No.	Sample	Age (yr)
	accumulations of bat dung above them. Trench A was in the back of the cave, behind trench B, where water collected).	
P-37 P-12 P-38 P-39	The remaining samples are from trench D of Hotu Cave, which underlies trenches A and B, below a marked soil change and an abrupt change of surface level. The C^{14} record gives a minimum of 910 and a maximum of 2610 yr for this time gap. Whereas the soils of trenches A and B are cultural deposits, those of trench D are geologic. The soil in trench D contains angular limestone rubble, which is rare or lacking above. The flints found in Gravels I to III, including those associated with sample P-37 (Gravel II), are extremely crude. The fauna consists largely of sheep, ox, and red deer. Whether or not the questionable and unproved site contamination of the levels above might also have extended into the underlying soils of trench D is unknown.	
P-37	765 cm, Gravel II (A-49), sub-Neolithic.	Trench D, 8070 ± 500
P-12	950 cm, Gravel IV, hearth under skeletons No. 2 and 3 (vole eaters). This sample consists of charcoal taken from the hearth under and associated with Hotu skeletons No. 2 and 3.	Trench D, 9190 ± 590
P-38	1015 cm, Black under Red I (vole eaters). The next hearth down in the red gravels, and nearly identical in time with P-12, makes these two levels a chronological unit. Culturally the vole eaters are represented by only 19 implements—too few for certain identification. The fauna, except for a few possible intrusions at the top, consists entirely of vermin and small birds, notably the mole-vole (*Ellobius* sp.), and thrush (*Turdus turdus*). Although they are roughly contemporaneous with the gazelle hunters of Belt Cave (sample P-24, 24a), these vermin-collectors cannot, on the basis of present evidence, be considered to have been the same people.	Trench D, 9220 ± 570
P-39	1115 cm, Black under Red II (seal hunters?). A hearth lower down in the red soil complex, apparently contemporaneous with the Seal Mesolithic of Belt Cave (sample P-20, 20b). Its industry, a blade culture, is also inconclusive, but could have resembled that of the Seal Mesolithic of Belt. These men hunted both seal and gazelle. In an even lower level for which we have no charcoal was found one bone of a giant wild ox (*Bos primigenius*).	Trench D, 11,860 ± 840

References and Notes

1. I wish to express my gratitude to Gaylord P. Harnwell, president of the University of Pennsylvania, and to Froelich G. Rainey, director of the University Museum, for the initiation and generous support of this laboratory; to William E. Stephens, professor of physics, for his invaluable advice; and to Carleton S. Coon, curator of general ethnology, for preparing the descriptions of the caves and for his advice. I also wish to express my appreciation to W. F. Libby for allowing me to work in his laboratory in October 1951, and for his advice.
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Existence of Periods in the Stock Market

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THE existence of periods in economic time series still seems to be a subject of controversy. A recently published book (*1*) claims that periods of 3½, 9, 18, and 54 yr (as well as a few others) can be demonstrated in certain economic series and suggests various physical phenomena, including sunspots, as underlying causes. On the other hand, E. B. Wilson (*2*) has found that neither the periodogram technique nor the autocorrelation function gave any evidence of periodicity in the *Ayres Index of American Business Activity.* Wilson's negative results are not surprising, however, considering the nature of the Ayres index; it is a composite of a number of individual series, and the constituents have not been the same throughout the entire period under consideration (1790–1930).

Many claims have been made regarding the existence of periods in the prices of common stocks. Some fairly convincing evidence of a 9-yr period in one index of common-stock prices does exist (*1*, p. 91). A description of a mechanism that could account for a period of this magnitude is to be found in a study by Smith and Erdley (*3*) of a closely related parameter, namely, the rate of flow of investment capital. By means of measurements performed on an electronic analog of Kalecki's model of an economic system, Smith and Erdley found that the system was unstable and oscillated with a 10-yr period.

Oscillations of the type that are observed in the Smith-Erdley analog are not caused by an impressed periodic force but are transient oscillations of a resonant system that is excited by random "noise." Such filtered noise constitutes a time series of the type that is called a stationary random function. Stationary random functions have been studied exhaustively by Wiener (*4*), who has demonstrated that they are predictable (in a statistical sense), and Bode and Shannon (*5*) have published a simplified derivation of the Wiener theory which provides a physical insight into the mechanism of prediction. Using the Wiener theory as a basis, Lee and Stutt (*6*) have constructed an electronic system that predicts filtered noise for the simple case of a tuned filter with a single resonant frequency.

I selected the *New York Times* "Index of industrial stocks" (*7*) for a search for periods. The autocorrelation function was chosen as a tool, because autocorrelation analysis is preferable to the periodogram technique or to Fourier analysis for investigating the possibility of prediction. The specific time series adopted was composed of the mid-year and year-end closing prices for the period 1911–52, inclusive. In common with most other industrial stock indices, the *New York Times* index, when plotted logarithmically, appears to oscillate about a straight line which corresponds to a 3-percent per annum rise. In order to express the times series in terms of oscillations about this line as an axis, the index values were therefore divided by $(1.03)^t$, where t is elapsed time in years. The autocorrelation function was computed from the defining relationship in the form

$$\phi(\tau) = \frac{1}{T-\tau}\int_0^{T-\tau} f(t)f(t+\tau)\,dt,$$

in which the averaging takes place over the interval $T-\tau$, which decreases as τ increases. This method results in increased accuracy for small values of τ and is therefore particularly valuable in detecting small-amplitude periods of short duration in the presence of longer periods of large amplitude.

Curve *A* of Fig. 1 is a plot of the normalized values of $\phi(\tau)$ for the *New York Times* index. The oscillation which has peaks at 0, 11, and 22 yr indicates that $f(t)$ behaves like the output of a tuned filter resonant at 11 yr and excited by random noise. No periods shorter than 11 yr are in evidence. A period that is a multiple of 11 yr could be present but would be difficult to detect because it would be too large a fraction of the time interval covered by the data. The fact that $\phi(0)$ is much greater than the amplitude with which the curve oscillates indicates the presence of considerable additional random noise superimposed on the filtered noise. The trend toward negative values of $\phi(\tau)$ for very large values of τ could be due to the existence of a much longer period but could also be due to the fact that the arbitrary axis that was chosen is not a true equilibrium state (*8*).

Since the results demonstrated the complete absence of any periods shorter than 11 yr, a second computation was made, using a 2.5-yr running average of the price index. This is equivalent to distributing pur-

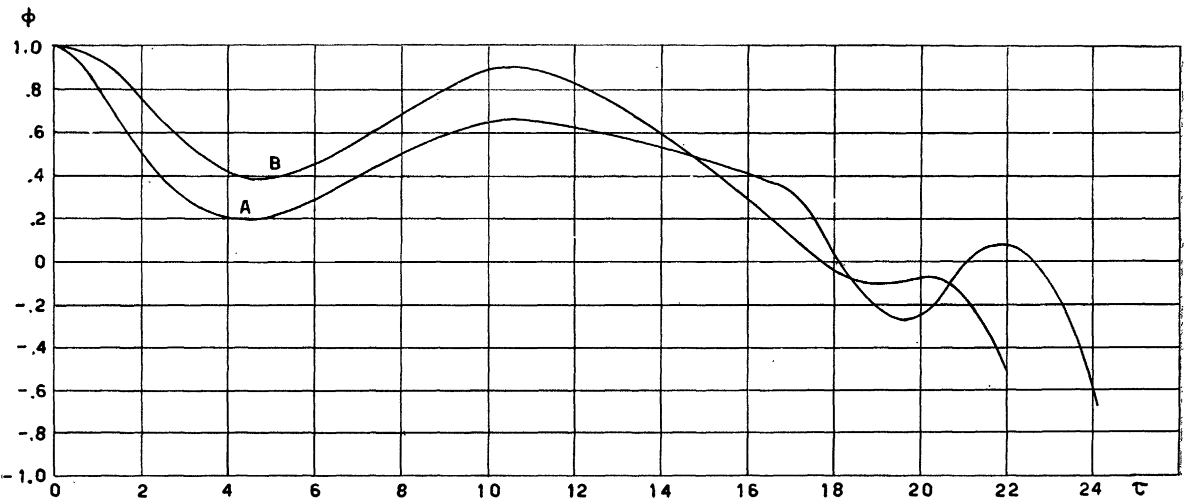

Fig. 1. Autocorrelation function of the *New York Times* index (1911–52): *A*, mid-year and year-end closing prices; *B*, 2.5-yr running average.

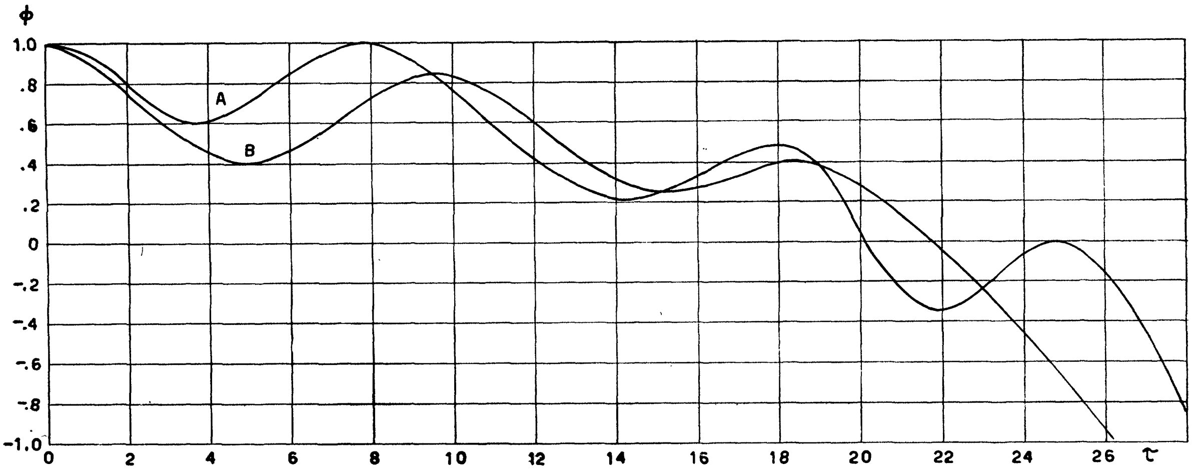

Fig. 2. Autocorrelation function of the Axe-Houghton index: *A*, 1855–1901; *B*, 1902–49.

chases or sales uniformly over the averaging interval and has the effect of filtering out short-term fluctuations. $\phi(\tau)$ for the running average is shown in Fig. 1*B*. The resonance period is now 10.5 years and the value of the ordinate at $\tau = 10.5$, which gives the correlation between the smoothed price index at time t and $t + 10.5$, is 0.9.

The time interval covered by the *New York Times* index is too short to give any information on whether or not the series is stationary (*9*). To obtain this information, therefore, the Axe-Houghton index (*10*), which has been compiled back to 1854, was selected. A 3-yr running average of this index was used, and the series was broken up into two intervals, covering the years 1855–1901 and 1902–49, inclusive. Figure 2 shows $\phi(\tau)$ for the two intervals. Although the general character of the two curves is the same, the mean period increased from 8 to 9.5 yr, and there was some change in the superimposed noise and in the degree of damping. The correlation between the index at a given time and its value one period later was 1.0 and 0.84 for the two intervals. (The value of 1.0 is so high that it is obviously fortuitous.) Although the series is not strictly stationary (and this is the criterion for predictability), the prediction theory could probably be applied, using average values for superimposed noise and damping and an extrapolated value for the period, if it were not for one other consideration. The results were obtained with respect to an arbitrarily chosen monotonically rising axis which does not represent a true equilibrium state. The application of the Wiener method involves the integration of $f(t)$, and large cumulative errors could be caused by an incorrectly chosen time-axis. It may be that some other economic series, perhaps in the form of a ratio, can eventually be found that does possess a natural equilibrium state or axis. If this series reflects the periodicity inherent in the Smith-Erdley analog, successful application of the Wiener method of prediction should be possible.

The information obtained from the foregoing analysis is of interest both to the economist and to the investor. To the economist, it demonstrates the existence of a period quite close to that predicted by Smith and Erdley and thus tends to strengthen the belief that the actual economic system does behave very much like the Kalecki model. To the investor, the results are chiefly of value in a negative sense. They demonstrate the existence of a 10-yr period but lead to the conclusion that application of the Wiener prediction method is not feasible because of the lack of information regarding the axis of the time function. The uncertainty regarding the axis, together with the masking effect of the superimposed noise, also almost completely rules out the possibility of a qualitative estimate of the future trend of the market. Finally, it should be emphasized that even if prediction of the stock market by Wiener's method were possible, the result would be purely statistical; that is, it would be the center of a probability distribution. An occasional large deviation would occur and, inasmuch as no period shorter than 10 yr is present, opportunities for averaging out a loss due to such a deviation would be few and far between.

Note added in proof. Subsequent to the preparation of this paper, an analysis was made of the Axe-Houghton index for the entire span 1854–1949. The autocorrelation function indicated the presence of an additional period, namely, one of 18 yr. The occurrence of this period can probably be attributed to a reflection in the stock market of the building construction cycle, which is known to have such a period.

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6. Y. W. Lee and C. A. Stutt, *Statistical Prediction of Noise* (Tech. Rpt. No. 129, Research Laboratory of Electronics, Mass. Inst. of Technology, 1949).
7. *The New York Times Daily and Yearly Stock Averages*, published annually by the *New York Times*.
8. It can be shown that the use of an averaging interval that approaches zero for large values of τ will cause $\phi(\tau)$ to become negative if the true axis deviates in certain ways from the assumed axis.
9. A stationary series is one, the statistical properties of which are invariant with time.
10. The Axe-Houghton index is compiled by E. W. Axe and Co., Inc., 730 Fifth Ave., New York 19.

News and Notes

Alaskan Science Conference

The 5th Alaskan Science Conference was held in Anchorage 7–10 Sept. 1954, with the Cook Inlet Branch of the Alaska Division, AAAS, as host. Two hundred and thirty-seven registrants and many other interested persons attended the 26 sessions. About 25 percent of the participants were from outside Alaska, mainly the United States and Canada; one representative was from England.

Following the opening session when Warren Weaver, president of the AAAS, presented the main address, sessions embracing a well-rounded scientific program of 142 papers began. Perhaps the most consistent feature noted throughout the conference and present in all fields of science was the importance of scientific research to Alaska. It is evident that a great amount of scientific study is being applied today to various problems in Alaska. Many of these problems are unique to the North.

One of the four sessions on geology was devoted to special lectures on geochemical prospecting and exploration in Alaska. It was disclosed that such investigations have been conducted with success in southeastern Alaska. Also of interest were the papers by members of the U.S. Geological Survey that dealt with the petroleum and coal possibilities and ground water resources of the territory. Other papers in the geology sessions were "Engineering geology program of the U.S. Geological Survey in Alaska," "Quantitative measurements of the 1937 advance of Black Rapids Glacier, Alaska," "History and economic geology of copper deposits in Copper River areas, Alaska," and "Pyrite deposits at Horseshoe Bay, Latouche Island, Alaska."

The concluding geology session was a stimulating lecture by Geoffrey A. Kellaway, principal geologist of the British Geological Survey, on "Pleistocene structures in the British Isles." He reported that an examination of permafrost in Alaska revealed information that helped to explain the origin of many strange structures in the consolidated and unconsolidated rocks of England.

The remaining three sessions in the Physical Science Section were devoted to physics, geophysics, and meteorology, with several papers reporting latest findings in several fields of auroral research.

Among some of the interesting papers of the four sessions and two symposiums of the Social Sciences Section were those presented in the symposium on *Family Life*. It was reported that Alaska's first scientific mental health team concluded that most people in Alaska needing psychiatric services are under 40 yr of age. Juvenile delinquency studies were also reported in this symposium. Some of the papers presented in a valuable anthropology session were "Cape Denbigh archeology," "Archeology at Unalaska, Aleutians," "Copper River archeology," and "The potlach and social equilibrium."

A day-long session devoted to fisheries was one of the most stimulating of the sessions in the biological sciences. It was reported that Japanese fishermen, using fishing gear and methods that differ widely from American gear and methods, and operating in the North Pacific, caught more salmon during 1954 than in any other year since World War II. Another paper revealed that scientific studies of the commercial possibilities of fresh-water fish in Alaska shows an untapped fishery resource. Some idea of the wealth of information presented in the other biological science sessions may be visualized by noting such titles as "Beaver management in Alaska," "Influence of environmental temperature on acclimatized and nonacclimatized rats," and "Notes on the role of the Crustacea, especially Malacostraca, in arctic Alaskan waters." It was also reported in the biological sessions that research in Alaska revealed that the blood's chemical content changes under the influence of low temperatures. A day-long symposium entitled *Resource Planning in Northern Alaska—A Problem in Biological, Anthropological, Economic, Social and Moral Interrelationships* drew good attendance from a variety of persons interested in the use of renewable natural resources.

In sessions concerned with agriculture and forestry scientists discussed cause, control, and effect of fires on forests. Other papers in this section were, "Relationship of forest soils and site quality in southeast Alaska," "Use of the working circle concept in management of the national forests of southeast Alaska," "Physical properties and certain morphological features of potential agricultural soils of the upper Cook Inlet region," and "Socialized agriculture in U.S.S.R.: progress or failure."

An important and timely paper entitled "Report on poliomyelitis epidemic, St. Paul Island, Alaska" was presented at the session devoted to medicine and public health. This report stated that gamma globulin had no effect on the spread of polio on St. Paul Island. The island proved to be an ideal place for