ogburn, 1922b: 105-106). Similarly, the greater the number of inventions, the greater the number of new inventions generated: "when the material culture was small inventions were few, and now when the material culture is large the inventions are many (Ogburn, 1922b: 105). The fact of his measuring an accelerating rate of inventions stems from defining invention as a complex of elements, a combination.

The idea of combination was widespread for centuries in discussing "invention". Among the first theories of imagination, psychological in kind, was that on the association of ideas (Locke, Hume): complex ideas emerge from the creative combination of simple ones (Rapaport, 1974). To Ogburn, [9] invention is the combination of prior art and ideas, "the combination of known elements into a new element" (Ogburn and Nimkoff, 1940: 790; see also p. 780, 789). However, combination is more than the mere "material or physical" combining. To Ogburn, combination refers to a social and evolutionary process. First, invention depends on many individuals, not one genius, as discussed above. Again, the argument was first offered in nineteenth century Britain (Macleod, 2007: chapter 6).

[8] Ogburn's exponential curve has been criticized regularly throughout history. See for example: Sorokin (1933) and Schmookler (1966: 59-63). For an influential user, see Price (1961; 1963).
[9] And to G. Tarde, Gilfillan, Schumpeter and many others: O. T. Mason, A. P. Usher, J. Rossman and H. G. Barnett.

Second, invention as combination is "the cumulative effects of many small inventions" (Ogburn and Gilfillan, 1933: 124); "The new element in the invention is relatively small (Ogburn, 1926: 38), In fact "the great majority [of inventions] are minor ones, or represent only small improvements", Ogburn stated (Ogburn and Gilfillan, 1933: 159): "The majority of inventions are merely slight improvements on some existing device (…). The story [of invention] is incomplete (…) without consideration of the influence of smaller inventions" (Ogburn and Gilfillan, 1933: 160). [10] As Gilfillan put it, invention is the result of accumulation and accretion of minor details, modifications, perfectings, and minute additions over centuries, rather than a one-step creation (Gilfillan, 1935b: 3; 1937b: 18). [11] To both authors, an invention is "a step in a process rather than the entire creation of something new" (Ogburn, 1926: 38). Inventions are "not born full-grown as Minerva in mythical history" (Ogburn, Adams and Gilfillan, 1946: 60). They have a "life history". It is worth mentioning here that Ogburn's accumulation, or evolutionism, is selective accumulation: "new forms of material culture are added and some old ones discarded" (Ogburn, 1922a: 75). Ogburn regularly deplored "a tendency to overemphasize [the] cumulative nature [of invention and the failure] to recognize the amount that is lost" (Ogburn, 1922b: 76).

Third, invention is more and more systematic, or organized. This element of the definition was absent from Ogburn's theory, but was discussed later by Gilfillan and others. [12] Recalling industrialists' discourses of the time, sociologists observed a movement from the independent inventor toward organized research in industrial laboratories (Gilfillan, 1935b: 52-54, 63; Hart, 1931: 552-562). This would soon define the contemporary understanding of invention, first of all among economists – who have never studied the psychological aspects of it. Invention came to be equated to research and development (R&D), and "opening the black box" of R&D became a *leitmotif* among many researchers (Godin, 2009a) who saw invention as a combination or complex of

[10] To Ogburn, minor does not refer to the physical dimension of the technology but to its social influence.
[11] In sociologists' hands, the idea became a *leitmotif*, although one had to wait until the 1980s and after for empirical studies of what came to be called technological "development". For an early discussion of technological development among sociologists, see Jewkes *et al*. (1958: chapter 8).
[12] A brief mention of the phenomenon appeared in the report from Ogburn's Committee on Technological Trends, discussed below (US National Resources Committee, 1937b: vi).

diverse elements and activities: design, science, material, method, capital, skill and management (Gilfillan, 1935b: 6).

In sum, "a great discovery or invention often requires many years of effort, usually by several inventors and the contributions of many inventions" (Ogburn, Adams and Gilfillan, 1946: 59). It is a threefold combination of previous inventions, many individuals and diverse activities.

Cultural Lag as Framework

Like Tarde and most anthropologists, to Ogburn "diffusion is relatively the much more common occurrence" than invention itself in explaining change (Ogburn, 1922b: 89). However, Ogburn did no study of diffusion: how inventions are diffused, by whom, and why inventions are adopted. It was left to agricultural sociology to develop sociological theories on the diffusion of inventions starting in the 1940s. Ogburn seems not to have been aware of this literature. In fact, as E. M. Rogers put it, there was relative isolation and lack of communication between the different traditions (Rogers, 1962: 54-55; Valente and Rogers, 1995). However, Ogburn's concept of cultural lag was his framework to address the question of diffusion: lags are witness to imperfect diffusion or no diffusion.

During the twentieth century, there were two influential theoretical frameworks for studies on science, technology and innovation. One was the linear model of innovation, the origins of which are due to W. Rupert Maclaurin from MIT: innovation starts with basic research, then applied research, then development (Godin, 2006; 2008b). The other was that dealing with lags. According to Ogburn, psychological and social resistance to the diffusion and use of inventions leads to social maladjustments. To Ogburn, adjustment (and maladjustment) is a relative term: "only in a few cases would there be a situation which might be called perfect adjustment or perfect lack of adjustment" (Ogburn, 1922b: 212). Ogburn identified two sorts of maladjustments. One concerns the adaptation of man to culture. The other is that between the different parts of culture:

"various parts of modern culture are not changing at the same rate, some parts are changing much more rapidly than others (…). A rapid change in one part of our culture requires readjustments through other changes in the various correlated parts of culture" (Ogburn, 1922b: 200). Hence the source of cultural lags: "A cultural lag occurs when one of two parts of culture which are correlated changes before or in greater degree than the other part does, thereby causing less adjustment between the two parts than existed previously" (Ogburn, 1957a: 167). To Ogburn, lags were "a problem of only modern times. In very early times changes were not sufficiently numerous and frequent to give rise often to any very significant problem of this nature (…)" (Ogburn, 1922b: 265).

Ogburn is principally interested in the lags or delays between the material part of culture and the non-material part, or adaptive culture (rules, religion, family, policy). To Ogburn, "a preponderant number of [cultural] changes are begun in the material culture causing changes in the non-material culture" (Ogburn, 1922b: 275). In fact, "the material and natural scientific part of the cultural base appears to be growing more rapidly than the non-material part (…). The social life (…) is compelled to adjust itself to changes in material culture" (Ogburn, 1933-34: 332).

What are the causes of cultural lags or, differently put, of the obstacles to the adoption of invention? There are psychological and social factors such as survival of old customs, utility and easiness of existing cultural forms, vested interests, tradition, habit and conservatism, and difficulties in diffusion (like geographical isolation, climate or natural environment, differences between two cultures) (Ogburn, 1922b: 145-196). This leads to lack of (social) invention in the adaptive culture. To Ogburn, values are an important factor here. Ogburn contrasts "fear of the new and respect for the traditional" to "valuation upon originality, invention, research" (Ogburn, 1933-34: 333). This is a recurrent contrast in the literature on invention. Ogburn once examined stationary societies *versus* changing ones based on eighteen cultural traits (Ogburn, 1936a). He also contrasted radicals and conservatives: "modern populations tend to be split into conservatives and radicals, according to the position they take relative to [social] changes (…). The radical is very much interested in furthering change, at least in certain

directions, while the conservative in general resists most efforts to alter the present situation" (Ogburn and Nimkoff, 1940: 814).

In *Social Change*, Ogburn illustrated his thesis on lags with examples taken from industrial relations, taxation, family, international relations and democracy. But he could not measure these lags because of methodological difficulties: 1) adaptation is a matter of degree, 2) changes are sometimes quite gradual and 3) defining the adaptive culture is difficult (Ogburn, 1922b: 254-256). Ten years later, he was a bit more confident: of the four great social organizations (economy, government, church, family), only the economy has "adjusted to mechanical invention as is shown by the remarkable gains in the records of productivity (…) with consequent increases in the standards of living" (US President's Committee on Social Trends, 1933: xiv). In collaboration with his colleague Gilfillan, Ogburn estimated that "there is a long period of time between the date of originating an invention and the time when it becomes ready for commerce (…). This interval (…) [varies] from two years to several hundred, the median interval being thirty-three years" (Ogburn and Gilfillan, 1933: 163).

The lag concept was fruitful for Ogburn in many senses, among them in forecasting inventions, as discussed below. It also allowed Ogburn to define invention broadly. As to his inclusion of material objects in his (broad) definition of culture, Ogburn included social inventions alongside technological ones in his definition of invention. In fact, if there were to be social adjustments, there had to be social inventions to reduce lags and maximize the benefits of technology. To Ogburn, social change and social invention are the solutions to maladjustments between technology and culture: material invention invites social invention. Social invention is "any invention that is not mechanical and that is not a discovery in natural science" (Ogburn and Nimkoff, 1940: 859-860). It consists, for example, of policies like forest conservation or workers' compensation (Ogburn, 1922b), and includes such things as clearing houses, IQ tests, chain stores, patent laws, passports, lock-outs, basketball (Ogburn and Gilfillan, 1933: 162), proportional representation, social insurance, the holding company, and the League of Nations

(Ogburn, 1936b: 2). Ogburn identified fifty such social inventions (Ogburn and Gilfillan, 1933: 163) (see Appendix 2).

What is the relationship between the two types of invention, technological and social? To Ogburn, "mechanical invention is [not] the source of all change (…). Just as mechanical inventions furnish an incentive for certain social inventions, so social inventions sometimes stimulate the making of mechanical inventions (…)" (Ogburn and Gilfillan, 1933: 124). Which comes first, the mechanical invention or the social invention? To Ogburn, "in some cases, the social invention is first (…). But in other cases the mechanical development comes first (…)" (Ogburn and Gilfillan, 1933: 125). The close relationship between social and mechanical invention is characteristic of the nature of the influence of inventions on society (Ogburn and Gilfillan, 1933: 124): "the more one studies the relationship between mechanical and social invention, the more interrelated they seem" (Ogburn, 1936b: 2).

The source of the concept "social invention" was sociologist L. Bernard, who first used it in a paper contrasting two periods of invention – the empirical and the purposive (scientific) – and applied the analysis to social as well as technological invention (Bernard, 1923). The concept also owes something to F. Stuart Chapin's *Cultural Change* and his study of the growth of cultural traits and social institutions (Chapin, 1928). However, the study of social invention had few followers. In line with the traditional hierarchy of knowledge between the mechanical and the liberal arts, social researchers, including Ogburn, preferred to concentrate on material (technological) invention: "it is necessary in this paper to eliminate from the idea of invention these extensions [social inventions] into the field of non-material culture" (Ogburn, 1942: 66). [13]

The lag concept, which has forerunners in Eugène de Roberdy (1908: chapter 11), was much discussed (and criticized) among sociologists in the following decades (Woodard, 1934; Choukas, 1936; Herman, 1937; Mueller, 1937; Schneider, 1945; Carr and Stermer, 1952), owing partly to its popularization in *Recent Social Trends* (see below) and the

[13] Nevertheless, the concept of social invention is widely discussed, alongside that of mechanical invention, in Ogburn and Nimkoff, 1940: Part 7.

widespread use of the concept in the debate on technological unemployment in the United States in the 1930s. Ogburn had to defend the concept throughout his life (Ogburn, 1957).

However, the lag concept has also provided a very influential conceptual framework to science, technology and innovation studies, and to policy. The concept was used by many early students of technology (Chapin, 1928; Stamp, 1929; Bernal, 1935: 50; 1939: 131; Gilfillan, 1935b; 1952; Hart, 1957; Hart and Allen, 1957), and then in economists' discussions of adjustments to technological innovation (Kuznets, 1972; Mansfield, 1968). The concept of lag was also in the background of the influential linear model of innovation. Here, cultural lags were transformed into "time lags" between invention and commercialization. This gave rise to a literature on measuring the time period between invention and innovation or first use (Gilfillan, 1953: 371; Enos, 1962; Posner, 1961; Lynn, 1966; Hufbauer, 1966; Mansfield, 1968: chapter 4) – and to the idea of technological gaps (Godin, 2002). Finally, such lags became a frequently-heard argument for not measuring the social effects of invention (evaluation studies), and/or became a methodological difficulty and a limitation worth mentioning when measuring the effects of technology (economics).

The concept also became part of the vocabulary of policy-makers. Ogburn himself was responsible for bringing the concept into the government's language. *Recent Social Trends* (1933), of which Ogburn was director, looked at dozens of dimensions of society like population, natural resources, economy, science and technology, education, social attitudes, family, arts, religion and government, and their interrelationships, namely how they "act and react upon each other". The report suggested that "not all parts of our organization are changing at the same speed or at the same time. Some are rapidly moving forward and others are lagging" (US President's Research Committee on Social Trends, 1933: xiii). To the committee, "social institutions are not easily adjusted to inventions" (US President's Research Committee on Social Trends, 1933: xxvii). The report recommended better coordination for "slowing up the changes which occur too rapidly and speeding up the changes which lag (…). Social invention has to be stimulated

to keep pace with mechanical invention" (US President's Research Committee on Social Trends, 1933: xv; see also p. xxviii).

Equally, *Technological Trends and National Policy* (1937), the very "first major [public] attempt to show the kinds of new inventions which may affect living and working conditions in America in the next 10 to 25 years" (US National Resources Committee, 1937b: iii), that is, the first exercise in technological forecasting (Inouye and Susskind, 1977), with Ogburn as chairman of the committee, promoted the lag concept using various terms (lag, interval, lapse). Here, lags were not only a social problem to be studied but an opportunity for planning technological change: The time lag between first development and full use "is sufficiently slow to permit time for study and planning" (Ogburn, 1937a: 13) (see below).

Above all, the cultural lag was the concept through which Ogburn turned to the study of the social effects of technology.

A Systemic Approach

While Ogburn offered no real theory of invention (only principles), nor a real theory of diffusion (a lag is a sign of no diffusion), he did offer a theory on a third dimension of innovation: the effects of invention. To Ogburn, "inventions are chiefly interesting to sociologists for their social influences" (Ogburn, Adams and Gilfillan, 1946: 68). Ogburn's theory, the rudiments of which appeared in *Recent Social Trends* (1933), was really developed in *Technological Trends* (1937), then in *Sociology* (1940) and in many subsequent papers (Ogburn, 1941b; 1947; 1952; 1957b).

Recent Social Trends (1933) represented a turning point in Ogburn's thoughts. In this report, Ogburn contributed a chapter of his own in collaboration with Gilfillan. The chapter summarized what Ogburn had said so far on invention, and added new dimensions he would study in the next decade. First, he offered again his theory on lags: "There is often a delay or lag in the adaptive culture (…). [This] means that there is a

lack of harmony, frequently a grievous maladjustment, and always a failure to make the most out of a possible development. The problems of social change are then, first for man to adjust himself to a new environment consisting of a huge material culture and, second, for man to adjust himself to varying rates of change in the material and social culture" (Ogburn and Gilfillan, 1933: 125).

Second, Ogburn offered some measurements. In fact, the paper can be considered as an essay on the measurement of invention. [14] He computed the number and growth of inventions, and the rapidity and acceleration of change, based on various data: patents, scientific discoveries, production and use of invention – electrical, chemical, metals, power, transportation, building, production machinery, consumer goods, biological – and concluded on their "phenomenal increase from year to year" (Ogburn and Gilfillan, 1933: 125). [15] It was also in this paper that Ogburn calculated "delays" of 33 years in developing an invention (Ogburn and Gilfillan, 1933: 163).

Finally, the paper was a survey of the effects of (major) invention on society. This was the new dimension of Ogburn's interest in invention. Ogburn chose (defined) the inventions studied on the basis of "the significance of social change and not, as is the case in many lists of inventions (…) of the ingenuity represented in their mechanical properties and arrangements" (Ogburn and Gilfillan, 1933: 130, footnote 7). He looked at effects such as the dependence on machines, the increase in the standard of living, technological unemployment, industrial production, and communication and standardization of social life (Ogburn and Gilfillan, 1933: 130). There was no measurement of effects, but social effects for many new technologies were discussed over seventeen pages.

The study concluded with a series of general propositions about the process of invention and the influence of inventions on society (Ogburn and Gilfillan, 1933: 158-163):

[14] Ogburn has been criticized for his emphasis on measurement. Sociologist P. A. Sorokin strongly criticized *Recent Social Trends* (1933) because of the "predominance of quantitative description" (Sorokin, 1933). Ogburn replied in the same issue of the journal. See Ogburn, 1933a.

[15] Ogburn's combination of several statistics, or multiple indicators, to measure science and technology preceded Merton's (1938: 8-54).

- An invention often has many effects spreading out like a fan.
- A social change often represents the combined contributions of many inventions.
- Inventional causes and social effects are intertwined in a process.
- An invention has a series of effects following each other somewhat like the links of a chain.
- Groups of similar inventions have an appreciable social influence, where that of any particular one may be negligible.
- The accumulation of the influences of the smaller inventions is a significant part of the process.
- The majority of inventions are merely slight improvements on some existing devices.
- There are social factors as well as mechanical ones in social change.
- Social factors in social changes are often derivatives, in part from mechanical inventions, and vice versa.
- The effects of invention on society are of various degrees and kinds (habits, social classes, organizations, social institutions, ethics, systems of thought or social philosophies).
- It takes time for the social influences of inventions to become fully felt.
- There are social inventions as well as mechanical ones effective in social change.

Ogburn's theory on the social effects of invention relies on several concepts. Ogburn first makes a distinction between use and effect of invention. The distinction rests on time: use occurs simultaneously with adoption, whereas effect appears later; use applies to individuals, effect to social organizations and "organized" habits (Ogburn, Adams and Gilfillan, 1946: 69). The social effect of an invention is a function of the frequency of its use: "One person riding down the streets of a city in an automobile has no particular social effect, but where tens of thousands cross in both directions at a cross road there arises social effect in injuries and accidents which calls for social movements to lessen

this danger (…). The social effects of an invention depend on how widely the invention is used" (Ogburn, 1941b: 171).

To Ogburn, effects are many: social, cultural, environmental, health, political, and are not reducible to economic effects – as they frequently are today. It has always been "desirable to look at technology from various points of view" (Ogburn, 1957c: 3). For example, Ogburn identified 150 effects of information and communication technologies on behaviour, recreation and entertainment, transportation, education, dissemination of information, religion, industry and business, occupations, and government and politics (Ogburn and Gilfillan, 1933: 153-156) (see Appendix 3). This list would be frequently reproduced in subsequent papers and books.

Having distinguished effect from use, Ogburn went on to distinguish kinds of effects. [16] There are immediate or direct effects, and there are derivative effects. Immediate effects (use of technology) are the effects on producers and users. Inventions influence society "first by being produced in large quantities in factories and secondly by being used by large numbers of consumers" (Ogburn, 1947: 81). To Ogburn, the "adaptation is relatively rapid because producers and users change their habits immediately in producing and in using the invention" (Ogburn, 1947: 83). With regard to production, for example, the effects Ogburn mentioned are: new business, changes in the economic organization (integration, competition), business cycles, expansion of industries and new industries, and new occupations. However, "more changes are directly caused by the users of an invention than by the producers", like changes in habits (Ogburn, 1947: 82).

Derivative effects are changes in social and political institutions. To Ogburn, the derivative effects are "greater" than immediate effects, but are delayed longer because of an additive process (of effects) and the combination of many determining factors (Ogburn, 1937a: 11-12; Ogburn, 1947: 86). This leads to difficulty of observation and

[16] The most explicit definition of effects does not come from Ogburn but from Gilfillan: "The effect of an invention is not what was done with it, but the difference and remainder when we subtract from what was done with it, that which would have been done without it, using its substitutes (…)" (Gilfillan, 1945: 75). See also Gilfillan (1953: 201-202).

measurement: derivative effects are somewhat far removed from the original effect, several derivative causes may operate conjointly, the influence of an invention diminishes through time, and some inventions have not just one effect but many: they disperse and radiate. To Ogburn, "the pattern of causation is like that of a network": "everything is connected" (Ogburn, 1957b: 20-23). In sum, "the picture of the process is one where a new invention or scientific discovery is made; and, if adopted or accepted, effects are soon felt by users and producers, sometimes in many different areas. These are followed by successive derivative effects in other parts of society which are also being affected by changes coming from various other sources" (Ogburn, 1957b: 23). The process is further complicated because of "resistances which delay or prevent resulting changes (lags)".

To Ogburn, these difficulties explain much of the attitude of sociologists to invention: "It is difficult to measure or even to trace the effect of a single invention because of convergence and its sequential nature (…). Because of this difficulty, social scientists have been slow to appreciate the phenomenon of derivative social effects of technological developments. Also, because of the interrelationship of these changes, social scientists have done little to trace the many causes of a social change (…). The reason of the complexity of the pattern of social change resulting from technology is the vast number of interconnexions that exist between the different parts of society" (Ogburn, 1952: 271).

To make sense of this complex process of invention, Ogburn propounded two general principles. The first is that of convergence: "The influence of many inventions canalizes on a single point. It is a common occurrence to have influences from several inventions converge on a single social institution" (Ogburn, 1941b: 181). This principle of addition is parallel to that on independent and duplicate inventions. Inventions tend to occur in "functional groupings, or clusters of inventions (Ogburn, 1937a: 10), as Gilfillan suggested in 1935. Following Gilfillan, Ogburn now discussed the phenomenon of independent and duplicate inventions in terms of "clusters": inventions appear in clusters because social demand influences the direction of inventions. The second principle is that of successive derivative influences or effects: "The influences of inventions resulting from a succession of impacts are generally called derivative influences, first, second,

third, and so on" (Ogburn, 1941b: 171-172). This principle suggests that the influences of an invention tend to diminish through successive derivative stages (exhaustion or decline): "if there are four such converging influences of the first derivative change, then the influence of a single invention is one in four; and if there are six on the second derivative change from this invention, then the influence of the original invention is one in ten" (Ogburn, 1952: 270-271).

Ogburn documented the social effects of specific technologies with case studies on aviation (Ogburn, Adams and Gilfillan, 1946), politics (international relations) (Ogburn, 1949b), cities (Ogburn, 1946a; 1960), and family (Ogburn and Nimkoff, 1955). [17] In the last decade of his life, Ogburn also conducted measurements of "economic" effects, like changes in the standard of living. In fact, Ogburn had already suggested in *Technological Trends* that "of the four material factors that determine the economic well-being of nations, to wit, invention, population, natural resources, and economic organization, the first (invention) changes the most frequently in the modern world and hence is most often a cause" (Ogburn, 1937a:3). In the 1950s, Ogburn contributed three measurements of these factors (Ogburn, 1951; 1955; Ogburn and Allen, 1959). In Ogburn's view, the standard of living was measured either as minutes of labour required to earn enough money to buy articles of consumption, or as a composite index of family expenditures, earnings of workers and per capita national income. Technology was measured as the use of energy (electricity in kilowatts-hours) and capital. Five countries were studied, [18] and a correlation of 0.7 was computed between technology and standard of living. [19] To Ogburn, the correlation between technology and workers' wages and salaries is "contrary to the earlier views of labor adherents who, in England, broke up new equipment and who have recently opposed the introduction of new machinery in the United States. Their motive was to avoid unemployment and to hold their present jobs. They probably did not realize what is here evident – that new machinery would increase production and bring higher pay" (Ogburn and Allen, 1959: 129-130).

[17] Other works worth mentioning are Rosen and Rosen (1941), Allen (1957; 1959) and Gilfillan (1953).
[18] China, India, UK, USA and USSR.
[19] Other variables were population, natural resources and the economic system.

The study of the effects of invention led Ogburn to propose a highly influential idea in science, technology and innovation studies: that of invention as a sequential process. Already in 1922, Ogburn had studied invention as a process, that of a social adjustment. Starting with *Recent Social Trends* (1933), Ogburn began to describe invention as a process that goes through stages or steps. He suggested many such time sequences. They fall into two categories. A first series is concerned with the process of invention itself: "Invention is a process, beginning with the earliest inception of the idea and proceeding through a definite set of stages to its wide adoption" (Ogburn, 1941b: 184). Gilfillan measured the interval between these steps on three occasions (Ogburn and Gilfillan, 1933; Gilfillan, 1935b; 1952), and concluded that the whole process required from fifteen to fifty years for the most important inventions, the average being 33 years (Ogburn and Gilfillan, 1933). [20] Ogburn was not the first to suggest such time sequences. He had in fact combined two sequences: one of a psychological type, like that of historian A. P. Usher (Usher, 1929), with a sequence on the industrial development of technological products, first suggested by sociologists (Bernard, 1923), economists (Epstein, 1926) and industrialists (Mees, 1920; Holland, 1928; Jewett, 1932):

> Idea → trial device → model or plan → first demonstration → practical device → regular use → widespread adoption (Ogburn and Gilfillan, 1933: 132).
>
> Idea → model → test → development → marketing → sales → use → effects (Ogburn, 1937b: 368).
>
> Idea → plan or model → design → improvements → sales → marketing → production on a large scale (Ogburn, 1937a: 6).
>
> Idea → Development → Model → Invention → Improvement → Marketing (Ogburn and Nimkoff, 1940: 822)
>
> Idea → plan → tangible form → improvements → production → marketing → sales (Ogburn, 1941a: 4).

[20] The average intervals are: "between when the invention was first thought of and the first working machine or patent, 176 years; thence to the first practical use, 24 years; to commercial success 14 years, to important use 12 years; or say 50 years from the first serious work on the invention, to important use from it" (Gilfillan, 1935b: 96).

Where Ogburn innovated was in a second series of sequences, concerned with the social effects of invention, and the sequence between these effects. To Ogburn, the sequence of effects is like a "network" of interrelationships. At other times, Ogburn discusses the phenomenon as a "chain": "The impact of an invention produces a chain reaction. An effect is at the same time a cause, that is, a cause of another effect which is also a cause, and so on, like the links of a chain" (Ogburn, 1957b: 20). To Ogburn, "an invention may be likened to a billiard ball, which strikes another ball, which in turn strikes still another, and so on until the force is spent" (Ogburn, 1937a: 10). Together with the idea of adjustment/maladjustment between parts of society, the idea of a chain of effects is the rudiment of what became an influential framework: the systemic (or, as M. Kranzberg called it, ecological) approach to innovation. Every part or element of society interacts with the others, and change in one part produces a chain reaction.

Again, there are many chains or time sequences of effects in Ogburn's works, even slightly different ones in the same paper, but they all sum up to: Technology → industry [21] → social institutions [22] → people [23]. As Ogburn put it, "there is a great variety in these sequences; but in the past in many important cases the change occurred first in the technology, which changed the economic institutions, which in turn changed the social and governmental organizations, which finally changed the social beliefs and philosophies" (Ogburn, 1937a: 10; see also Ogburn, 1936b: 4):

> Scientific discoveries and inventions → changes in organizations (family, government, school, church) → social philosophies and codes of behaviour (US President's Research Committee on Social Trends, 1933: xiii-xiv).
>
> Primary effects (production, consumers) → secondary effects (economic organization) → derivative effects (social institutions) (Ogburn, 1937a: 9-10).
>
> Scientific discoveries → technology → direct effects (production and distribution, then consumption), then derivatives (Ogburn, 1957b: 19-20).

[21] Economy.
[22] Including government.
[23] Attitudes.

Ogburn's series of sequences culminated in the one proposed in 1950. In a new chapter added to the 1950 edition of *Social Change*, Ogburn suggested a theory to explain cultural evolution. The theory summarizes thirty years of thought on invention. To Ogburn, cultural evolution is not a matter of inherited mental ability, but a process involving factors, or steps, as in biological evolution (variation, natural selection, heredity) (Ogburn, 1950: 393): invention → accumulation → diffusion → adjustment. Let's have a look at each step.

To Ogburn, invention is the (first and) central factor, as mutation is to biological evolution (Ogburn, 1950: 377). Also, "invention is not confined to mechanical invention but includes social inventions, such as the League of Nations, and innovation in other parts of culture, as, for instance, the invention of a religious ritual or an alphabet. It also comprises scientific discoveries" (Ogburn, 1950: 378).

To Ogburn, invention is "the combination of existing and known elements of culture, material and/or non-material, or a modification of one to form a new one" (Ogburn, 1950: 378). Equally, invention consists not only of major inventions (basic or important inventions), but includes minor ones and improvements. Inventions come from three sources: mental ability, demand and cultural base. By mental ability, Ogburn does not suggest a heroic account of invention where inventors are geniuses and have superior mental ability, but refers to that proportion of a population with superior ability (education) as a necessary (but not sufficient) factor for invention. As for demand, Ogburn denies that necessity or demand directs invention. Many inventions are made accidentally. "The use of an invention, however, implies a demand" (Ogburn, 1950: 379).

The cultural base as a source of invention leads Ogburn to discuss the second stage in his theory: accumulation. Inventions accumulate selectively, but over time more elements are added than are lost. Inventions accumulate because they have utility: the more efficient replaces the less efficient. This accumulation tends to be exponential "because an invention is a combination of existing elements, and these elements are accumulative" (Ogburn, 1950: 381). Accumulation is a function of the size of the cultural base. "Put in

figures, this argument would mean that if a cultural base of a hundred thousand elements yielded one invention, then a cultural base of a million elements would yield a thousand inventions (…). But in reality the yield of the second cultural base would be more than a thousand inventions (…). [A]s the existing elements increase, the number of combinations increases faster than by a fixed ratio" (Ogburn, 1950: 382). As Ogburn has already put it, "social changes are more numerous now than formerly because the cultural elements are so much more numerous" (Ogburn, 1933-34: 332); "accumulation of inventions means not only a greater amount of social change but a more rapid social change" (Ogburn, 1933-34: 331). This exponential rate is cyclical: it flattens out eventually or declines, then experiences a further period of growth.

The third stage in Ogburn's theory is diffusion: the spread of inventions from the area of origin to other areas, helped by communication and transportation. In line with the findings of anthropology, Ogburn suggested that most inventions are acquired by diffusion, or importing them from elsewhere. Ogburn explained the unequal levels of culture not by racial ability, but by location plus diffusion (Ogburn, 1950: 387).

Ogburn's time sequence concludes with adjustment. An invention in one part of culture occasions a change in another part, following a delay or lag. "Social evolution goes forward by inventions which produce a disequilibrium in society, which in turn sets up forces which seek a new equilibrium" (Ogburn, 1950: 390). The social inventions responsible for the adjustments are governmental organizations and social and economic institutions.

This time sequence from 1950, or at least the terms composing it, are directly inspired by one proposed by sociologist F. Stuart Chapin 20 years before (Chapin, 1928). Such sequences would proliferate among sociologists in the following decades (Table 1) – and a third kind of sequence developed on stages in the process of adoption of invention: awareness → interest → evaluation → trial → adoption (Beal and Bohlen, 1955). Business schools and economists would soon follow. In the hands of the latter, the sequence came to be called the "linear model of innovation" (Godin, 2006; 2008b; 2009b). It would feed

policy analyses for several decades, before it became a contested idea among scholars and policy-makers.

Table 1.
Sociologists' Sequences of Invention/Innovation

Tarde (1890)	Invention, imitation, opposition
Ogburn (1922)	Invention (and diffusion), maladjustment (lag)/adjustment
Bernard (1923)	Formula, blue print, machine [24]
Chapin (1928)	Invention, accumulation, selection, diffusion
Ogburn and Gilfillan (1933)	Idea, trial device (model or plan), demonstration, regular use, adoption
Gilfillan (1935)	Idea; sketch; drawing; model; full-sized experimental invention; commercial practice
US National Resources Committee (1937)	Beginnings, development, diffusion, social influences
Gilfillan (1937b)	Thought, model (or patent), first practical use, commercial success, important use
Ogburn (1937a)	Idea, plan or model, design, improvements, sales, marketing, production on a large scale
Ogburn and Nimkoff (1940)	Idea, development, model, invention, improvement, marketing
Ogburn (1941a)	Idea, plan, tangible form, improvement, production, promotion, marketing, sales
Ogburn (1950)	Invention, accumulation, diffusion, adjustment
Rogers (1962)	Innovation**,** diffusion, adoption [25]
Rogers (1983)	Needs/problems, research, development, commercialization, diffusion and adoption, consequences

Understanding invention as a process represented a certain "advance" over anthropology. "The comparative frequency of invention and diffusion have (*sic*) been a central theme among anthropologists for years", stated Ogburn (Ogburn, 1922b: 89). In fact, among anthropologists, invention was generally contrasted to diffusion (Smith *et al*., 1927) – as it was also among early sociologists like Gabriel Tarde. From Ogburn onward, invention was comprehended as a process where both the invention and its diffusion (sometimes

[24] For social invention, the stages are: theory, rules, organizations and institutions.
[25] Adoption itself is composed of steps, or stages, as suggested by Beal and Bohlen (1955).

called imitation) are unquestionably dimensions (Nimkoff, 1957) – and sequential steps: "The social heritage in its material aspects grows through inventions and (…) by diffusion" (Ogburn, 1922b: 103).

Forecasting

If a lag gave rise to the idea of a time sequence, the idea of effects (and their sequence) gave rise to the idea of predicting invention. In his chapter in *Recent Social Trends* (1933), Ogburn had identified two types of problems for policy purposes. One is that of the encouragement of invention. Since it takes 33 years to bring an invention to commercial production, financial incentives other than patents have to be offered to inventors in the meantime. The other problem for policy is the direction which invention takes and the lag in adoption: "The problem of the better adaptation of society to its large and changing material culture and the problem of lessening the delay in this adjustment are cardinal problems for social change" (Ogburn and Gilfillan, 1933: 166). Ogburn's solution to this problem was to develop studies "to anticipate inventions and their social effects".

Ogburn's interest in predicting invention lasted several years starting in the mid-1930s, with papers on general ideas of forecasting (Ogburn, 1935), limitations and methodology (Ogburn, 1934b; 1946), a program of action in seven steps (Ogburn, 1937b) and a book on predicting *The Social Effects of Aviation* (Ogburn, Adams and Gilfillan, 1946). However, Ogburn's main output was the very first exercise in forecasting (later called technology assessment, then foresight) in the United States, conducted for the US National Resources Committee and published in 1937 as *Technological Trends and National Policy*, with a subtitle referring directly to social effects: *Including the Social Implications of New Inventions*. [26] Authors who contributed to the report were, among others, S. C. Gilfillan, B. J. Stern (early sociologist of medicine, Columbia University),

[26] Accompanying documents to the report are: a summary (US National Resources Committee, 1937a), a pamphlet (Ogburn, 1938a), a paper from Ogburn based on his introduction to the report (Ogburn, 1941a) and a textbook rendition of the report (Rosen and Rosen, 1941).

and D. Weintraub (early "statistician" of technological change, Director, Works Progress Administration).

To Ogburn, forecasting is not about forecasting inventions themselves, but about forecasting the social aspects of invention. Certainly from the late 1920s onward, Ogburn (and his colleagues) constructed mere lists of new technological inventions – as a piece of information to anticipate the effects of inventions and reduce maladjustments or lags. The annual lists were published in the *American Journal of Sociology* from 1928 to 1933 (Ogburn, 1928, 1929; Tibbitts, 1930; 1931; Gilfillan, 1932; 1933). However, "it is trends in the social effects of technology rather than trends in technology that should interest us as members of a changing society", Ogburn later claimed (Ogburn, 1938a: 9).

The rationale of the committee responsible for *Technological Trends* was invention as "a great disturber". "It is fair to say", stated the committee, "that the greatest general cause of change in our modern civilization is invention (…). Hence a study of the trends of inventions furnishes a broad perspective of many great movements of change and basic general information for any planning body (…)" (US National Resources Committee, 1937b: vi). Based on the study of major inventions, selected on the basis of their social significance, the report's major findings were threefold. First, the increase, or "rising curve" in the growth of inventions, as measured using the number of patents, and the large and increasing part of these inventions that come from basic science and research, and increasingly so from organized laboratories (US National Resources Committee, 1937b: vi). Second, the problem of technological unemployment, which falls in two parts: a) inventions create jobs as well as take them away (Weintraub, 1937), b) occupational obsolescence and the necessity of adjustments and adaptations (US National Resources Committee, 1937a). Some years before the report, during the debate in the United States on technological unemployment (Fano, 1991, Bix, 2000), Ogburn had contributed his views on the issue of technological unemployment in two pamphlets: *Living with Machines* (1933) and *You and Machines* (1934). Ogburn had opted for an optimistic view, like economic advisers, to whom technological unemployment was only temporary. "It is undoubtedly true", stated Ogburn, "that machines throw many men out

of work, and it is not easy to say how long they will stay out of work before finding other jobs" (Ogburn, 1933b: 4). However, "we forget that machines create employment" too: "certainly a very large percentage of new inventions make new jobs" (Ogburn, 1933b: 5-6). To Ogburn, machines' effects are "infinitely more far reaching than merely taking jobs away from men, serious as it is (…). New machines have deprived many of their jobs, but in the long run have given us all more of the good things of life" (Ogburn, 1933b: 15-16). To Ogburn, the trouble is "economics, not engineering", and "the economic problem is far more complicated than the mechanical one" (Ogburn, 1933b: 10). Ogburn interpreted labour displacements due to technological changes in industry as a case of cultural lag: "Our institutions do not keep up with lags" (Ogburn, 1933b: 14).

In fact to Ogburn, technology is both a troublemaker and a creator of wealth. Technology brings about positive as well as negative social effects (see the many examples analyzed in Ogburn, 1933b; 1934c; 1952). Man is both "master and slave": "Man appears to be the master in the particular use he makes of the machine, but he seems not to be able to control all the derivative results of its creation and manufacture" (Ogburn, Adams and Gilfillan, 1946: 9). As a result, we need "more speed in social invention"; we need "to foresee social effects"; we need "social planning" (Ogburn, 1933b: 15).

The third major finding of *Technological Trends* was the effect of inventions on all "great" social institutions – family, church, school, local community, State, industry (Gilfillan, 1937a) – and people's attitudes and resistance as "serious" obstacles to planning (Stern, 1937). All in all, there is need for "better accounting methods and greater appreciation of the rate of the inventional development" (US National Resources Committee, 1937b: viii). The report ends with a series of recommendations, such as studies on important inventions, a committee on technological unemployment, science committees in every Federal department, a review of the patent system and a permanent Planning Board.

What deserves emphasis, in the context of this paper, is the report's use of the argument that the time lag between the first development of an invention and its full use is an

opportunity to anticipate and plan social effects. This argument would be proposed by Ogburn and Gilfillan in many subsequent papers. Technological development is a sequential process that takes time (Ogburn, 1937a: 6, 13; see also Gilfillan, 1937b: 18), and "the time element furnishes an opportunity of studying and forecasting what the social consequences may be" (Ogburn, 1937a: 11): "Since it requires a quarter of a century more or less for an invention to be perfected and to be put into wide use, it is possible to anticipate their results some years ahead" (Ogburn, 1937a: 3; see also Ogburn, 1941a: 4; Gilfillan, 1937b: 19; Ogburn, Adams and Gilfillan, 1946: iii).

Another argument for the possibility of forecasting is the same as that developed for effects, namely convergence, turned here into a methodological opportunity. First, different inventions lead to much the same social result (Ogburn, 1937a: 10): "Most of the inventions that will influence American social institutions during the next generation are in existence now, and many of them are already used to a considerable extent. It is possible to select out of the vast number of inventions a list of those which appear to be most influential, and it is also possible to state what will be the nature of their influences on different social institutions (…). Where several inventions exert an influence in the same direction, and where all of them seem powerful, the institution is likely to be modified in that direction" (Ogburn, 1937b: 370).

Second, inventions appear in clusters (Ogburn, 1937a: 10), a popular concept in innovation studies today (technological clusters as cause of economic waves). An invention is due in part to another invention. This intermeshing of inventions, this convergence, this additive process "makes the prediction of the social effects of inventions more reliable" (Ogburn, 1947: 86). Equally, to Gilfillan "prediction may be carried on with high average of success", because inventions form trends (agglomerations of small inventions) which can be extrapolated (Gilfillan, 1937b: 18). Gilfillan talks of "functionally equivalent inventions": identical solutions arrived at by different men about the same time, and equivalent base (or means) for reaching the same goal (Gilfillan, 1937b: 22): "If the inferences from numerous trends and other facts converge to the same conclusion, one may be more confident one is right. If the indications be somewhat

contradictory we must express doubt" (Gilfillan, 1937b: 20). To Ogburn and Gilfillan, "we can be more certain that an invention will produce a particular effect if we know that many other inventions or factors have similar additive or converging influences", or if the invention is in line with social trends (Ogburn, Adams and Gilfillan, 1946: 76-78). This is now a familiar argument in evaluation studies (Martin, 1996), and the methodological lesson has made an "industry" of forecasting exercises.

However, with regard to effects, there are difficulties in measurement. The report is not silent on the difficulties. Ogburn identified many problems which sum up to two general ones (Ogburn, 1941b: 184): the prediction of inventions themselves (invention is a process that takes time) and the prediction of their influences. With regard to the former, Ogburn identifies the high death rate of inventions, the length of time required for perfecting an invention, and the difficulty of determining what inventions will be put successfully into commercial use (because of technical faults, substitutes, costs, business ability, state regulations, popular opinion) (Ogburn, 1937a: 6-7). With regard to predicting social effects, this is particularly difficult because of unanticipated consequences, the differences between the use of an invention and its social effect (Ogburn, 1941b: 169) and the delayed impact of derivative effects (Ogburn, 1937a: 11-12): "The tendency of the social influence of an invention is sometimes easily singled out, but it is not easy to say whether this tendency will be significant or negligible (…). Furthermore, a tendency may be negated by an opposing tendency or another factor in another direction" (Ogburn, 1937b: 369).

All in all, proper measurement of the social effects of invention "is not as easy as for material things" (Ogburn, 1941b: 177). Social effects are intangible. Furthermore, the social effects of technology are so vast in number and extent that it is "impossible to calculate" (Ogburn, 1937a: 5). However, "some approximations can undoubtedly be made" and forecasting is, to a certain extent, possible (Ogburn, 1937b: 368).

This brings me to conclude this section with the role of statistics in Ogburn's works. Although Ogburn believed in social laws, and documented, with the aid of statistics,

many trends that would soon occupy researchers worldwide, [27] he was completely aware of the limitations of statistics, as discussed when counting duplicate inventions, measuring effects or forecasting effects. He also contributed many papers of a methodological nature. To Ogburn, statistics cannot offer cause and explanation, but only "concomitance" (Ogburn, 1937a: 5). Statistics needs interpretation. Ogburn went so far as to suggest that "the role of statistics is often that of making more exact something that is already known" (Ogburn, 1934a: 13). Ogburn could measure only what he could find data for, and he regularly deplored the fact that data were too few. Since then, statistics and indicators have proliferated and are part of every study on innovation (Godin, 2005).

Nevertheless, to Ogburn, measurement is the essence of scientific sociology: "The extent to which social thought and theory will pass from the sphere of opinion, conjecture and contemplative analysis to that of fact, knowledge and control, will depend on their permeation by the scientific methods of measurement and statistics" (Ogburn and Goldenweiser, 1927: 9). This was a familiar discourse at the time. To Ogburn, theory was philosophy and intellectuality, and the quantitative sociologist was soon to replace the executive as the source of information. "In this future state", he suggested, "every one will be a statistician" (Ogburn, 1930: 303); "we cannot have a science without measurement" (Ogburn, 1922a: 74).

Conclusion

One would probably not err in concluding that Ogburn has been as important to the sociology of technology as Robert K. Merton was to the sociology of science. Equally, Ogburn has been as important as, if not more important than, J. A. Schumpeter was to the study of technological innovation. While it was left to the students of Schumpeter to develop systematic ideas on innovation as a process, Ogburn himself discussed, to a different extent, all three dimensions of the innovation process over thirty years: the

[27] The exponential growth of inventions (as measured by patents, multiple discoveries, production and use of inventions), the S-shaped curve of diffusion (jump-like curve: stability, change, stability), lags (33 years), social effects (standard of living) and business cycles (Ogburn and Thomas, 1922b; Ogburn, 1923).

origins of invention, its diffusion and its effects. [28] Certainly, the origins of invention were discussed in "philosophical" rather than empirical terms, and the study of lags (as witness to lack of diffusion) got precedence over studies of diffusion. Ogburn also concentrated on technological innovation and neglected other types of innovation, despite his suggestion. He also did no study of innovation in firms, a major topic of later innovation studies. Finally, he offered a sequential model not foreign in method to the evolutionists' stages that he criticized.

However, the modeling of (social) effects of technology was a real innovation. Ogburn developed an influential conceptual framework for the study of innovation (cultural lag), and he offered the rudiments of a dynamic and systemic approach to innovation. Ogburn's sequences culminated in what came to be called the linear model of innovation, until recently a highly influential framework for innovation theory and policy (Godin, 2006; 2008b; 2009b). In the last few years, many of Ogburn's other ideas have come back. To name but a few: combination for explaining innovation (Arthur, 2009), social innovation, an idea much in vogue today (Mulgan, 2007), clusters (OECD, 1999, 2001), and technology foresight as a modern exercise in forecasting technology and its impacts, for which a handbook has recently been published (Georghiou *et al*., 2008).

Ogburn developed his ideas on innovation in three steps. The first was *Social Change* (1922) and the decade which followed. Here, he put forward the ideas on invention he had already been thinking about for five years. Then Ogburn developed these ideas further in two steps, following reports he directed for the government. One period is centered on *Recent Social Trends* (1933) and the study of diffusion, the other on *Technological Trends* (1937) and the study of effects. Whether Ogburn's ideas benefited from these works as sources of new ideas, or whether the works were led by new ideas of his own, is difficult to answer. In any case, there was definitely a co-construction of

[28] One more distinction between Schumpeter and Ogburn deserves mention. Schumpeter' ideas on innovation put emphasis on the role of major innovations and of a few entrepreneurs (as in Great Men theories), then large firms, while Ogburn sees innovation as a cumulative series of small steps and the result of many individuals' efforts. The two views correspond to different philosophies of history, and both have been influential in subsequent studies on science, technology and innovation. However, over time, Ogburn's kind of philosophy has become the preferred (or dominant?) one among many academics. For an excellent critique of economists' views on major innovations, see Rosenberg (1976; 1978).

concepts and theory between Ogburn's purely academic work and his works of a more applied nature. There were no two individuals with different discourses, nor a good and a bad science, but rather synergy and conceptual productivity.

Certainly to some, Ogburn will appear as a "man of action" as much as, if not more than, a "pure" scientist. As to many social scientists of the time (Lyons, 1969), he served as expert to government, and he had a real interest in planning (social adjustments) and in prediction (forecasting social effects). These motivated many of his researches. Furthermore, Ogburn conducted few empirical studies: he did no study of a historical kind to validate his views; while he had recourse to statistics regularly, he generally used others' statistics (as most economists did), and rarely conducted his own surveys. If Ogburn were writing today, he would most certainly be part of the science policy network, rather than that of "pure" research. However, Ogburn brought forth new ideas, new concepts and a fruitful conceptual framework for the time, all intellectual contributions that have, for better and for worse, remained influential until today, under many different guises.

What remain to be explained are Ogburn's sources of ideas. We have mentioned that change was central to Ogburn's theory. Innovation as change has a long history: introducing change was the meaning of innovation when the category first emerged in the sixteenth century. Ogburn's focus on social change and the role of technological invention is in line with this idea. On many other points, Ogburn is witness to intellectual context. While Ogburn rejected anthropologists' theories on stages of cultural development, he nevertheless developed a theory of stages, or steps of invention. He also followed anthropologists' (broad) definition of culture and invention. While rejecting great men theories, Ogburn reproduced many of the arguments (invention as a social process) delivered during the patent controversy in nineteenth century Britain (Macleod, 2007). While Ogburn never cited the French sociologist Tarde, many of his ideas (as well as those of Gilfillan, who did cite Tarde) existed already in Tarde's writings. Ogburn also borrowed many ideas from Chapin (combination, social invention, sequence).

In turn, many of Ogburn's ideas (which he shared with some others) have got into the economics of technological innovation and innovation studies: lag, sequence, cluster, forecasting. However, one term Ogburn did not use is innovation. Nevertheless, Ogburn was a key contributor to defining innovation in a way that would soon become a dominant interpretation over the twentieth century: innovation as use of technological invention, as opposed to invention itself. As a matter of fact, one may have the thing (innovation) without the word – as was the case for economists and technological change as precursor to innovation in the 1930s and after (Godin, 2009a). Today, things are different. No one would hesitate to use the word. Innovation has become a major category of Western thought.

Bibliography

Allen, F. R. *et al*. (eds.) (1957), *Technology and Social Change*, New York: Appleton-Century-Crofts.

Allen, F. R. (1959), Technology and Social Change: Current Status and Outlook, *Technology and Culture*, 1 (1): 48-59.

Allport, F. H. (1924), Social Change: An Analysis of Professor Ogburn's Cultural Theory, *Journal of Social Forces*, 2: 671-676.

Arthur, B. (2009), *The Nature of Technology*, New York: Free Press.

Barnett, H. G. (1953), *Innovation: the Basis of Cultural Change*, New York: McGraw Hill.

Beal, G. M., and J. M. Bohlen (1955), *How Farm People Accept New Ideas*, Cooperative Extension Service Report no. 15, Ames (Iowa).

Bernal, J. D. (1935), Science and Industry, in S. D. Hall *et al*. (eds.), *The Frustration of Science*, London: Allen and Unwin: 42-144.

Bernal, J. D. (1939), *The Social Function of Science*, Cambridge (Mass.): MIT Press, 1973.

Bernard, L. (1923), Invention and Social Progress, *American Journal of Sociology*, 29 (1): 1-33.

Bix, A. S. (2000), *Inventing Ourselves Out of Jobs? America's Debate over Technological Unemployment*, 1929-1981, Baltimore: Johns Hopkins University Press.

Brannigan, A. (1981), *The Social Basis of Scientific Discoveries*, Cambridge: Cambridge University Press.

Carr, L. J., and J. E. Stermer (1952), *Willow Run: A Study of Industrialization and Cultural Inequality,* New York: Harper.

Chapin, F. S. (1928), *Cultural Change*, New York: The Century Co.

Choukas, M. (1936), The Concept of Cultural Lag Re-Examined, *American Sociological Review*, 1: 752-760.

Duncan, O. D. (1959), An Appreciation of William Fielding Ogburn, *Technology and Culture*, 1 (1): 94-99.

Duncan, O. D. (1964), *William F. Ogburn on Culture and Social Change: Selected Papers*, Chicago: University of Chicago Press.

Ellwood, C. A. (1918), Theories of Cultural Evolution, *American Journal of Sociology*, 23 (6): 779-800.

Enos, J. L. (1962), Invention and Innovation in the Petroleum Refining Industry, in National Bureau of Economic Research, *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Princeton: Princeton University Press: 299-321.

Epstein, R. C. (1926), Industrial Invention: Heroic, or Systematic?, *The Quarterly Journal of Economics*, 40 (2): 232-272.

Fagerberg, J., and B. Verspagen (2009), Innovation Studies: The Emerging Structure of a New Scientific Field, *Research Policy*, 38: 218-33.

Fano, E. (1991), A "Wastage of Men": Technological Progress and Unemployment in the United States, *Technology and Culture*, 32 (2): 264-292.

Georghiou, L., J. Cassingena, M. Keenan, I. Miles and R. Popper (2008), *The Handbook of Technology Foresight*, London: Edward Elgar.
Gilfillan, S. C. (1927), Who Invented It?, *Scientific Monthly*, 25: 529-534.
Gilfillan, S. C. (1932), Inventions and Discoveries, *American Journal of Sociology*, 37 (6): 868-875.
Gilfillan, S. C. (1933), Inventions and Discoveries, *American Journal of Sociology*, 38 (6): 835-844.
Gilfillan, S. C. (1935a), *Inventing the Ship*, Chicago: Follett Publishing.
Gilfillan, S. C. (1935b), *The Sociology of Invention*, Cambridge (Mass.): MIT Press.
Gilfillan, S. C. (1937a), Social Effects of Inventions, in US National Resources Committee, *Technological Trends and National Policy, Including the Social Implications of New Inventions*, Washington: USGPO: 24-38.
Gilfillan, S. C. (1937b), The Prediction of Inventions, in US National Resources Committee, *Technological Trends and National Policy, Including the Social Implications of New Inventions*, Washington: USGPO:15-23.
Gilfillan, S. C. (1945), Invention as a Factor in Economic History, *Journal of Economic History*, 5, Supplement: 66-85.
Gilfillan, S. C. (1946), Some Results of Failure to Prepare for Technological Change, *Social Science*, 21: 172-181.
Gilfillan, S. C. (1952), The Prediction of Technical Change, *Review of Economics and Statistics*, 34 (4): 368-385.
Gilfillan, S. C. (1953), Social Implications of Technical Advance: A Review of the Literature, *Current Sociology*, 1 (4): 191-211.
Godin, B. (2002), Technological Gaps: An Important Episode in the Construction of Science and Technology Indicators, *Technology and Society*, 24: 387-413.
Godin, B. (2005), *Measurement and Statistics on Science and Technology: 1920 to the Present*, London: Routledge.
Godin, B. (2006), The Linear Model of Innovation: the Historical Construction of an Analytical Framework, *Science, Technology, and Human Values*, 31 (6): 639-667.
Godin B. (2008a), *Innovation: the History of a Category*, Project on the Intellectual History of Innovation, Montreal: INRS. Available at http://www.csiic.ca/innovation.html.
Godin, B. (2008b), In the Shadow of Schumpeter: W. Rupert Maclaurin and the Study of Technological Innovation, *Minerva*, 46 (3): 343-360.
Godin, B. (2009a), *A Historical Perspective on Technological Innovation Studies, 1960-2010*, Paper presented at the 50th Anniversary Conference on "The Rate and Direction of Inventive Activity: A New Agenda", National Bureau of Economic Research, Dana Point, California, 13-14 July.
Godin, B. (2009b), *The Linear Model of Innovation (II): Maurice Holland and the Research Cycle*, Project on the Intellectual History of Innovation, Montreal: INRS. Available at http://www.csiic.ca/innovation.html.
Godin, B. (2010), *"Meddle not With Them That Are Given to Change": Innovation as Evil*, Project on the Intellectual History of Innovation, Montreal: INRS (Forthcoming).
Hart, H. (1931), *The Technique of Social Progress*, New York, Henry Holt and Co.

Hart, H. (1957), The Hypothesis of Cultural Lag: A Present-Day View, in F. R. Allen *et al*. (eds.), *Technology and Social Change*, New York: Appleton-Century-Crofts: 417-434.
Hart, H., and F. R. Allen (1957), Major Problems Arising From Rapid Social Change, in F. R. Allen *et al*. (eds.), *Technology and Social Change*, New York: Appleton-Century-Crofts: 435-451.
Herman, A. P. (1937), An Answer to Criticisms of the Lag Concept, *American Journal of Sociology*, 43 (3): 440-451.
Holland, M. (1928), Research, Science and Invention, in F. W. Wile (ed.), *A Century of Industrial Progress*, American Institute of the City of New York, New York: Doubleday, Doran and Co., pp. 312-334.
Hufbauer, G. (1966), *Synthetic Materials in International Trade*, Cambridge: Harvard University Press.
Huff, T. E. (1973), Theoretical Innovation in Science: The Case of William F. Ogburn, *American Journal of Sociology*, 79 (2): 261-277.
Inouye, A., and C. Susskind (1977), "Technological Trends and National Policy", 1937: The First Modern Technology Assessment, *Technology and Culture*, 18: 593-621.
Jaffe, A. J. (1969), Ogburn, William Fielding, in S. Shills (ed.), *International Encyclopedia of the Social Sciences*, New York: CollinMacmillan: 277-281.
Jewett, F. B. (1932), The Philosophy and Practical Application of Industrial Research, in M. Ross (ed.), *Profitable Practice in Industrial Research*, New York: Harper, pp. 1-39.
Jewkes, J, D. Sawers and R. Stillerman (1958), *The Sources of Invention*, London: Macmillan.
Kroeber, A. L. (1917), The Superorganic, *American Anthropologist*, 19 (2): 163-213.
Kroeber, A. L. (1918), The Possibility of a Social Psychology, *American Journal of Sociology*, 23 (5): 633-650.
Kuznets, S. (1972), Innovations and Adjustments in Economic Growth, *The Swedish Journal of Economics*, 74 (4): 431-451.
Lynn, F. (1966), The Rate of Development and Diffusion of Technology, in *Technology and the American Economy*, National Commission on Technology, Automation, and Economic Progress, Washington: USGPO, Appendix, Volume 2: 31-44.
Lyons, G. M. (1969), *The Uneasy Partnership: Social Science and the Federal Government in the Twentieth Century*, New York: Sage.
Macleod, C. (2007), *Heroes of Invention: Technology, Liberalism and British Identity, 1750-1914*, Cambridge: Cambridge University Press.
Mansfield, E. (1968), *The Economics of Technological Change*, New York: Norton & Co.
Martin, B. R. (1996), The Use of Multiple Indicators in the Assessment of Basic Research, *Scientometrics*, 36 (3): 343-62.
Martin, B. (2008), *The Evolution of Science Policy and Innovation Studies*, Working Paper, Center for Technology, Innovation and Culture, University of Oslo.
McGee, D. (1995), Making Up Mind: the Early Sociology of Invention, *Technology and Culture*, 36: 773-801.
Mees, C. E. K. (1920), *The Organization of Industrial Scientific Research*, New York: McGraw Hill.

Merton, R. K. (1938), Science, Technology and Society in Seventeenth Century England, *Osiris*, 4 (2): 360-632.
Mueller, J. H. (1938), Present Status of the Cultural Lag Hypothesis, *American Sociological Review*, 3: 320-327.
Mulgan, G. (2007), *Social Innovation: What It Is, Why It Matters and How It Can Be Accelerated*, Working Paper, Center for Social Entrepreneurship, Oxford: Said Business School.
Nimkoff, M. F. (1957), Obstacles to Innovation, in F. R. Allen *et al*. (eds.), *Technology and Social Change*, New York: Appleton-Century-Crofts: 56-71.
Odum, H. (1951), William F. Ogburn, in H. W. Odum, *American Sociology: the Story of Sociology in the United States through 1950*, New York: Longman: 147-152.
OECD (1999), *Boosting Innovation: The Cluster Approach*, Paris: OECD.
OECD (2001), *Innovative Clusters: Drivers of National Innovation Systems*, Paris: OECD.
Ogburn, W. F. (1922a), Bias, Psychoanalysis, and the Subjective in Relation to the Social Sciences, *Publications of the American Sociological Society*, 17: 62-74.
Ogburn, W. F. (1922b), *Social Change with Respect to Culture and Original Nature*, New York: Viking Press.
Ogburn, W. F. (1923), The Fluctuations of Business as Social Forces, *Journal of Social Forces*, 1 (2): 63-78.
Ogburn, W. F. (1926), The Great Man Versus Social Forces, *Social Forces*, 5 (2). Reprinted in O. D. Duncan (1964), *William F. Ogburn on Culture and Social Change: Selected Papers*, Chicago: University of Chicago Press: 33-43.
Ogburn, W. F. (1928), Inventions and Discoveries, *American Journal of Sociology*, 34 (1): 25-39.
Ogburn, W. F. (1929), Inventions and Discoveries, *American Journal of Sociology*, 34 (6): 984-993.
Ogburn, W. F. (1930), The Folkways of a Scientific Sociology, *Publications of the American Sociological Society*, 16: 1-11.
Ogburn, W. F. (1932a), Statistics and Art, *Journal of the American Statistical Association*, 27 (177): 1-8.
Ogburn, W. F. (1932b), The Volume of Knowledge, *Journal of Adult Education*, 4: 26-29.
Ogburn, W. F. (1933a), A Reply, *Journal of Political Economy*, 41 (2): 210-221.
Ogburn, W. F. (1933b), *Living with Machines*, Chicago: American Library Association.
Ogburn, W. F. (1933-34), Social Change, in E. R. A. Seligan (ed.), *Encyclopedia of the Social Sciences*, New York: Macmillan, Vol. 3: 330-334.
Ogburn, W. F. (1934a), Limitations of Statistics, *American Journal of Sociology*, 40 (1): 12-20.
Ogburn, W. F. (1934b), Studies in Prediction and the Distortion of Reality, *Social Forces*, 13 (2): 224-229.
Ogburn, W. F. (1934c), *You and Machines*, Chicago: University of Chicago Press.
Ogburn, W. F. (1935), Prospecting for the Future, *The Social Frontier*, 1(7): 20-22.
Ogburn, W. F. (1936a), Stationary and Changing Societies, *American Journal of Sociology*, 42 (1): 16-31.

Ogburn, W. F. (1936b), Technology and Government Change, *Journal of Business of the University of Chicago*, 9 (1): 1-13.
Ogburn, W. F. (1937a), National Policy and Technology, in US National Resources Committee, *Technological Trends and National Policy, Including the Social Implications of New Inventions*, Washington: USGPO: 3-14.
Ogburn, W. F. (1937b), The Influence of Inventions on American Social Institutions in the Future, *American Journal of Sociology*, 63 (3): 365-376.
Ogburn, W. F. (1938a), *Machines and Tomorrow's World*, Washington: National Resources Committee.
Ogburn, W. F. (1938b), Technology and Sociology, *Social Forces*, 17 (1): 1-8.
Ogburn, W. F. (1941a), National Policy and Technology, in S. M. Rosen and L. Rosen (eds.), *Technology and Society: Influence of Machines in the United States*, New York: Macmillan: 3-29.
Ogburn, W. F. (1941b), Technology and Planning, in W. F. Ogburn and G. B. Galloway (eds.), *Planning for America*, New York: H. Holt and Co.: 168-185.
Ogburn, W. F. (1942), Inventions, Population, and History, in P. Lond (ed.), *Studies in the History of Culture*, Menasha (Wisconsin): Geo Banta. Reprinted in O. D. Duncan (1964), *William F. Ogburn on Culture and Social Change: Selected Papers*, Chicago: University of Chicago Press: 62-77.
Ogburn, W. F. (1946a), Inventions of Local Transportation and the Pattern of Cities, *Social Forces*, 24 (4): 373-379.
Ogburn, W. F. (1946b), On Predicting the Future, in W. F. Ogburn, J. L. Adams and S. C. Gilfillan, *The Social Effects of Aviation*, Boston: Houghton Mifflin, chapter 3.
Ogburn, W. F. (1947), How Technology Changes Society, *Annals of the American Academy of Political and Social Science*, 249: 81-88.
Ogburn, W. F. (1949a), Science and Society, in R. P. McKeon (ed.), *Science and Civilization*, Madison: University of Wisconsin: 197-212.
Ogburn, W. F. (ed.) (1949b), *Technology and International Relations*, Chicago: University of Chicago Press.
Ogburn, W. F. (1949c), The Process of Adjustment to New Inventions, in W. F. Ogburn (ed.), *Technology and International Relations*, Chicago: University of Chicago Press: 16-27.
Ogburn, W. F. (1950), *Social Change with Respect to Culture and Original Nature*, Gloucester (Mass.): Peter Smith.
Ogburn, W. F. (1951), Population, Private Ownership, and the Standard of Living, *American Journal of Sociology*, 56 (4): 314-319.
Ogburn, W. F. (1952), Social Effects of Technology in Industrialized Societies, *International Social Science Bulletin*, 4 (2): 269-279.
Ogburn, W. F. (1955), Technology and the Standard of Living in the United States, *American Journal of Sociology*, 60 (4): 380-386.
Ogburn, W. F. (1956), Technology as Environment, *Sociology and Social Research*, September-October: 3-9.
Ogburn, W. F. (1957a), Cultural Lag as Theory, *Sociology and Social Research*, January-February: 167-174.

Ogburn, W. F. (1957b), How Technology Causes Social Change, in F. R. Allen *et al*. (eds.), *Technology and Social Change*, New York: Appleton-Century-Crofts: 12-26.
Ogburn, W. F. (1957c), The Meaning of Technology, in F. R. Allen *et al*. (eds.), *Technology and Social Change*, New York: Appleton-Century-Crofts: 3-11.
Ogburn, W. F. (1959), Technological Development and Per Capita Income, *American Journal of Sociology*, 65 (2): 127-131.
Ogburn, W. F., and F. R. Allen (1959), Technological Development and Per Capita Income, *American Journal of Sociology*, LXV (2): 127-131.
Ogburn, W. F. (1960), Technology and Cities: Dilemma of the Modern Metropolis, *Sociological Quarterly*, 1: 140-153.
Ogburn, W. F., J. L. Adams and S. C. Gilfillan (1946), *The Social Effects of Aviation*, Cambridge (Mass.): Riverside Press.
Ogburn, W. F., and S. C. Gilfillan (1933), The Influence of Invention and Discovery, in US President's Research Committee on Social Trends, *Recent Social Trends in the United States*, New York: McGraw-Hill, Volume 1: 122-166.
Ogburn, W. F., and A. Goldenweiser (eds.) (1927), *The Social Sciences and their Interrelations*, Boston (Mass.): Houghton Mifflin Co., 1974.
Ogburn, W. F. and M. F. Nimkoff (1940), *Sociology*, Cambridge (Mass.): Riverside Press.
Ogburn, W. F. and M. F. Nimkoff (1964), *Sociology*, Fourth edition, Cambridge (Mass.): Riverside Press.
Ogburn, W. F., and M. F. Nimkoff (1955), *Technology and the Changing Family*, Cambridge (Mass.): Riverside Press.
Ogburn, W. F. and D. S. Thomas (1922a), Are Inventions Inevitable? A Note on Social Evolution, *Political Science Quarterly*, 37 (1): 83-98.
Ogburn, W. F., and D. S. Thomas (1922b), The Influence of the Business Cycle on Certain Social Conditions, *Journal of the American Statistical Association*, 18 (139): 324-340.
Posner, M. V. (1961), International Trade and Technical Change, *Oxford Economic Papers*, 13: 323-341.
Price, D. J. S. (1961), *Science since Babylon*, New Haven (Conn.): Yale University Press.
Price, D. J. S. (1962), *Little Science, Big Science*, New York: Columbia University Press.
Rapaport, D. (1974), *The History of the Concept of Association of Ideas*, New York: International Universities Press.
Roberdy, Eugène (1908), *Sociologie de l'action: la genèse sociale de la raison et les origines rationnelles de l'action*, Paris: Félix Alcan.
Rogers, E. M. (1962), *Diffusion of Innovations*, New York: Free Press.
Rogers, E. M. (1983), *Diffusion of Innovation*, New York: The Free Press.
Rosen, S. M., and L. Rosen (eds.) (1941), *Technology and Society: Influence of Machines in the United States*, New York: Macmillan.
Rosenberg, N. (1976), Problems in the Economists' Conceptualization of Technological Innovation, in N. Rosenberg, *Perspectives on Technology*, Cambridge: Cambridge University Press: 61-84.
Rosenberg, N. (1978), The Diffusion of Technology: an Economic Historian's View, in M. Radnor, I. Feller and E. Rogers (eds.), *The Diffusion of Innovations: An*

Assessment, Center for Interdisciplinary Study of Science and Technology, Evanston (Ill.): Northwestern University.
Schmookler, J. (1966), *Invention and Economic Growth*, Cambridge (Mass.): Harvard University Press.
Schneider, J. (1945), Cultural Lag: What Is It?, *American Sociological Review*, 10: 786-791.
Skinner, Q. (1988), Language and Social Change, in J. Tully (ed.), *Meaning and Context*, Princeton: Princeton University Press: 119-32.
Smith, G. E., *et al*. (1927), *Culture: the Diffusion Controversy*, New York: Norton.
Sorokin, P. A. (1933), Recent Social Trends: A Criticism, *Journal of Political Economy*, 41 (2): 194-210.
Spencer, H. (1877), *Principles of Sociology*, Volume 1, New York: D. Appleton and Co.
Stamp, J. (1929), Invention, in *Some Economic Factors in Modern Life*, London: P. S. King: 89-121.
Stern, B. J. (1927), *Social Factors in Medical Progress*, New York: Columbia University Press.
Stern, B. J. (1937), Resistances to the Adoption of Technological Innovations, in US National Resources Committee, *Technological Trends and National Policy, Including the Social Implications of New Inventions*, Washington: USGPO: 39-66.
Tarde, G. (1890), *Les lois de l'imitation*, Paris: Seuil, 2001.
Tibbitts, C. (1930), Inventions and Discoveries, *American Journal of Sociology*, 35 (6): 888-899.
Tibbitts, C. (1931), Inventions and Discoveries, *American Journal of Sociology*, 36 (6): 885-893.
US National Resources Committee (1937a), *Technology and Planning*, Washington: USGPO.
Usher, A. P. (1929), *A History of Mechanical Inventions*, New York: Dover, 1988.
US National Resources Committee (1937b), *Technological Trends and National Policy, Including the Social Implications of New Inventions*, Washington: USGPO.
US President's Research Committee on Social Trends (1933), *Recent Social Trends in the United States*, New York: McGraw-Hill, Two volumes.
Valente, T. W. and E. M. Rogers (1995), The Origins and Development of the Diffusion of Innovations Paradigm as an Example of Scientific Growth, *Science Communication*, 16: 242-273.
Volti, R. (2004), William F. Ogburn: Social Change with Respect to Culture and Original Nature, *Technology and Culture*, 45: 396-405.
Weintraub, D. (1937), Unemployment and Increasing Productivity, in US National Resources Committee, *Technological Trends and National Policy, Including the Social Implications of New Inventions*, Washington: USGPO: 67-87.
Wissler, C. (1916), Psychological and Historical Interpretations of Culture, *Science*, XLIII (1102), February 11: 193-201.
Woodard, J. W. (1934), Critical Notes on the Culture Lag Concept, *Social Forces*, 12 (3): 388-398.

Appendix 1.
Ogburn's Vocabulary

Ogburn made few uses of the term innovation. His preferred terms were material culture, then, from the 1930s onward, technology. Invention and discovery as terms were also used in every writing. For a time he also made use of machines (Ogburn, 1933a, 1934c; 1938a) and occasionally he elected to use the term knowledge (Ogburn, 1932b). All of these terms were used interchangeably, and meant both technical (and social) inventions and scientific discoveries: For example, "the word technology will be used to include applied science and will be interchanged with invention and scientific discovery (…)" (Ogburn, 1938b: 1). In fact, Ogburn had a broad concept of invention. He identified three meanings of invention and/or technology (Ogburn, 1942; Ogburn, 1957c). First, a strict definition refers to technological invention. A second meaning includes scientific discoveries, both basic and applied, and was widely used by Ogburn. A third meaning, which he preferred, includes social inventions and considers the social aspects of technology: what it does, and its use and function. This meaning suggests that the sociologist as student of technology gives attention to the social effects of technology.

Ogburn made use of the term innovation only twice (Ogburn, 1941a: 3, 14, 16, 18; 1950: 378), while the chapter by B. J. Stern in Ogburn's *Technological Trends and National Policy* (1937) used it widely, concurrently with other terms like technological change. To Ogburn, innovations are "inventions that have served to transform the environment profoundly". Then, in the fourth edition of *Sociology*, published five years after Ogburn's death, his collaborator Meyer M. Nimkoff replaced invention by innovation in the title of the chapter dealing with the social effects of invention (but used the term only once in the chapter, without explicit definition) (Ogburn and Nimkoff, 1964: 697; 710). By that time, innovation was in fact getting increased attention in the sociological literature (Stern, 1927; Chapin, 1928; Hart, 1931; Gilfillan, 1935b; [29] Nimkoff, 1957; Rogers, 1962).

[29] As with Ogburn, Gilfillan used the term innovation only twice (Gilfillan, 1935b: 59; 1937b: 20).

Whether Ogburn was consciously reluctant to use the term innovation is most probably impossible to know. That the term innovation was rather "pushed" by Nimkoff is attested by its occurrence in Ogburn's works written with this author (and its absence elsewhere). The first edition of *Sociology* used it frequently in part 7 dealing with social change (Ogburn and Nimkoff, 1940: 828, 832, 836, 838, 858, 863. See also Nimkoff (1957).

Appendix 2.

Social Inventions

Armistice day.
Auto tourist camp.
Australian ballot.
Basketball.
Bonus to wage earners.
Boycott.
Chain store.
Charity organization society.
City manager plan.
Civil service system.
Clearing house.
Community chest.
Company union.
Correspondence school.
Day nursery.
Direct primary.
Esperanto.
Federal Reserve system.
Four-H club
Group insurance.
Holding company.
Indeterminate sentence.
Intelligence tests.
Investment trust.
Installment selling.
Junior college.
Juvenile court.
Ku Klux Klan.
League of Nations.
Legal aid society.
Lock out.
Matrimonial bureau.
Minimum wage law.
Mother's pension.
National economic council.
One-step.
Passport.
Patents.
Psychological clinics.
Proportional representation.
Recall.
Research institute.
Rochdale cooperative.
Rotary club.
Seminar.
Social settlement.
Summer camp.
Tag day.
Universal suffrage.
Visiting teacher.

Appendix 3.

Effects of the radio telegraph and telephone and of radio broadcasting

I. On uniformity and diffusion

1. Homogeneity of peoples increased because of like stimuli.
2. Regional differences in cultures become less pronounced.
3. The penetration of the musical and artistic city culture into villages and country.
4. Ethical standards of the city made more familiar to the country.
5. Distinctions between social classes and economic groups lessened.
6. Isolated regions are brought in contact with world events.
7. Illiterates find a new world opened to them.
8. Restriction of variation through censorship resulting in less experiment and more uniformity.
9. Favouring of the widely spread languages.
10. Standardization of diction and discouragement of dialects.
11. Aids in correct pronunciation, especially of foreign words.
12. Cultural diffusion among nations, as of United States into Canada and vice versa.

II. On recreation and entertainment.

13. Another agency for recreation and entertainment.
14. The enjoyment of music popularized greatly.
15. Much more frequent opportunity for good music in rural areas.
16. The manufacture of better phonograph music records encouraged.
17. The contralto favored over sopranos through better transmission.
18. Radio amplification lessens need for loud concert voices.
19. Establishment of the melodramatic playlet with few characters and contrasted voices.
20. Revival of old songs, at least for a time.
21. Greater appreciation of the international nature of music.
22. Entertainment for invalids, blind, partly deaf, frontiersmen, etc.
23. With growth of reformative idea, more prison installations.
24. Interest in sports increased, it is generally admitted.
25. Slight stimulation to dancing at small gatherings.
26. Entertainment on trains, ships and automobiles.

III. On transportation

27. Radio beams, enabling aviators to remain on course.
28. Directional receivers guide ships to port with speed and safety.
29. Aid furnished to ships in distress at sea.

30. Greater safety to airplanes in landing. Radio system also devised now for blind landing.
31. Chronometers are checked by time signals.
32. Broadcast of special weather reports aids the aviator.
33. Brokerage offices on ships made possible.
34. Receipt of communications en route by air passengers.
35. Communication between airplanes and ships.
36. Ships directed for better handling of cargoes.

IV. On Education

37. Colleges broadcast classroom lectures.
38. Broadcasting has aided adult education.
39. Used effectively in giving language instruction.
40. Purchasing of text books increased slightly, it is reported.
41. Grammar school instruction aided by broadcasting.
42. Health movement encouraged through broadcast of health talks.
43. Current events discussion broadcast.
44. International relations another important topic discussed, with some social effects, no doubt.
45. Broadcasting has been used to further some reform movements.
46. The government broadcasts frequently on work of departments.
47. Many talks to mothers on domestic science, child care, etc.
48. Discussion of books aids selection and stimulates readers.
49. The relationship of university and community made closer.
50. Lessens gap schooling may make between parents and children.
51. Provision of discussion topics for women's clubs.
52. New pedagogical methods, i.e.: as to lectures and personality.
53. Greater knowledge of electricity spread.
54. The creation of a class of radio amateurs.

V. On the dissemination of information

55. Wider education of farmers on agricultural methods.
56. Prevention of loss in crops by broadcasting weather reports.
57. Education of farmers on the treatment of parasites.
58. Market reports of produce permitting better sales.
59. Important telephone messages between continents.
60. Small newspapers, an experiment yet, by facsimile transmission.
61. News to newspapers by radio broadcasting.
62. News dissemination in lieu of newspapers, as in British strike.
63. Transmission of photographic likenesses, letters, etc., especially overseas where wire is not yet applicable.

64. Quicker detection of crime and criminals, through police automobile patrols equipped with radio.

VI. On Religion

65. Discouragement, it is said, of preachers of lesser abilities.
66. The urban type of sermon disseminated to rural regions.
67. Services possible where minister cannot be supported.
68. Invalids and others unable to attend church enabled to hear religious service.
69. Churches that broadcast are said to have increased attendance.
70. Letter-writing to radio religious speakers gives new opportunity for confession and confidence.

VII. On Industry and business

71. In industry, radio sales led to decline in phonograph business.
72. Better phonograph recording and reproducing.
73. Lowering of cable rates followed radio telegraph development.
74. Point to point communication in areas without wires.
75. The business of the lyceum bureaus, etc., suffered greatly.
76. Some artists who broadcast demanded for personal appearance in concerts.
77. The market for the piano declined. Radio may be a factor.
78. Equipment cost of hotel and restaurant increased.
79. A new form of advertising has been created.
80. New problems of advertising ethics, as to comments on competing products.
81. An important factor in creating a market for new commodities.
82. Newspaper advertising affected.
83. Led to creation of new magazines.
84. An increase in the consumption of electricity.
85. Provision of employment for 200,000 persons.
86. Some decreased employment in phonograph and other industries.
87. Aid to power and traction companies in discovering leaks, through the assistance of radio listeners.
88. Business of contributing industries increased.

VIII. On Occupations

89. Music sales and possibly song writing has declined. Studies indicate that broadcasting is a factor.
90. A new provision for dancing instruction.
91. A new employment for singers, vaudeville artists, etc.
92. New occupations: announcer, engineer, advertising salesman.
93. Dance orchestras perhaps not increased by being given prominence.

IX. On Government and politics

94. In government, a new regulatory function necessitated.
95. Censorship problem raised because of charges of swearing, etc.
96. Legal questions raised beginning with the right to the air.
97. New specialization in law; four air law journals existing.
98. New problems of copyright have arisen.
99. New associations created, some active in lobbying.
100. Executive pressure on legislatures, through radio appeals.
101. A democratizing agency, since political programs and speeches are designed to reach wide varieties of persons at one time.
102. Public sentiment aroused in cases of emergencies like drought.
103. International affairs affected because of multiplication of national contacts.
104. Rumours and propaganda on nationalism have been spread.
105. Limits in broadcasting bands foster international arrangements.
106. Communication facilitated among belligerents in warfare.
107. Procedures of the nominating conventions altered somewhat.
108. Constituencies are kept in touch with nominating conventions.
109. Political campaigners reach larger audiences.
110. The importance of the political mass meeting diminished.
111. Presidential "barn-storming" and front porch campaign changed.
112. Nature of campaign costs affected.
113. Appeal to prejudice of local group lessened.
114. Campaign speeches tend to be more logical and cogent.
115. An aid in raising campaign funds.
116. Campaign speaking by a number of party leaders lessened.
117. Campaign promises over radio said to be more binding.
118. High government officers who broadcast are said to appear to public less distant and more familiar.

X. On other inventions

119. Development stimulated in other fields, as in military aviation.
120. The vacuum tube, a radio invention, is used in many fields, as for leveling elevators, automobile train controls, converting electric currents, applying the photo-electric cell, as hereinafter noted. A new science is being developed on the vacuum tube.
121. Television was stimulated by the radio.
122. Developments in use of the phonograph stimulated by radio.
123. Amplifiers for radio and talking pictures improved.
124. The teletype is reported to have been adapted to radio.
125. Geophysical prospecting aided by the radio.

126. Sterilization of milk by short waves, milk keeping fresh a week.
127. Extermination of insects by short waves, on small scale, reported.
128. Body temperature raised to destroy local or general infections.
129. The condenser with radio tubes used variously in industry for controlling thickness of sheet material, warning of dangerous gas, etc.
130. Watches and clocks set automatically by radio.

XI. Miscellaneous

131. Morning exercises encouraged a bit.
132. The noise problem of loud speakers has caused some regulation.
133. A new type of public appearance for amateurs.
134. Some women's clubs are said to find the radio a competitor.
135. Late hours have been ruled against in dormitories and homes.
136. Rumour as a mode of expression perhaps hampered in broadcasting.
137. Growth of suburbs perhaps encouraged a little.
138. Letter-writing to celebrities a widespread practice.
139. Irritation against possible excesses of advertising.
140. Development of fads of numerology and astrology encouraged.
141. Automobiles with radio sets have been prohibited for safety, in some places.
142. Additions to language, as "A baby broadcasting all night."
143. Aids in locating persons wanted.
144. Wider celebration of anniversaries aids nationalism.
145. Used in submarine detection.
146. Weather broadcasts used in planning family recreation.
147. Fuller enjoyment of gala events.
148. Home duties and isolation more pleasant.
149. Widens gap between the famous and the near-famous.
150. Creative outlet for youth in building sets.