

**Forecasting the Telephone:
A Retrospective Technology Assessment**

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Forecasting the Telephone: A Retrospective Technology Assessment

by
Ithiel de Sola Pool

*Research Program on Communications Policy
Massachusetts Institute of Technology*



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Ithiel de Sola Pool

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**Forecasting the Telephone:
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I

Introduction

This is a book about forecasting. More specifically, it deals with forecasts about the telephone and what that new invention would do to society. These forecasts appeared between 1876, the year of Bell's invention, and 1940, by which time, in the United States, there was a mature telephone system in place. In those 65 years hundreds of forecasts were made. The magazines of the day were fond of discussing this exciting new technology and the revolution in life that it had produced. This attention was similar to that paid to the space program today. Both of these technologies caused revised conceptions of man's place in the universe.

The forecasts that appeared from 1876 to 1940 can be considered as a kind of "technology assessment." That phrase was not used in those days, but the objective was the same. Thinkers sought to assess the future of the phone and how it would change life. Sometimes they did well and sometimes they did badly. For us, in retrospect, the interesting question is to understand the successes and failures and the reasons for success or failure. What lessons can we learn from these early attempts at technology assessment?

THE THESIS

In successful technology assessment, market and technical analyses must be brought to bear simultaneously. Alone either of them fails; together they can produce some very prescient forecasts. That is the lesson gained from this case study of the telephone and its effects upon society.

The conclusion may sound banal, but if prevailing practice is any evidence, it is not. A large proportion of current technology assessments make little use of market analysis. Many of them compile expert evaluations of:

- available and likely technologies
- the potential uses of them
- their side effects
- their interaction with other alternative technologies and with social goals

without much serious effort toward a market analysis of the cost and demand for the alternatives. That sort of analysis, in the late 19th and early 20th centuries, resulted in some misled anticipations about the prospects of telephony. Some good assessments were also made, however, by people who focused simultaneously on the market and on technical features of the new technology.

Our study of the telephone is a case study, and like any case study, it does not provide extensional testing of its hypothesis. To define the boundaries within which our conclusion holds would require us to go beyond one case. Certainly, the telephone is not unique, but all we actually demonstrate here is that in the case of the telephone the crux of good technology assessment was and would have been the intimate melding of technical and market analyses.

We base that conclusion on a review and analysis of 186 forecasts about the social impact of the telephone system—some relatively prescient and some quite wrong. Before we look at those forecasts, however, let us consider the general concept of technology assessment and the place of forecasting in it.

THE CONCEPT OF TECHNOLOGY ASSESSMENT

Members of self-conscious disciplines are fond of debating the definition of their discipline. The younger and less recognized the discipline, the stronger that search for identity.

The debate about the definition of technology assessment is not one we choose to enter. It is not very useful to do more than note the kinds of things people do who call themselves practitioners of the art.

Technology assessors are interested in evaluating the social consequences of technological changes. They are forecasters. They seek to foresee not only which technological alternatives are likely to be adopted, but also what secondary consequences such adoption or non-adoption will have. The consequences of any technological development are partly other technical developments; for example, mastering the technology of electric circuits

made possible the technology of telegraphy. Other consequences, however, are social; e.g., electricity was widely forecast to favor smaller plants than did steam power; based on that assumption, a dispersal of human aggregations was also predicted.¹

Most technology assessments seek to catalog all the effects of a given technology, but some, on the other hand, seek to explore the technological conditions of a particular effect. Lord Ashby, for example, has studied the historical debate about smoke abatement legislation in Great Britain in the 19th century.²

Some authors make a distinction between technology forecasting and technology assessment, reserving the latter term for assessments of social consequences. We will make no such distinction here. Some technology assessments are highly normative, the assessment incorporating judgments of what is good or bad for society; such assessments are commonly made by environmental activists, for example. Other assessments are purely descriptive. Some assessments seek rigor by using various formal methodologies such as the Delphi technique or cross-impact analysis; others use the intuitive insights of historians or ethnologists.

What almost all who call themselves technology assessors share is a belief that if rational methods are used to anticipate consequences of different technical alternatives, better social choices can be made. That optimistic notion rests on two premises. One premise is that knowledge leads to more enlightened action; we shall not question this premise here. The second premise is that it is possible to forecast the consequences of technology with some success; this is the premise we seek to test in this case study.

It is not a foregone conclusion that forecasting of technology is feasible beyond a very limited time period and range of events. The argument for the infeasibility of forecasting is that invention and discovery are by their nature surprise events. Indeed, it is sometimes said, if one can anticipate a discovery it is not a discovery.

We do not accept the logic of that argument. Almost every important invention and discovery has been anticipated in fantasy long before it was proven by practice or science. Mythology is full of men flying, walking on the moon, transmuting materials one to another, or communicating without being present. Each of these innovations was also discussed by serious scholars long before the particular ones who actually pulled off the trick of discovery or invention. Leonardo anticipated Orville Wright, though the conditions for successful realization did not exist. The word "Telephone" was used on a number of occasions throughout the 19th century by people who could conceive one, but not yet build one. We do not need to argue theoretically against the notion that discovery cannot be forecast. The issue is empirical. Some amazingly good forecasts have been made; that is a palpable fact that cannot be denied. We shall examine historically the circumstances in

which, good or bad, the forecasts were made in a particular technical field, namely forecasts of the consequences of the telephone.

RETROSPECTIVE TECHNOLOGY ASSESSMENTS

This study is not itself a technology assessment as we have described that art above. It is a review of technology assessments that other people made over the past century. We ourselves make no effort to forecast or to evaluate possible consequences of future technologies. Our study is a historical one; it looks at the assessments that writers made in the past as they wrote about the telephone. We judge how good or bad the assessments were and try to distinguish what factors led to good assessments and what to bad. Finally we ask a “what if” question: if good methodologies had been followed and good data collected, how far could the consequences of the telephone (as we see them with our presumed 20/20 hindsight) have been anticipated in advance? That is why we call it a “retrospective technology assessment.”³ In a different social research tradition this might have been called a “gedanken-experiment,” and in still other traditions it might have been called a study of “what if” or an examination of “counterfactuals.”

The question before us is how, and how well, might observers at the turn of the century have anticipated the social impacts that the telephone has had?

Put that way, however, it is not a well defined question. It is, nonetheless, a type of question we ask all the time. Juries in damage cases try to decide if a defendant could reasonably have anticipated the consequences of what he did. A board of directors tries to decide whether a chief executive who has suffered a loss could properly have anticipated the market trends better than he did. When the medicine our physician prescribes fails to cure us, we ask ourselves whether he could have made a better diagnosis. In each such case we implicitly postulate a certain corpus of knowledge which the responsible actor should have used; we do not expect him to be omniscient. Until we define what knowledge base we expect him to have used, the question of what he could have known is an ill-defined one.

In the present study we ask what could have been anticipated about the impact of the telephone. We do not ask what a 1970s social scientist armed with the tools of econometric modelling, technology assessment, and survey research might have done if he were by some time warp wafted back to 1900. We propose a much more modest question: how well were people at that time able to anticipate consequences of the new technology, given only the knowledge and tools that existed in those days?

We chose this more modest question as our point of reference in part because answering it does not require us to engage in blue sky science fiction

writing. By examining the analyses and forecasts that were actually made we can get some hold on the question of how well forecasters succeeded.

Within the constraints of the knowledge-base of their day, different observers made different forecasts—some good, some bad. The distribution of assessments that were actually made presumably represents the range from very nearly the best that anyone could reasonably have done at the time to somewhere near the worst. The question that we can fruitfully explore is: what led to good assessments and what to bad ones? What were the characteristics of the people who were good forecasters; what kinds of methods did they use; what kinds of data did they start from?

The answers to those questions have some practical value for the practice of technology assessment today. Granted, the existence of new analytic techniques and better data bases means that one would not today slavishly imitate even the best analyses of 1876-1940. Still, we have not made so much progress in social analysis that the lessons of that earlier period are irrelevant. If we can identify the ingredients that led to good technology assessments in that period, presumably the same general factors, *mutatis mutandis*, would be significant today.

A common naive assumption is that with the benefit of hindsight there should be no problem in grading a past forecast as right or wrong. In a previous publication this author has analyzed why that is not so.⁴ On the one hand, very few assessments are stated unambiguously enough to be rigorously testable against the facts, and on the other hand, the facts themselves are often almost as hard to establish in retrospect as they are to forecast. Professional historians, after all, spend most of their time discovering and debating what past facts were.

The problem of testing the reliability of both predictions and postdictions can be illustrated by an example of typical difficulties. The telephone, it is often said today (and was said as early as the 1870s) is an invader of our privacy. (See Section 10.6 for a discussion of this topic.) There is no question that its imperious ring frequently interrupts domestic quiet. But the overall relation of the telephone to privacy is very complicated indeed, and it is hard to say whether its net effect has been to increase or decrease the extent of privacy in modern life. Early concerns about privacy had to do with listening in by operators on the line, accidentally crossed circuits, and, and above all, party lines. Comments on the telephone as a threat to privacy, when predicated on those features of the early phone system, might have been good analyses for those days, but poor forecasts for the era of the automatic dial phone. Yet concern about privacy persists, now focused partly on the matter of wiretapping. Indeed, intrusions on privacy by wiretapping are possible (perhaps more easily than steaming open of letters) and have occurred. But let us note some reverse aspects—those in which the telephone has improved privacy.

For one thing, the telephone permits confidential messages to be sent without the risks attendant on their commitment to writing. Besides that, the telephone has profoundly changed the mores regarding "dropping in." In the days before the telephone, intrusions on domestic seclusion took the form of someone dropping by. The polite thing in many circumstances was to call in person to pay one's respects. Conventions restricted this by time of day; also, servants might protect affluent masters with polite lies. But it is hard to argue that the ring of the phone—now in many circumstances a *de rigueur* precedent to visiting—is more intrusive on privacy than the physical arrival of a caller one hesitates to offend. Yet precisely because the phone call is so much lesser an intrusion than the unannounced visit that it replaced, it is indulged in much more frequently and undertaken more lightly.

So, given these various considerations (the great frequency of phone calls, their tendency to reduce unannounced visits, the privacy of the unwritten exchange, the small but existent possibility of tapping), what is the net impact of the telephone on privacy? And if one is to evaluate a turn of the century statement about the telephone and privacy, should one assume it to have been meant as a forecast stretching beyond the end of the operator and party line? Looking backward, are we any more sure what the effects of the phone have been on privacy than a forecaster would have been? Neither of us is sure.

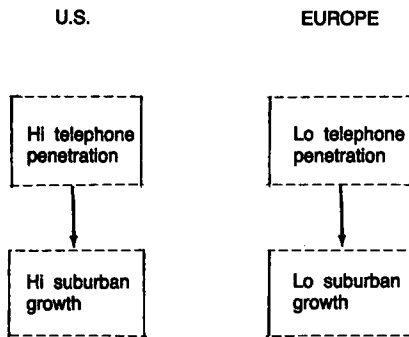
Comparisons across time of judgments of the impact of the telephone, even if not easy, are nonetheless useful in giving us perspective. So are comparisons across space. We commissioned Professor Bertil Thorngren of the Stockholm School of Economics and Professor Michael Gibbons of the University of Manchester in England to search early sources of comment on the telephone in those countries. This cross-national comparison is important, because it is very easy in a study of one country (in this instance the United States) to misperceive some development as a natural consequence of the telephone itself, when it is in fact just one among alternative ways in which the device can be used. For example, is the phone a democratizing instrument or one which introduces a new element of status hierarchy? The U.S. experience, where the phone became fairly universal in half a century (and was always intended to be universal) provides considerable support (which we shall review below) for the view that the telephone has been a democratizing influence. In France and England phone penetration has gone much more slowly, and for a much longer period the telephone remained a prerogative of the rich. In 1904, there were 6.5 phones per hundred persons in Manhattan and Bronx, and 1.4 per hundred in London.⁵ In 1912, when phone penetration in New York was 8.3 per 100 persons, and in Boston 9.2 per hundred, phone penetration in London was 2.8 per hundred. In 1914, when there were ten million phones in the U.S. There were 650,000 in Great Britain. Seventy percent of the world's phones were then in the U.S.

The extreme counter-example, however, is the Soviet Union, which has a very different phone system. Phone books are not made generally available, so unless one knows a person's number one can call only by using directory assistance, and many important numbers are not given out. The system, therefore, becomes to a great degree one of group communication within closed circles. That philosophy is further expressed in the existence of several segregated telephone networks for different institutions. The most significant is the "key" system which links members of the top elite, and which can only be dialed by someone with a key to unlock the instrument. In the Soviet Union the total of phones on the several segregated networks is apparently greater than that of the public network.

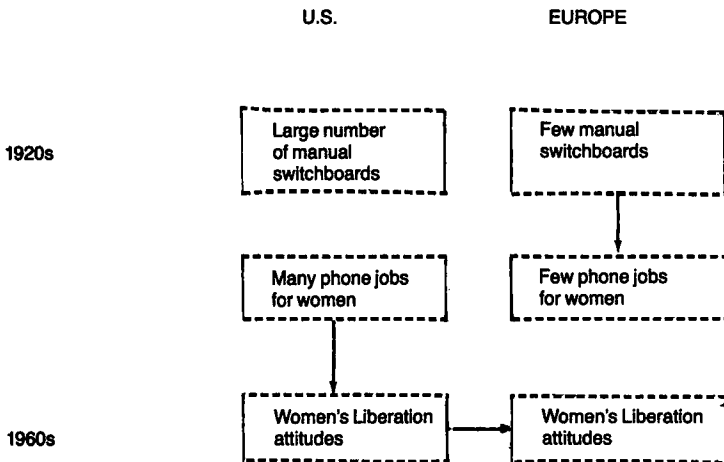
Just as a study of a single country could confuse one impact of the telephone with its necessary impact, so it may confuse the impact of other social circumstances with the impact of the telephone. For example, every modern country needs a good means of rapid dissemination of business information. If one looks only at the United States it is easy to believe that the telephone is the natural medium for that purpose. Perhaps it is. But other countries with less satisfactory phone systems tend to use alternative technologies to a greater extent than we do. There is a replacement effect. The European phone systems are less good and more expensive than the U.S. system; the European telex system is better and cheaper than that in the U.S. Correspondingly, European businessmen use telex much more frequently than Americans do, and use the phone less frequently.

Thus a second methodology that enters into our research to a certain degree is that of comparative analysis. One might design a study of the social impact of a technology like the telephone by systematic analysis of comparative data. Degrees of telephone penetration in different countries at different times could be correlated with various other social data. There are a number of studies of that kind on the subject of communication and development.⁶ Various measures of penetration of telephones, newspapers, radios, and other communications media are found to correlate highly with indices of development. Causal models have been fitted to that multi-regression data.

There is, however, a problem to such a research design. Its validity depends upon a strong predominance of direct causal relations within each nation or other unit that is observed, over any interactions among those units. Let us explain the point by comparing the problems involved in testing two propositions about the telephone which are discussed later in this book: (1) The telephone fosters movement to suburbs, and (2) The manually switched telephone fostered women's liberation. Proposition 1 might very plausibly be sustained by a statistical comparison of the rate of telephone penetration and the rate of suburbanization between countries. For example the causal pattern might be thus:



On the other hand, the causal pattern for telephone and women's liberation is likely to be more complex. What follows is an expository example, not a serious assertion about the fullness of reality.



If that sort of pattern prevails to some significant degree, then a correlation, country by country, of manual switchboards with women's liberation would fail to appear, but to interpret that as denying that there had been a causal relationship would be an error. In the illustrative facts postulated in the diagram, manual switching did causally promote women's liberation in the United States, and via that, in Europe. So a causal relation is not refuted by the absence of a correlation across countries between manual switching and women's liberation.

For the most part the relationships of the telephone to society entail substantial interactions of the latter kind, which do not make a simple correlational analysis across countries very fruitful.

So the international comparisons that we have introduced into our

research, while important, serve more to alert us to possible alternative paths of social development than to allow systematic correlational hypothesis testing.

The Procedure That We Followed

The data assembled for this study were assertions and forecasts that we found in writings between 1876 and 1940. Our data collection involved inventorying what social effects of the telephone were asserted; noting by whom, when, and where those effects were observed, or in some instances noting a failure to observe them; and attempting to identify the considerations or line of reasoning that went into those observations. Once that collection of statements was assembled, we attempted to evaluate the insightfulness of those informal technology assessments made during the course of the development of the telephone, and also to suggest how such anticipations could have been improved. There is clearly no simple mechanical way in which we can grade a series of forecasts for accuracy. As we have already noted, the statements in the record are too subject to interpretation, and the facts still too debatable. What we can do, and what we intend to do, is to list as many statements as seem to us to be reasonably arguable theses about the social impact of the telephone, then search the literature to find early and clear intimations of those impacts.

This is not an antiquarian search for the first man ever to make a certain statement. That futile enterprise is popular among scholars. Indeed it has been a popular game regarding the invention of the telephone. General Carty, the one-time Chief Engineer of AT&T, notes some claim that there was a 10th century inventor of the phone!⁷ We do search for early statements, because we are interested in how soon a particular social impact was perceived or anticipated. We are, however, equally or more interested in the clarity and fullness of the statements.

We are not interested in frequency counts of statements. It is relevant whether a certain observation was a rare perception or a common comment. But there is no well defined universe for which we could create a sensible sample frame, allowing a rigorous count; nor would that have been valuable if it were possible. Any statement anyone made in the early years of the telephone is grist for our mill if it said anything significant by way of assessment of that technology. For us to find it today, the statement would have to have been preserved—perhaps in a book or an article, perhaps in a newspaper story, perhaps in the transcripts of legislative or administrative proceedings, perhaps in a private letter, perhaps on a phonograph disc⁸ or moving picture. For us the appropriate search rule was to search where the ore was likely to be richest, not to sample the universe; that would have been appropriate if our question concerned a frequency distribution. The use of

overall sampling where the purpose is to find a particular nugget is well described in the familiar fallacy of the drunkard's search—the drunk who looks for his lost key under the streetlight because the light is better, not where he thinks he dropped it.

The places we did search, because we thought the ore was rich, were many: *The New York Times Index*; popular magazines covered in *Reader's Guide* and other periodical indexes; books on the telephone as an institution; on AT&T, on the invention of the telephone and on the lives of Bell, Vail and other key figures; sociological books from before World War II on communication and social change; FCC reports on relevant topics, most particularly the Walker Report;⁹ trade journals, of which *Telephony* proved most valuable; leading treatises on the fields of the dependent variables in our propositions (e.g., urban planning, police work, fire prevention, economic history, political campaigning, and diplomacy) to see what they said about the telephone.

A fortuitous event that aided this project was the coincidence of the centenary of the telephone with our research. A centenary convocation was held at MIT under the sponsorship of AT&T. The author was in charge of a symposium there on the social impact of the telephone. This permitted him to invite about 20 papers from leading scholars on various aspects of the telephone in society during the past century.¹⁰ Many important sources and insights emerged from that exercise.

It should be emphasized that our purpose in this study is something other than *testing* hypotheses about the telephone. We are about to *state* a large number of such hypotheses, ask who put them forward, when, and under what circumstances there was good analysis of them. There is no implication that all of these hypotheses are necessarily valid, although to some degree most of them probably are. We are enumerating hypotheses, not affirming them. In some instances we shall even list contradictory hypotheses. All that we affirm is that these hypotheses are important enough, and have support enough so that a historical review of a technology assessment should explore them.

The list of hypotheses that we are about to present is by no means exhaustive. What criteria did we apply in making this inventory? First of all we were concerned with *social* effects of the telephone—not with its purely technical effects, nor with the social effects of the policies and behavior of AT&T. Either of those lists would be a much longer one. Bell Labs has produced two thick volumes of a series on the history of Bell System technical accomplishments.¹¹ There are literally tens of thousands of technical developments that can trace some part of their ancestry back to research and development for the telephone system. So too, the list of social effects that AT&T as an organization has had in every city and town in the United States could go on indefinitely. AT&T happens to be an enlightened company

which for several decades has encouraged participation of its executives in cultural programs for overall enrichment. We do not consider that choice of policies by AT&T to be an effect of the telephone. The adoption of such policies was an option that any top management could have made, or alternatively could have rejected. For inclusion of any social phenomenon in our inventory we have to see some causal chain tracing the effect back to the technology itself.

Furthermore, our inventory is of effects that were discussed, assessed, or denied in the period from 1876 to 1940. That means we would generally miss any effects which occurred but which were not noticed. We have included only a couple of points that have been largely overlooked, because they seemed to us so very important that their oversight itself was significant. But those are exceptions.

Thus the primary criteria for inclusion of an hypothesis in our inventory were that (a) it is an assertion about the social impact of telephone technology, (b) it is at least moderately important, and (c) some discussion of it occurred in the early telephone years.

One last point: when we talk of the impact of "the telephone" we use that phrase as shorthand for the telephone system. We are not studying just the effects of the handset, but rather the effects of a switched point-to-point network of voice communication in the society.

A Review Of The Inventory

In this introduction, it seems fit to summarize a few of the more striking social effects of the telephone that we shall discuss more fully in the central part of the book.

Among the most significant impacts of the telephone were those in modifying the pattern of human settlement. It made farm life less isolated, made suburbs more practical, helped break up single industry neighborhoods, allowed offices of industrial companies to move away from the plant into downtown office buildings, and made skyscrapers economic. A parallel set of effects operated on businesses and bureaucratic organizations. Creation of large units and decentralized management of them were both facilitated by telecommunications. The labor requirements of the growing telephone system stimulated technical education and also employment of women. Telephone canvassing changed marketing and politics. Telephone reporting changed the relation of journalists and editors. Field telephones extended the range of command and control in warfare. The growth of telephony caused both the telegraph and postal services to run into the red. Out of telephone research grew many new technologies such as the transistor and computers. Using the telephone system many new business services sprang up, such as answering services and taxi calling. The telephone changed

social habits and etiquette in such matters as calling upon strangers. These are simply a few among 186 impacts we discuss later.¹²

We have stated above our major conclusion, namely that for a large class of technologies *a technical—economic market analysis is the place to begin in successful technology assessment*. A taxonomy of 186 propositions found in the inventory that is to follow establishes a particular structure of precedence and dependence among the asserted patterns of causation.

About half of all the propositions (91 out of the 186) take the form of forecasting that the new telephone technology would be used in a certain way; the reasoning behind these forecasts almost always involved a market analysis. For example, it was seen that the phone could be used by company officers to locate their offices downtown while at the same time keeping in touch with their plant on the outskirts. It was also forecast that the phone would be used to listen to concerts without leaving home. Of these two forecasts, one was right and one wrong. The logic of both arguments, however, was that there were enough people ready to pay what the service would have to cost, given the technology available, so that the service could be successfully offered.¹³

Fifty-two more of the propositions use the same logic but carry it one step forward. The logic underlying the 91 above-mentioned propositions had the form:

Given alternative technologies, their costs, and consumer demand, the technology will be used in manner X.

The 52 additional propositions had the form:

The technology will be used in manner X, and so society will be changed in manner Y.

To illustrate: A proposition of the first type was that the telephone would be used to keep in touch with physicians on their rounds. A proposition of the second type was that because the phone could keep their offices in touch with physicians on their rounds, medical neighborhoods would break up since co-location of doctors was no longer necessary.

Thus 143 of the 186 propositions are directly derived from a technical and economic analysis of the market.¹⁴ Of the remaining 43 propositions, which do not rest on telephone market analysis, 36 have the logical form:

Given that telephones come to be widely used, society will be changed in manner Y.

These last propositions do not rest upon a market analysis of demand for a particular use of the phone, but only on the prevalence of the phone in general. Examples of these 36 propositions are the assertions that letter writing and handwriting would deteriorate in the telephone age.

Five of the residual seven propositions are psychological. These are the assertions that women would talk more on the phone than men, that young people would talk more than old, that young people would use the phone for safe sexuality, that people would prefer a private earphone to a loudspeaker phone, and that the ability to talk to a distance would erode an orthodox religious view of the universe. Finally, there are the propositions that the telephone was used by authors (particularly of drama) as a device for bringing remote agents into their plots, and that understanding of telephony would lead to understanding of telepathy.

Any classification of complex ideas is interpretive and subject to error. Readers will argue that we have misclassified some propositions; probably so. One would have to disagree on a large number of cases, however, to change the main conclusions. For those who are bothered by some of the decisions we made, they are all on record in the text, the reader can revise them if he wishes and draw conclusions accordingly.

In Part II, we present the inventory of propositions about the impact of the telephone. Here, as in the listing of the contents, each item in the inventory is classified as follows:

Type A	Telephone will be used in manner x.	Type C	With wide use of phones, society will be changed in manner y.
Type B	Telephone will be used in manner x, so society will be changed in manner y.	Type D	Other propositions.

The outline that we have followed in the inventory organizes the substantive contents of the forecasts in one particular way. Any such outline is partly unsatisfactory, for cross-cutting topics may be relevant in more than one place. Rather than following the literary convention of avoiding repetitions, we have chosen to adhere strictly to the chosen outline of forecasts. The reader may be bothered by a few repetitious topics, wherever the same developments contributed to more than one effect. Effects of the telephone on government and on business, for example, appear at different points in the outline. But both the state and the firm are large organizations, so the effect of the telephone in facilitating large scale institutions is noted in two places.

Generally we state propositions in the future tense, as if they were forecasts at the time that they were stated. But when a proposition may have been a significant trend primarily at the early time when it was observed, and especially if it is no longer so, we drop into present or even past tense. Our symbolic use of tenses should not be confused with any implication that the authors, whose writings we are analyzing, formulated their expressions in this

way. They were writing for their purposes, not ours. We are often imposing a reconstruction on what they wrote to turn their statements into forecasts. Many explicit forecasts exist. General John J. Carty, a key figure in American telephone development, wrote an anonymous column called "The Prophet's Corner" in the journal *Electrical Engineering*, and H.G. Wells wrote a book of forecasts for the 20th century called *Anticipations*.¹⁵ More often, however, the statements that we have framed as forecasts were analyses of newly emergent trends which the author clearly expected to keep going.

One conclusion, already labelled as our central thesis, seems inescapable from this retrospective look at the forecasts that were made:

A successful and comprehensive technology assessment of the telephone would have had to start with an informed analysis of the technological prospects and possibilities of the device, coupled with a good market analysis of demand for different types of phone and phone service. If from that one anticipated that there would be extensive use of the telephone for certain functions or extensive use of it in general, then one could draw further inferences about how that would affect society.

The conclusion that we have drawn about the requirements for a good telephone assessment holds particularly because the telephone was introduced as a consumer product.

For some technologies which are not consumer products a different mode of analysis would be relevant. It is important to note that S. Myers and D.G. Marquis found that 75 percent of 567 innovations were a response to market needs or manufacturing economy.¹⁶ Still, the residual quarter of the cases were not such a response.

Some assessments among these non-consumer products would be quite similar to those of the consumer products except that the sponsors, whose economic support had to be assured, were not the general public. A technology assessment of a weapons system, for example, also requires a market analysis, but the consumers whose favor must be won are governments.

Ideologists have tried to lay down philosophically based rules about what historians, sociologists, or technology assessors ought to study. We are not trying to establish such rules. We have tried to be empirical, cataloguing what people have found worthwhile to say about the impact of the telephone. When we do that, we discover—not surprisingly—that the majority of interesting propositions ask both what was technically possible and also who was ready to pay how much for that.

In the case of telecommunications, as in many other technologies, a variety of alternative means were available to meet the basic human need being served, in this instance rapid remote communication. The choice among technological alternatives as to which to use, and in which ways they should

be used, was determined in almost every case by an economic-technical set of considerations. There were technical parameters as to what was possible, but almost always several alternatives were within the range of possibility. What actually emerged was determined by what could be effectively marketed, what activities capital could be raised for, and what arrangements would allow for efficient billing—in short, by economic considerations.

Often when new technologies are introduced, choices are made in the light of currently visible costs and benefits which foreclose alternatives that later on appear desirable. For example, use of narrow bandwidth in the phone system to make phoning cheap for conversations later precluded video delivery by phone. One cannot do everything, and every choice made to optimize for one purpose has drawbacks for other purposes.

One evaluation a retrospective technology assessment can make is to identify which of those early decisions later turn out to be mistakes. Not every such penalty on the future for the sake of the present is a mistake, however.

Today, when cable television is being adopted to meet the public's demand for a wider choice of video material, we wish that the universal telephone network had been designed to accommodate those broader band signals, but no rational decision maker would have burdened past generations with the cost of a more expensive system than they needed for the sake of satisfying a want that is just now emerging. So too, receivers of nuisance phone calls today may wish that the phone system had been designed to make it possible to identify the source of a call from the receiving end. Now that "junk" advertising calls are becoming common, that would be particularly useful as a means of allowing the recipient to filter calls. With the coming of integrated digital telephone networks with common control signalling, that facility can be cheaply provided. But in an analog system with in-band signalling, the cost of acquiring that additional information would have been considerable. In the first century of the telephone, the only information that needed to be kept on who was calling was billing information for toll calls. To have burdened the system with the extra cost of retaining knowledge at the receiving end of who was calling whom, would have levied a high charge on early users for needs as yet dimly perceived, for the benefit of generations as yet unborn.

Sometimes, however, we can in retrospect say that a mistake was made, i.e., that incurring the added costs for a different system would have proved to be the wise choice. Thus in the energy field one can point to building designs and numerous other investments that would have been made or made differently in the 1960s if one had anticipated the energy shortage of 1973 and the rise in the price of oil. We cannot point to such clear cases or obvious mistakes in the history of the telephone.

Whether the choices made were wise ones or mistakes, the pervasive process of choosing present economy at someone else's later cost was visible

throughout the telephone's development. In the history of the telephone, the tradeoff between economy now and capacity for adaption to novel needs in the future was generally made in favor of meeting demands that were predictable in the time frame that an investor would consider.

Telephone service was introduced as a commodity. The decisions faced were marketing decisions. What ended up being provided was whatever entrepreneurs could see a prospect of selling at a profit. Costs for facilities for which there was little market demand were eliminated wherever possible. For example, we shall note later that facilities which would have been useful in crime control and fire fighting were not provided on the universal switched system because city police and fire departments were not promising customers. One cannot fault telephone entrepreneurs for that decision. On the whole they judged well and accurately what the market demanded. They created a universal phone system by meeting that demand at a modest price. To put it more accurately, the entrepreneurs who succeeded acted in that way. There were plenty of dreams over the past century about things that the telephone might do, but which it did not do. The developers whose forecasts and plans embodied those dreams fell by the wayside. The phone was a consumer commodity, and its course was charted by market demand that could be felt within a modest time frame.

The best forecasts, it is interesting to note, arose from people involved in the industry. That is where we find people who understood the technology, who also sought to assess how to implement it in a way that would pay.

FOOTNOTES

¹Frederick A. C. Perrine, *Electrical Engineering and Social Reform. Electrical Engineering*, 1894, 3, (2) 39.

²Eric Ashby and Mary Anderson. Studies in the Politics of Environmental Protection: The Historical Roots of the British Clean Air Act, 1956. *Interdisciplinary Science Review*, 1976, (4) 279-290 and 1977, 28 (1) 9-26.

³Vary T. Coates and Bernard Finn, *A Retrospective Technology Assessment: Submarine Telegraphy*, San Francisco: San Francisco Press, 1979; Joel A. Tarr (ed.). *Retrospective Technology Assessment*. San Francisco: San Francisco Press, 1976.

⁴Ithiel Pool. Alternatives in Social Science Forecasting. In Nazli Choucri and Thomas Robinson (Eds.), *Forecasting in International Relations: Theory, Methods, Problems, Prospects*. San Francisco: W.H. Freeman, 1978.

⁵Merchants' Association of New York, *Inquiry Into Telephone Service and Rates* 1905.

⁶Such studies are reviewed by Frederick Frey. Communication and Development. In I. Pool and W. Schramm (Eds.), *Handbook of Communication*. Chicago: Rand McNally, 1973.

⁷Carty in 1891 alluded to a common unsubstantiated assertion that the telephone, presumably the string or "Lovers" telephone, had been invented by the ancient Chinese at the time of Confucious. (John J. Carty. *Electrical Review*, August 22, 1891, 13 (26), 334.)

⁸ One such is "Cohen on the Telephone," cited in Martin Mayer. *The Telephone and the Uses of Time*. In Ithiel Pool (Ed.), *The Social Impact of the Telephone*. Cambridge: MIT Press, 1976, p. 240.

⁹ Federal Communications Commission, *Investigation of the Telephone Industry in the United States*. U.S. Government Printing Office, 1957. (Also published as 76th Congress, 1st Session, House Document No. 340; Reprinted by Arno Press, 1975.)

¹⁰ Pool. *The Social Impact of the Telephone*.

¹¹ M.D. Fagen (Ed.). *A History of Engineering in the Bell System* (2 vols.). New York: Bell Telephone Laboratories, 1975)1978.

¹² The inventory consists of 186 propositions and 40 headings. They are listed in sequence in the Contents and organized by type.

¹³ In four of the 91 cases, while economic as well as technical considerations were important, the economic considerations were internal cost considerations rather than consumer demand considerations. Thus, for example, the failure of the phonograph to be used as telephone repeater was because other technologies could do the job better more cheaply.

¹⁴ We did two independent content analyses of the inventory. The first count found 127 out of 181 propositions fitting that model; on the second count the result was 143 out of the 185. There is, of course, a margin of judgment in the classification. The discrepancy is twelve disagreements plus four cases that were placed in a category added in the second count that had to do with internal costs rather than market demand. In this report we use the figures from the second count because in it we subdivided some of the earlier categories for more refined analysis.

¹⁵ H.G. Wells. *Anticipations*, New York: Harper Bros., 1902).

¹⁶ S. Myers and D.G. Marquis, *Successful Industrial Innovations* (NSF 69-17). Washington D.C.: National Science Foundation, May 1969.

II

Inventory of Propositions on the Impact of the Telephone

1

Prognoses for Telephone Development

We start with forecasts about the development of the telephone system itself, for the shape of the system to come would determine its social impact.

Perhaps the most remarkable single forecast of the future of the telephone is in a letter that Alexander Graham Bell wrote to a group of British investors as early as 1878, just two years after his invention. It describes a universal point-to-point service connecting everyone through a central office in each community, which in turn would be connected by long distance lines.

At the present time we have a perfect network of gas pipes and water pipes throughout our large cities. We have main pipes laid under the streets communicating by side pipes with the various dwellings, enabling the members to draw their supplies of gas and water from a common source.

In a similar manner it is conceivable that cables of telephone wires would be laid under ground, or suspended overhead, communicating by branch wires with private dwellings, counting houses, shops, manufactories, etc., uniting them through the main cable with a central office where the wire could be connected as desired, establishing direct communication between any two places in the city. Such a plan as this, though impracticable at the present moment, will, I firmly believe, be the outcome of the introduction of the telephone to the public. Not only so, but I believe in the future wires will unite the head offices of telephone companies in different cities, and a man in one part of the country may communicate by word of mouth with another in a distant place.¹

1.1 The telephone will become pervasive.

From the start Bell and his colleagues foresaw the telephone as a widely distributed consumer service. The Bell letter and various similar statements anticipated the prospect of millions of phones. Numerous articles from 1900 on projected the observed growth curve.²

1.1.1 The telephone will become "universal." (Type A)

The word "universal" was part of Vail's favorite slogan: "One policy, one system, and universal service", used by him, for example, in AT&T's 1909, 1910 and 1911 Annual Reports:

The Bell system was founded on broad lines of "One System," "One Policy," "Universal Service," on the idea that no aggregation of isolated independent systems not under common control, however well built or equipped, could give the country the service that an interdependent, intercommunicating, universal system could give. One system with a common policy, common purpose and common action; comprehensive, universal, interdependent, intercommunicating like the highway system of the country, extending from every door to every other door, affording electrical communication of every kind, from every one at every place to every one at every other place. (1910)³

There is a certain ambiguity. "Universal" implied either to "everyone," or to "everywhere," without clear specification.

1.1.2 The telephone will be used by the poor. (Type A)

A clearer formulation of the expectation that the phone would reach virtually every home was contained in statements that the phone would become cheap enough to be used by the poor. Graham Bell, talking about automatic exchanges, said they will "so reduce the expense that the poorest man cannot afford to be without this telephone."⁴

The price of phone service when that prediction was made was very high. At such prices phone service could never have become universal. In 1882 the New York residential rate had been \$150 a year, and in Chicago, Philadelphia, and Boston \$100.⁵ In New York City in 1896 phone service cost \$20 a month, compared to the average worker's income of \$38.50 a month.

It was recognized by both the Bell System and the independents that achieving the goal of wide or universal service depended on finding a way to reduce the cost of service for ordinary users. One solution was the pay phone, the first of which was introduced in Springfield, Mass. in 1883. Six years later, in 1889, the coin phone was introduced in Hartford, Conn. By 1902, 81,000 (3½%) of the 2,315,000 phones in service in the U.S. were pay phones.⁶

Another solution was metered service. The problem was to bring the price of service down for the small user while still collecting adequate amounts from businesses and large users. In 1896 the New York phone company introduced message unit charges.

One solution, adopted by many rural independent companies but rejected by the Bell System, was to create rudimentary small scale systems for

local service only. These minimal systems, which were often built and maintained by farmers for themselves, commonly retained no reserve for depreciation, sometimes used fence wires for transmission, used party lines, and had a primitive exchange, often with only part time manning. Such systems could be very cheap if they stayed small and were not interconnected. (cf. Section 2.2.3.2)⁷

A basic assumption of Graham Bell's that was shared by the later developers of the independent rural systems was that the basic telephone device was a simple one, lending itself to a low cost service. In particular the contrast between telephony and telegraphy was often noted. While the Morse key instrument too was simple, the transmission of code required a professional operator, and therefore the lines went only to telegraph offices, not to homes and places of work. In section 7.2.1 we shall take note of the attempts of telegraphers to break out of that constraint by using electrical call bells to summon telegraph boys and by the installation of cumbersome printing telegraphs.⁸ Here we need only note that the requirement for a device that could be wired to every home and office for direct instantaneous use was recognized early.

In 1846, *Punch* (vol. 11, p. 253) argued that telegraphy was "too good a thing to be confined to public use" and that it should be introduced into "the domestic circle." In 1848 (vol 15, p. 275) it reported (wrongly) that in the U.S. songs were being sent by telegraph from Boston to New York: "It must be delightful for a party at Boston to be able to call upon a gentleman in New York for a song." In 1858 (vol. 35 p. 254) it returned to the theme of a telegraph with lines reaching to the customer, or at least "within a hundred yards of every man's door." "With a house telegraph," *Punch* concluded, "it would be a perpetual tete-a-tete."⁹

Telephone enthusiasts like Bell may have anticipated a service that would be cheap enough to serve everyone, including the poor, but that expectation was not shared by all. Phone service as it actually existed in the early days was a luxury for the rich, and many people expected it to stay just that. Various quotations can be found minimizing the value and economic prospects of the telephone.¹⁰

I fancy the descriptions we get of its use in America are a little exaggerated, though there are conditions in America which necessitate the use of such instruments more than here. Here we have a superabundance of messengers, errand boys and things of that kind. . . . The absence of servants has compelled America to adopt communications systems for domestic purposes. Few have worked at the telephone much more than I have. I have one in my office, but more for show. If I want to send a message—I use a sounder or employ a boy to take it.¹¹

The assistant Postmaster General could scarcely believe that a man of Vail's sound judgment, one who holds an honorable and far more responsible position than any man under the Postmaster General, should throw it up for a d--d old Yankee notion (a piece of wire with two Texas steer horns attached to the ends with an arrangement to make the concern bleat like a calf) called a telephone.¹²

Such expectations, when held by those in power, tended to be self-fulfilling prophecies. The development of a widespread low-cost phone system depended upon sympathetic treatment by the law. In the U.S. the telegraph law that was applied (see Section 4.3.1) was largely supportive of the phone companies, encouraging entrepreneurs to go into business and providing them with rights of way for stringing up lines. In other countries such as England and France the governments' assumptions about the phone systems' potential utility were quite different, and legal policies were restrictive.

In France a basic assumption was that the primary function of telecommunications was national defense. Service to private citizens was subordinated. The phone (especially a diffused network) was considered to have certain disadvantages from a security point of view as compared with the telegraph.¹³ In Britain the phone was seen as a businessman's convenience which threatened the national investment in the telegraph system. Even after nationalization of the phone system (in 1912) Labor critics sometimes objected to the Post Office using its funds to build up the businessman's telephone instead of the common man's means of communication, the post.¹⁴

A crucial factor underlying predictions about telephone diffusion was the forecaster's expectation about potential trends in the cost of service. The expectations themselves, however, had to some degree the character of self-fulfilling prophecies. In the U.S., where a system of low cost universal service was anticipated from an early date, such a system was in fact created. Where there were less sanguine expectations about the telephone's general utility and economy, the system grew more slowly and has not become universal even today.

1.2 Telephony will be a switched service offered as a public utility. (Type A)

The device Bell invented could have been marketed in various ways. One of the first issues that Bell and his backers, Hubbard and Sanders, had to resolve was whether to sell or rent phones.¹⁵ The decisive development that shaped the decision and the system was the switchboard, introduced to telephony in 1878.¹⁶ It made a range of interconnections possible that would not otherwise have been feasible. In 1894 Arthur Vaughan Abbott calculated that a system of 10,000 subscribers (the approximate number then in New

York or Chicago) would have required underground ducts a yard square, or a pole 1000 feet high, if a separate line had to go between each pair of subscribers.¹⁷ Before the switchboard, pairs of phones, connected a business office and factory or businessman's home and office, but the potential utility of such intercoms, which could well have been sold, was far less than that of a switched phone system, which almost had to run as a billed utility service.¹⁸

The first phone switchboard was in New Haven, and came about almost accidentally. The local Bell licensee ran all the wires from his subscribers' pairs of phones through his office for ease of servicing. The inadvertent crossing of connections between subscribers quickly suggested a new and useful service.¹⁹

When the switchboard idea came to Bell's attention in a letter from John Ponton he reacted with pleasure, commenting that that was the way he had always anticipated the system developing.²⁰ Indeed, his 1877 lectures predicted that people would phone each other to chat in a way that implied a switched system.²¹ His 1878 letter talking of the phone as a utility presents the same picture.

Thus, very early, the Bell System pioneers developed the conception of what Vail in 1879 called the "grand telephonic system."

This is the system for which Vail's slogan was "one system, one policy, and universal service." The key elements of the concept of the "grand system" was that phone service should be provided by a monopoly, either of one national company "owning and operating the whole system," or of a series of affiliated regional companies "under the control of one central organization"²² (which ended up being the company with the long lines); that all exchanges should be interconnected; that rates should be set at a level to provide amortization of capital and an attractive return; that high quality reliable service should be provided; and that universal coverage of the country should be achieved with service offered on a public utility basis to all persons.

The most controverted of those propositions was the advocacy of a monopoly, an issue we discuss in section 4.4. The independents argued for the merits of competition and anticipated that there would be rival phone companies in operation. The "grand system" could have included telegraphy too, for the same wires could carry both phone calls and telegraphic messages. (cf. Section 7.2.3.) Indeed Bell and Vail conceived it that way.²³ It did not develop that way, but it did develop into a large, and in its area of operation, mostly monopolistic public utility.

1.2.1 Switching will be automatic. (Type A)

Until as late as the 1920s there was some debate as to the relative merits of an automatic as opposed to a manual switching system. Social impacts and utilities are very different for a system in which a human operator is an intermediary and one

without an operator. Later in this book we shall discuss operators in relation to the role of women (9.4.2), privacy (10.6), emergency services (5.2), information and advisory services on the telephone (8.2.2 and 2.2.1.6), and loneliness and sense of community (9.1.1). In all those respects operators performed a helpful function.

But operators also had many disadvantages. It was a fit of pique at an operator whom he believed to be discriminating against him, that led Strowger to invent the automatic switch in 1889. The first automatic exchange was established in La-Porte, Indiana, in 1892.

In some countries of Europe automatic switching was introduced more rapidly than in the United States. In Europe it spread after 1900;²⁴ in the U.S. among the independents a decade later, and in the Bell System two decades later. The Bell System in the U.S. had the largest sunk investment in manually switched plant. It had just converted to French central power phones and was reluctant to use scarce capital to make a second shift. Also in some European countries (e.g., France) women proved less willing to take operator jobs than in America. Also, language diversities in some places in Europe made dialing attractive.

The decisive reason for the ultimate introduction of automatic switching was the growth in the size of the phone network to the point where it would have required an infeasible number of operators. A general characteristic of networks is that the links increase combinatorially with the number of nodes. That basic fact was noted early by phone companies which found that the cost of service increased as systems grew. Tiny rural exchanges could charge much less than the \$20 a month charged in 1896 in New York City. Dilts quotes an early telephone manager: "All he had to do was get enough subscribers and the company would go broke."²⁵

Financial Notes of 1905 quotes Graham Bell as arguing that as the number of people in an exchange increases, the operators' work goes up exponentially; hence sooner or later exchanges will have to be automated. So as the network grew it became obvious that the transition to automatic switching would have to be made some day.

While the transition to automatic switching was seriously delayed in the United States by financial problems of AT&T, competition was a stimulus to action. In 1912, the Automatic Electric Company, an independent phone company, claimed 300,000 phones on automatic exchanges.²⁶ The Home Telephone company, another major competitor, had a dial patent; in 1910 AT&T absorbed it. After 1920 the Bell System finally began to shift to dial phones. By 1936 48% of U.S. phones were on automatic exchanges. In Europe by 1939 the figure was 64%.

1.3 Long distance service will be provided. (Type A)

The original telephones of the 1870s could operate over a range of about 20 miles. Yet from the start almost everyone who talked about telephony seemed to assume that it was only a matter of time before very long distance or even global communication could be achieved. As quoted at the beginning of this chapter, Bell in his 1878 letter declared that through wired connections between telephone of-

fices in different cities, long distance telephone communication would become possible.²⁷

Even earlier, long range communication was assumed by Sir William Thomson (later Lord Kelvin), when judging the technical exhibits at the Philadelphia Exposition in 1876. Though most of his report covers which words he had been able to understand and which he could not, using the primitive device at hand, he assumed that eventually the device would improve enough to function at a distance.²⁸

Similar expectations appeared in lay journals. The *Springfield Republican* observed on February 15, 1877;

The music of a prima donna could be distributed over the country . . . or the fluteplaying of an amateur, may be heard around the world.²⁹

The telephone entrepreneurs had a different vision of the telephone's usage, but not of its ability to transcend distance. Vail also anticipated a far flung global telephone network, and saw that strategic control would lie with the company running the long-line interconnections. "Tell our agents," he wrote to one of his staff in 1879, "that we have a proposition on foot to connect the different cities for the purpose of personal communication, and in other ways to organize a grand telephonic system."³⁰ Vail also said:

We may confidentially expect that Mr. Bell will give us the means of making voice and spoken words audible through the electric wire to an ear hundreds of miles distant.³¹

A commentator noted that:

This prophecy was expressed in the certificate of incorporation of the American Telephone and Telegraph Company formed in 1885 which certified that the general route of lines of this association . . . will connect one or more points in each and every city, town or place in the State of New York with one or more points in each and every other city, town or place in said state, and in each and every other of the United States, and in Canada and Mexico; and each and every other of said cities, towns and places is to be connected with each and every other city, town or place in said states and countries, and also by cable and other appropriate means with the rest of the known world.³²

The first long distance line was built between Boston and Lowell in 1880 with Vail's encouragement.

This success cheered Vail on to a master effort. He resolved to build a line from Boston to Providence, and was so stubbornly bent upon doing

this that, when the Bell Company refused to act, he organized a company and built the line. (1881) It was a failure at first and went by the name of "Vail's Folly." But one of the experts, by a happy thought, doubled the wire, . . .

At once the Bell Company came over to Vail's point of view, bought his new line, and launched out upon what seemed to be the foolhardy enterprise of stringing a double wire from Boston to New York. This was to be a line de luxe, built of glistening red copper, not iron. Its cost was to be \$70,000, which was an enormous sum in those hard-scrabble days. There was much opposition to such extravagance and much ridicule.

But when the last coil of wire was stretched into place, and the first "Hello" leaped from Boston to New York, the new line was a success.³³

By 1892 there were lines from New York to Chicago, by 1911 from New York to Denver, and by 1915 from New York to San Francisco. Experiments with overseas radio telephony took place in 1915, but the first trans-Atlantic commercial service began only in 1927.³⁴ While long distance telephony grew rapidly, Bell's and Vail's predictions preceded its reality. There were many technical difficulties, and not everyone anticipated (as did Bell and Vail) that they would be overcome.

Much of the effort to make long distance telephony work focused on repeaters, devices which rebuilt the deteriorating and fading signals that passed through long lengths of wire. Berliner developed one. Hammond Hayes, the Director of the Mechanical Department, decided that the company could most economically abandon its own fundamental research and instead rely on "the collaboration with the students of the Institute of Technology and probably of Harvard College."³⁵ On research concerned with long lines, however, Hayes made an exception (cf. Section 8.1). He employed George A. Campbell, who had been educated at MIT and Harvard, to study the essentially mathematical problem of maintaining transmission constants over long lines of cable. By 1899, Campbell had outlined the nature of discretely loaded electrical lines and had developed the basic theory of the wave filter.

Around 1900, Pupin at Columbia University developed the loading coil, which greatly improved the capabilities of long distance cable. Before 1900, long distance lines demanded wire about 1/8 inch thick; the New York—Chicago line consumed 870,000 pounds of copper wire. Underground wires in particular had to be very thick. One fourth of all the capital invested in the telephone system before 1900 had been spent on copper. With the Pupin coil, the diameter of the wire could be cut in half (cf. Section 6.3). Then, in 1907, the vacuum tube used in repeaters made long distance communication increasingly economical.

Vail wrote in the 1908 annual report:

It took courage to build the first toll line—short as it was—and it took more to build the first long-distance line to Chicago. If in the early days the

immediate and individual profit of the long-distance toll lines had been considered, it is doubtful if any would have been built."³⁶

One obvious speculation as to why the forecast of long distance communication was so successfully made by Bell and Vail is that the telegraph shaped their thinking; the telephone's invention, after all, had been a by-product of telegraphy. Bell had been employed to create a harmonic telegraph which would carry messages at different pitches simultaneously. The telegraph's great achievement had been the contraction of distance; it was not surprising, therefore, that when a way was found to make voice travel over wires, its transmission over distance seemed a realizable goal. Quite rightly, telephone enthusiasts saw the technical problems as temporary difficulties.³⁷ The sanguine expectations based on the telegraph analogy also led to some bad predictions that slid too easily over technical and economic realities.³⁸ In an interview with the *New York Sun*, printed February 20, 1877, Thomas Watson, Bell's assistant, stated that he had not the slightest doubt that in a few months a man could lecture in Boston and be heard by an audience in any part of the country.

No trial has been made, however, of the transmission of sounds to so great a distance as across the Atlantic. Mr. Watson said that as far as they had been able to ascertain, there seemed to be a limit to the distance over which the sounds could be made to travel; but he expressed himself as confident that in due time any given distance could be annihilated.³⁹

In May, 1877 the Springfield Republican said:

We have grown so used to new and marvelous additions to the power of telegraphy that nothing seems impossible, and Professor Bell's confident expectation that he will shortly be able to send his voice across the Atlantic and talk with men 3,000 miles away as readily as if they were in the next room, meets with no . . . satiric hearing . . .⁴⁰

The word "shortly" in the quotation is more likely the journalist's license than Bell's own. Yet even General Carty, later chief engineer of the Bell System, who should have had his eye firmly fixed on the problems of attenuation and repeaters, forecast a New York-San Francisco link by 1900,⁴¹ fifteen years ahead of the reality.

1.4 Forecasts about technological alternatives.

The components of a point-to-point communication system are terminals at the ends, a transmission medium linking them, and a switching center in the middle. There are many different things that can be done by a system of that concep-

tion, and many different types of hardware that can be used. The hardware chosen affects the practicable uses. A loudspeaker, for example, would be more relevant to a system used for broadcast than to one for point-to-point messages.

1.4.1 A switched teletypewriter system will be provided. (Type A)

Printing telegraphs existed before the telephone. In the 1840s in the U.S. the House printing telegraph had loomed as the main competition to the Morse telegraph; the latter won out because the Morse code key was such a simple, cheap terminal. By 1876, however, ticker telegraphs were coming into use. In Britain the ABC telegraph was being promoted at that time. In the U.S. the Gold and Stock printing telegraph service was being extended by Western Union primarily as a business ticker. It was the threat to that service that led Western Union into brief competition with Bell in trying to develop a telephone system of its own.

The printing telegraph was a technology that was essentially defeated by the telephone. It turned out to be less satisfactory than the phone for an end-to-end point-to-point service. Its main drawback was the clumsy mechanical terminal required for printing.⁴²

Had the phone not pre-empted the point-to-point market, progress undoubtedly would have been made in making the teletypewriter cheaper, smaller, and more reliable. But in the era before solid state electronics no one could see a way to make a printing terminal nearly as simple, durable, and economical as the telephone.

Had there been such a way, a human issue would have arisen of whether people preferred the ease of speaking or the advantages of a written record, or were willing to pay the extra cost for a dual mode system. Those issues, however, were not decisive and indeed hardly arose, for the economics were so unfavorable to the teletypewriter.

Today such human preferences are highly relevant, for computer terminals with a variety of forms of output, editing, and store and forward capabilities, and vastly changed costs and reliabilities, have upset the balance. Already by the 1920s a teletype was developed that was acceptable for some limited purposes such as those of news services and financial institutions. A switched teletypewriter service has been available in the U.S. since 1931.⁴³ Its use grew particularly in Europe where phone service was less good and more expensive than in the U.S. But computer networks reopen the competition in a wholly new way. In the period we are studying, however, the race was one-sided. The kind of telegraphy that *Punch* had in mind (cf. Section 1.1.2) never had a chance to develop once the telephone came along.

1.4.2 Plug in telephones will be used. (Type A)

Police systems (cf. Section 5.2.6.1) were offered a pocket telephone in 1912 that could be plugged into any call box.⁴⁴ Citizens too could carry it.

The argument was that they could carry it with them in neighborhoods where policemen were loath to patrol. Telephone linesmen carry phones that they can attach to the lines wherever they are.

The usefulness of a device that could go with the subscriber wherever he might be was thus obvious enough as soon as the phone lines were pervasive enough to cover a city reasonably well. That technical option was not developed, however, because it would have complicated the finances of the phone system. Billing would have been difficult, fraud easy, and with pre-electronic switching, finding a moving receiver also difficult.

It is only with land mobile radio telephony and now with CB transceivers that something approximating that device is coming into use. On an electronic switching system the billing of such a service also becomes practical. Indeed, long distance calls for some time have been billed to the subscriber's number from wherever he places the call. Only a sophisticated electronic switching system could do that for local calling at a tolerable cost.

Thus this forecast of portable phones failed, since though technically possible, they were economically impractical—the forecasters who focused on their usefulness failed to address these economic issues.

1.4.3 Phonographs.⁴⁵

Several different uses were forecast for the phonograph as part of the telephone system.

1.4.3.1 Phonographs will be used as repeaters. (Type A)

Mechanical recording of a voice message and then amplified replay of it was an early idea for creating a repeater for long distance calling. This cumbersome, slow, and expensive idea was pre-empted by better methods. Yet Edison invented the phonograph with a repeater in mind, because he believed that few people would be able to afford their own telephone. His notion was that offices (such as telegraph offices) would use it to record spoken messages that would be transmitted by phone to a recorder at another office where the addressee could come to hear it.⁴⁶ Partly as a result of this misperception, it took Edison 15 years to realize the entertainment potential of the phonograph.

1.4.3.2 Phonographs will be used for long-distance multiplexing. (Type A)

One of the available ways to economize on the capital plant of either the telegraph or telephone system was to multiplex messages on the transmission lines. That was the purpose of the harmonic telegraph on which Bell was working when he invented the telephone.

Gen. Carty saw multiplexing as the main prospective use of the phonograph.

The feature of the phonograph may become of greatest practical importance in telephony, by making it possible to carry on a number of conversations simultaneously over one circuit. . . .

By this phonographic multiplex system, it would be possible to carry on one conversation in the ordinary way, then to have a phonograph transmitting a message at such speed that the vibrations impressed upon the line should be below the audible limit of the ear, and, consequently, having no effect on the original conversation. These slow vibrations could then be taken off upon a phonograph at the far end and reproduced at the normal rate.⁴⁷

This approach, again, was pre-empted by more effective techniques.

1.4.3.3 Phonograph records will be sent as letters. (Type A)

Gen. Carty, among others, also predicted that people would start exchanging messages on phonograph records instead of written letters.⁴⁸ Before the wire recorder of 1905 the cumbersome wax discs were, however, hardly suitable for the purpose, but even today very mailable magnetic tapes and belts are little used for correspondence except in some developing countries where literacy is low. The often asserted preference of people for speaking over writing is apparently not dominant enough to cause letter writing to be replaced in this way. Senders would probably prefer to mail a voice recording; many letters start out in that form on a dictating machine. But the receiver's convenience is apparently better served by having a written letter which can be quickly scanned. So Gen. Carty's expectation is apparently not to be realized.

1.4.3.4 Phonograph records will be used as a storage medium in information retrieval systems. (Type A)

As soon as the phonograph appeared, the possible use of it for recording of phone messages was recognized. Gen. Carty wrote in 1901:

One of the developments may be confidently expected is the phonographic dictionary, which shall be soon constructed that the busy correspondent, by simply touching a button, may have any word properly spelled, pronounced and defined . . .⁴⁹

Not until the arrival of solid state electronics could sophisticated selective information retrieval by coded button-pushing become cheap enough to be of interest. Today magnetic discs and prospectively the video disc are important

information storage media, but electro-mechanical voice records were generally uneconomical as information storage devices. However, recording of some rudimentary information messages became a common adjunct to many phone systems. A good technological-economic analysis would have had to take account of the distinction between the economics of large and small message bases.

1.4.3.5 Telephone conversations will be recorded. (Type A)

The most important linkage of the telephone to recording machines has actually been for transcribing telephone conversations, as with telephone answering machines or for that matter in wire tapping. The use of recorders, however, has never reached levels that were sometimes anticipated. *Telephony* in 1901 predicted that the telephonograph “promises” to be one of the common conveniences of the coming century.”⁵⁰

When the first wire recorder was invented, *Telephony* saw it as primarily an enhancement for the telephone.

This Danish miracle will legalize all transactions by telephone. By means of a wire it is connected with the ordinary telephone instrument, you ring up “Central,” as usual, get your vis-a-vis, and go at him. Every word uttered by both speakers is recorded and can be carried to court.⁵¹

An unanticipated problem that has perhaps restricted the use of recordings is the man-hours required to listen to voice recordings.

1.4.4. Hands-free phones with loud-speakers will be used. (Type D)

Loud-speaker phones that allow one to talk while using both hands at work have been repeatedly marketed but have never acquired great popularity.⁵² The familiar hand set is a more private device that does not interrupt everything else going on by filling the room with sound; it has apparently proved satisfactory. Some people expected otherwise; they thought the loud-speaker phone that produces a more naturalistic situation would be desired.

1.4.5 Transmission without wires.

In early telephone systems the bulk of the capital investment was in the wires. Any method of wireless telephony offered a great economy. The figures on early investment in copper wire have been presented in section 1.3.

Two approaches were considered for communicating without wires: use of light waves and use of radio waves.

1.4.5.1 Photophones will be used. (Type A)⁵³

The first attempt at a wireless phone (which absorbed Bell in 1879–80) used light as a transmission medium, with a selenium receptor. However, until waveguides and optical fibers provided an entrapped light channel, the interferences in the natural environment precluded displacement of wire transmission by light. It is interesting to note that in April 1901, nine months before Marconi's transmission from Poldhu to Newfoundland but well after his 1896 patents, Carty, in his anonymous "Prophets Column" in the *Electrical Review*, evaluated radio waves versus light as possible means for long distance transmission and concluded that the prospects for light were better. He noted with interest the experiments showing the effect of sunspots on magnetic needles, but warned against promoters' talk of turning such phenomena to practical use for creating a trans-Atlantic voice cable. The ultimate possibilities he recognized:

Ether is the Africa of Science, and not all of the gold and ivory of the Dark Continent would equal the rewards which await its successful explorers.⁵⁴

But for his era he saw light as a more practical medium. He noted the success of Bell's photophone which enabled talk to be transmitted along a beam of light between two distant points not connected by wire.

If it is possible to talk for a few hundred feet, why not for a mile, and if for a mile, who can say what the limit is?

A system of telephony without wires seems one of the interesting possibilities and the distance on the earth through which it is possible to speak is theoretically limited only by the curvature of the earth . . .⁵⁵

1.4.5.2. Radio telephony will be used (Type A)¹⁶

After the turn of the century, interest turned from light to the invisible Hertzian waves whose long distance transmission capacity Marconi had just demonstrated. From then until the 1920s, radio was not only a promise, but also a shadow on the horizon for AT&T. Vail and Carty came to realize that they had underestimated it and had allowed a new technology to emerge which could conceivably displace the wired phone system. In 1907, at the same time as de Forest's experiments were succeeding, Vail wrote to a London banker assuring him that "the difficulties of the wireless telegraph are as nothing compared with the difficulties in the way of the wireless telephone.

By 1909, however, Carty was asking for funds for research on a telephone repeater that, he said, "might put us in a position of control with regard to the art of wireless telephony, should it turn out to be a factor of importance." By 1911 Carty had convinced Vail that it was important.⁵⁷ While on balance they thought (correctly) that radio would not prove capable of providing transmission for a total national point-to-point message system, they were uncertain and later recognized that it had been a close call.

One result was a fundamental change to a more aggressive research and development policy, which we will discuss later under that heading (section 8.1). Here it is relevant to note the various assessments that were made of the possible uses of radio waves and of their potential impact on the phone system.

A. H. Griswold stated AT&T's basic assessment in an article in the *Bell Telephone Quarterly* in April, 1922.

1. Radio telephony was a supplement to and not a substitute for wire service;
2. Radio telephony would never replace universal wire service; and
3. It is evident that the cost of radio service would be excessive and that the character of the very limited service . . . would be far inferior."⁵⁸

One use in which radio waves clearly had an economic advantage over the wired system was for one-to-many broadcasting, in which a single frequency band would be used simultaneously by very large numbers of listeners.⁵⁹ AT&T tried to get into that field too. That, however, is a story for our discussion of the telephone and the mass media, which comes later (section 4.7).

FOOTNOTES

¹ The letter, addressed "To the capitalists of the Electric Telephone Company," is reproduced in Pool, *The Social Impact of the Telephone*, pp. 156-7.

² The U.S. figures for number of telephones were:

1891	200,000
1894	291,000
1900	1,356,000
1902	2,370,000
1904	3,353,000
1908	6,484,000
1912	8,975,000
1914	10,046,000
1916	11,241,000
1920	13,329,000
1924	16,081,000
1928	19,341,000
1930	20,202,000

Among the many articles discussing this remarkable growth were: William Henry McDonough, "To Young Men Beginning Business: The Magic Telephone," *Saturday Evening Post*, June 14, 1902, in *Looking Forward*, Ray Brousseau, comp., New York: American Heritage Press, 1970, pp. 66-67; and also in *Telephony*, vol. 4, no. 2, August 1902, pp. 92-94 (with same title: "The Magic Telephone"). *Telephony*, August 1902, 4 (2), 92-94 with a projection for 1920 of over 15 million phones; Herbert Casson. The Telephone As It Is Today. *World's Work*, April 1910, 19, 12775-78; Casson. The Future of the Telephone. *World's Work*, May 1910 19, 12903-18, projecting to 1928; Henry Smith Williams. The Growth of the Telephone. *Science*, reprinted in *Hearst's Magazine*, October 1912, 22, 105-6; Burton J. Hendrick. Telephones for the Millions. *McClure's Magazine*, Oct. 1914, 44, 45-55, with a projection to 1930; William F. Ogburn. *The Social Effects of Aviation*. Boston: Houghton Mifflin, 1940 pp. 137-39, projecting from 1940.

³ Annual Report, 1910.

⁴ From *ATT Financial Notes*, 1905.

⁵ Sidney H. Aronson. Bell's Electric Toy: What's the Use? The Sociology of Early Telephone Usage. In Pool, *The Social Impact of the Telephone*, p. 31.

⁶ Aronson, Bell's Electric Toy, p. 32.

⁷ A third "solution" proposed by some reformers was nationalization as a way to lower rates. European phone rates were indeed low but the systems worked badly and were small. Nonetheless, rates the poor could afford were often postulated as a political demand. For example, Rep. David J. Lewis of Maryland, speaking in the House of Representatives (March 4, 1915) proposed nationalization, a one-cent a call rate, and a phone in every home. (*Congressional Record*, vol. 52, part 6, Appendix, p. 847).

⁸ Cf. Aronson, Bell's Electric Toy, and also section 1.4.1.

⁹ Cf. discussion in Asa Briggs, *The Pleasure Telephone: A Chapter in the Prehistory of the Media*. In Pool. *The Social Impact of the Telephone*.

¹⁰ Colin Cherry. "The Telephone System: Creation of Mobility and Social Change. In Pool. *The Social Impact of the Telephone*.

¹¹ Marion May Dilts. *The Telephone in a Changing World*. (New York: Longman's Green, 1941, p. 11.

¹² Dilts, p. 16.

¹³ Cf. Jacques Attali and Yves Stourdze. The Birth of the Telephone and Economic Crisis: The Slow Death of the Monologue in French Society. In Pool *The Social Impact of the Telephone*. David Ralston. Impact of Society on Technology: The Development of the Telephone in the United States, Great Britain and France from 1876 to 1914 (unpublished manuscript) (no date).

¹⁴ Cf. Charles R. Perry. In Pool. *The Social Impact of the Telephone*; Ralston. Impact of Society on Technology. The British Experience 1876-1912: The Impact of the Telephone During the Years of Delay.

¹⁵ Cf. Robert V. Bruce, *Bell: Alexander Graham Bell and the Conquest of Solitude*. Boston: Little Brown, 1973, p. 216.

¹⁶ Cf. Cherry, *The Telephone System*, p. 115, which notes the importance of the conceptual model provided by the somewhat different telegraph exchanges. A telegraph exchange functioned in Philadelphia as early as 1867. The first one goes back to 1837. Cf. also Aronson, *Bell's Electric Toy*; John E. Kingsbury. *The Telephone and Telephone Exchanges*. New York; 1972, p. 74.

¹⁷Arthur Vaughen Abbott. Bulletin of the University of Wisconsin, Engineering Series, 1894, 1(4), 70.

¹⁸On the policy "that telephones should be leased and never sold except for export" see Hubbard memor to Bell, Feb. 28, 1879 in *Walker Report*, Federal Communications Commission, vol. 1, Appendix A.

¹⁹Fred de Laud. Telephone Service: The Relative Cost to the User. *Electrical Engineering*, 1895 5, 337-346.

²⁰Bruce, *Bell*, p. 210.

²¹Aronson, "Bell's Electric Toy, p. 21

²²Tenth Annual Report; Cf. Theodore N. Vail. Public Utilities and Public Policies. *Atlantic Monthly*, March 1913, 111, 315-9; Sydney Brooks. Politics of American Business. *North American Review*, May 1911, 93, 713.

²³The 1876 patent clearly specified a device for providing both telephone and telegraph service. The two "T"s" in the company's initials were not inadvertant. The Bell System's first long distance line in 1879 was for telegraph service.

²⁴Cf. The Passing of the Telephone Girl. *Harpers Weekly*, Sept. 18, 1909, 53, 37, on Germany.

²⁵Dilts, *The Telephone in a Changing World*; p. 28. CF. ATT Annual Report, 1904.

²⁶I.W. Aitkin. Automatic Telephone Exchange Systems. *Science*, American Supplement, Jan. 13, 1912, 73, 20-22.

²⁷Pool. *The Social Impact of the Telephone*, p. 156.

²⁸Dilts. *The Telephone in a Changing World*.

²⁹Quoted in R.B. Hill. Some Early Telephone Prophecies. *Bell Telephone Quarterly*, April 1936, 15 (2), 123.

³⁰Casson. The Telephone As It Is Today, p. 12775. Vail understood the strategic advantage of controlling the long lines. From 1881 until 1897 the company issued a national telephone directory. Eventually it had to be regretfully abandoned, for it became too big.

³¹Roger Burlingame. *Engines of Democracy*. New York: C. Scribner, 1940, pp. 118f.

³²Burlingame, *Engines of Democracy*, p. 118-119.

³³Casson. The Telephone As It Is Today, p. 12776. Casson's tale simplifies; the Boston to New York Line was not an instant success. It was initially noisy and had the severe problems that all long distance lines did until adequate repeaters were developed. However, its very existence was a triumph, and quality of service gradually improved.

³⁴The Immediate Future of the Long-distance Telephone in *Current Literature*, May 1911, 50, no author 504, reports the laying of an experimental submarine telephone cable between France and England. Conversations between London and the whole European continent are, it says, now possible, and conversations are now possible over up to 1700 miles of cable. The article looks forward to the time, far in the future, when the whole globe will be linked together.

³⁵Stephen Dizard. *Industrial Development of the Telephone*, p. 3. (unpublished manuscript)

³⁶AT&T, Annual Report, 1908, p. 22.

³⁷It is worth noting that similar points can be made about Marconi and the history of wireless telegraphy. After Hertzian waves were discovered in 1888, a number of

scientists recognized that they could be used, in the way that electrical transmissions over wires were already being used, for communications devices. Marconi's important insight, aside from his entrepreneurial ones, was the conviction, successfully demonstrated by him, that those waves could go a long way. His great triumph was his trans-Atlantic transmission in 1901.

³⁸ Often optimistic forecasts eventually came true as technical and economic difficulties were overcome, but more slowly than the forecaster expected. In January 1901 Edward E. Clement heralded the new century with an article on Twentieth Century Possibilities, (*Telephony*, Jan. 1901, p. 5). He not only forecast long distance service, but that it would be without "heavy special trunk lines" and that callers could talk not only within their city, but among cities "without heavy expense or extra trouble." The trouble was eliminated only in recent decades with direct distance dialing; distance insensitivity of cost is still not quite here, but is likely to be with us by the end of the century, about which Clement was writing.

³⁹ Hill. Some Early Telephone Prophecies, p. 123.

⁴⁰ Hill. Some Early Telephone Prophecies, pp. 125-6. H.G. Wells in his 1902 book *Anticipations*, which forecasts the nature of life in the 20th century, notes the possibility of telecommunicating to "any part of the world."

⁴¹ John J. Carty, *Electrical Engineering*, 1891, 1, 160. W. Clyde Jones made the same forecast in the same journal, (*The Evolution of the Telephone*, 1893, p. 8.)

⁴² For that reason, new devices such as facsimile were sometimes forecast as means for evading that problem, e.g., Jones, *The Evolution of the Telephone*, p. 8 on the telautograph (1893); See also Aronson, *Bell's Electric Toy*, quoting E. A. Marland, *Early Electrical Communication*, (London: Abelard-Schuman, 1964), p. 185.

⁴³ An initial attempt at offering that kind of service was made by the Berlin phone company in 1903. "Berlin Teletyping Central Station" *Telephony* 8, No. 1, July, 1904, p. 36.

⁴⁴ A Pocket Telephone. *Literary Digest*, March 30, 1912, 44, p. 639.

⁴⁵ See also Section 8.1.1.

⁴⁶ Daniel Boorstein. *The Americans: The Democratic Experience*. New York: Random House, 1973, p. 379.

⁴⁷ Carty. Prophets Column. *Electrical Review*, 19 (5), 66, Sept. 26, 1891.

⁴⁸ Carty, Prophets Column. *Electrical Review*, 19 (1), 2, Aug. 29, 1891.

⁴⁹ Carty. The Prophet's Column. *Electrical Review*, 18, (7), 98. April 11, 1891.

⁵⁰ The Telephonograph. *Telephony*, Feb. 1901, 1 (2) 29. See also The Telephonograph. *Science*, vol. 12 (N.S.) Nov. 23, 1900, 12 (308), 812-3; The Telephone That Remembers, *Telephony*, 1904, 8 (1), 69.

⁵¹ New Recording Telephone. *Telephony*, Sept. 1905, 10 (3), 196. On admissability of telephone conversations in evidence, see Section 4.3.2.

⁵² E.g. the Weilaphone described in Improving Telephone Service. *American Architecture*, Dec. 18, 1918, 114, 753; Clement, Twentieth Century Possibilities.

⁵³ Cf., section 8.1.4.

⁵⁴ Carty. Prophets Column. *Electrical Review*, April 11, 1891, 18 (7), 98; For an example of speculation about communication by Hertzian waves see Clement, Twentieth Century Possibilities.

⁵⁵ Carty. Prophets Column. *Electrical Review*. April 25, 1891, 18 (9), 121.

⁵⁶ Cf., sections 4.7.2.3. and 8.1.4.

⁵⁷ N.R. Danielson. *AT&T: The Story of Industrial Conquest*. New York: Vanguard, 1939, pp. 104f. Cf. John Brooks. *Telephone*. New York: Harper and Row, 1976, p. 140. Cf. Dizard, *Business Planning and Telephone Research, 1875-1925* (unpublished manuscript).

⁵⁸ A.H. Griswold, The Radio Telephone Situation. *Bell Telephone Quarterly*, April 1922, 2, 4-7.

⁵⁹ Griswold's assessment noted that the Bell system was trying broadcasting in New York, and that if commercially successful this would spread, and stations could be networked by the long lines telephone plant.

