science news

Clean water: How high the cost?

There is little doubt clean air and water are becoming partisan political issues. The first confrontation came last year when the Administration opposed rigid auto emission controls drafted by Sen. Edmund Muskie's air and water pollution subcommittee and passed by the Senate. The final version hammered out by House and Senate conferees conformed closely to the Muskie version, but the President nonetheless signed the bill into law. Now, however, economists are having second thoughts over the economic wisdom of the auto emission controls—which may cost as much as $4 billion annually, money that might be spent elsewhere with a greater net gain to clean air (SN: 11/13/71, p. 332).

This year, Muskie's subcommittee drafted new water pollution legislation, and it passed the Senate unanimously. This time, the question of economic wisdom has become the prime focus of contention.

Last week, the House Public Works Committee reported out its version of the bill, and the economic aspects will surely occasion the major debate on the House floor and in conference when Congress reconvenes next year. It appears that by making his bill too tough, Muskie may have played into the hands of Administration conservatives who are trying hard to create an environmental backlash based on the alleged high cost of pollution abatement.

The Muskie bill calls for an absolute cessation of pollutant discharges into navigable waterways (virtually all waterways) by 1985, with interim goals for 1976 and 1981. The House version supports the no-discharge provision (although it refers to it as a "goal" rather than a "policy," the latter word Muskie's). This is a radical departure from earlier clean-water laws, which are based on maintaining "water quality," that is, tailoring of effluent limits to the "highest beneficial use" of the waterway in question. The House version does not altogether abandon this concept as does Muskie's bill.

The problem in attaining perfection in both air and water pollution abatement is that the cost of achieving a certain quantum of control gets much higher the nearer 100 percent clean-up is approached. Paul W. McCracken, chairman of the President's Council of Economic Advisers testified at House hearings, for instance, that it will cost

about $0.7 billion per percentage point to clean up the nation's waters to 85 to 90 percent. Then the next 10 percentage points will cost about $6 billion each and the final few points $60 billion each. McCracken figures the no-discharge goal will cost around $300 billion to achieve. Although McCracken's figures can certainly be questioned in a field where there is a shortage of precise data, engineers and scientists generally agree on the steeply rising cost curve.

Furthermore, the no-discharge provision is probably not necessary to achieving water quality high enough to protect environmental values, Administrator William D. Ruckelshaus of the Environmental Protection Agency testified. Ruckelshaus, who, unlike McCracken, cannot be counted among Administration conservatives, admitted that data are not yet available to delineate precise relationships between the kinds and amount of effluents that enter waterways and the quality of ambient water. But he said he expected EPA to have the data by 1976. In the meantime, efforts should be accelerated to abate gross pollution. Then in 1976,

precise effluent goals could be promulgated, Ruckelshaus suggested.

Another point of conflict between Muskie and the Administration is over the degree of Federal "oversight" of state water programs. Muskie wants EPA to have veto power over state decisions on each particular industrial effluent permit; the Administration is holding out for a far greater degree of state autonomy. House public works committee members, in leaning to the Muskie version, apparently believed environmentalists who told the committee that state efforts to date under existing laws have failed woefully.

A major problem with environmental legislation to date has been its too-great emphasis on abstract goals—such as "no discharge"—without reference to costs and benefits. The House version of the water bill calls for a study by the National Academy of Sciences of "the social, technological and economic effects" that would result from achieving the interim 1981 goals. Such a study, combined with EPA's study of effluents related to ambient water quality, might help make environmental legislation more rational and less political. □

On the invisible trail of binary black holes

A black hole is by nature invisible, and its name underlines the fact. A creature of modern theories of relativity, a black hole is a celestial object that has collapsed so far under the influence of its own gravity that its gravitational field is too strong for any matter or radiation to escape (SN: 12/26/70, p. 480).

A black hole is thus cut off from communication with the rest of the universe by light or radio or X-rays or emitted particles. However, it still exerts gravitational forces, and its presence could be detected by its effect on other visible bodies.

Binary stars, systems in which two stars are bound together gravitationally and revolve around each other, are an obvious place to look for black holes. Suppose that one member of a binary system became a black hole while the other remained visible. The black hole's presence could be deduced from the motion of the visible one.

Some astronomers have suggested
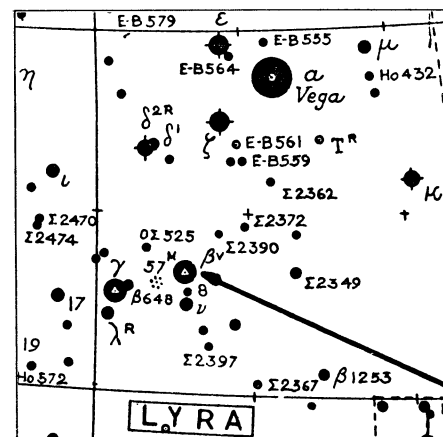
Norton's Star Atlas

Beta Lyrae: May have a black hole.

that there is more or less evidence for the existence of black holes in one or more binary systems. Others deny it. Several parts of the simmering argument have become public in recent weeks.

The first candidates for black hole status were eclipsing binaries. In an eclipsing binary the two components, one usually much darker than the other, periodically pass in front of each other,

perceptibly dimming the total brightness of the system. The dark companion is a possible candidate for a black hole (or a neutron star).

The size theoretically calculated for a black hole makes a difficulty, however. Alone it would be much too small to dim the brighter star perceptibly. In January (SN: 2/20/71, p. 129) A. G. W. Cameron of Yeshiva University suggested that such a black hole might be surrounded by a cloud of particles that revolved around it. This particulate cloud would do the eclipsing. He suggested that the binary star epsilon Aurigae might be constituted that way.

In September Edward J. Devinney Jr. of the University of South Florida suggested that beta Lyrae, one of the most famous of binary systems, might contain a black hole (SN: 10/2/71, p. 232). He suggests that the eclipsing is done by a disk of matter surrounding the black hole that the black hole ejected during collapse.

The Orbiting Astronomical Observatory has observed ultraviolet light from beta Lyrae. In the Dec. 17 NATURE, Robert E. Wilson of the University of South Florida reports that study of the changes in ultraviolet brightness as beta Lyrae goes through its revolutionary cycle supports Devinney's argument. From the data Wilson argues that the dark component is a very hot, very blue, highly condensed underluminous source lying in the center of a disk of matter. These are characteristics of a star that has collapsed to its gravitational radius, he says. That would make it a black hole or the next thing to it.

Another class of binary system is the spectroscopic binary. In this kind of system the two stars are so close together that no telescope can tell them apart. The binary nature is deduced from the behavior of spectral lines. The lines in the spectrum of the star shift toward the red as it goes away from the earth and toward the blue as it comes toward the earth. The cyclic nature of these changes indicates orbital motion on the part of the star. Some spectroscopic binaries are single-line, in which the spectrum of only one component is seen; others are double-line, in which both spectra are visible.

The single-line spectroscopic binaries, in which one component is invisible, are also candidates for black holes. In the Aug. 13 NATURE G. W. Gibbons and S. W. Hawking of the University of Cambridge in England suggested that three of them (HD 176318, 201 G Sgr and HD 194495) might bear further investigation as possibly having black holes.

The suggestion is based ultimately on eccentricities in the orbits of the stars. In swiftly revolving binaries (periods less than five days) any eccentricities in the orbit should be damped

out very quickly after formation of the binary, and the orbit should settle down to being a circle. If later one of the components becomes a black hole it might lose a great deal of mass very quickly during collapse. This would reintroduce eccentricity into the orbit. This eccentricity too would gradually be damped away, but if one happened to observe the binary shortly after formation of the black hole, the eccentricity would betray it.

It was thus necessary to search for short-period binaries with eccentric orbits, whose spectral classification showed them to be late in their evolutionary career. The three cited, say Gibbons and Hawking, are such.

In the Dec. 10 NATURE A. H. Batten and R. P. Olowin of the Dominion Astrophysical Observatory in Victoria, B. C., object that the measurement of eccentricities in spectroscopic binaries is unreliable. They also object to the statistical argument of Hawking and Gibbons that the greater incidence of high eccentricity in single-line binaries compared with double-line binaries indicates that there is something unusual in those high eccentricities, something the single-line binaries have that the double-line ones do not. Batten and Olowin say there may be some selection effect that makes it easier to find high-eccentricity single-line binaries, and that the sample is therefore not random.

In reply, in the same issue, Hawking and Gibbons accept the objection to the measurement of eccentricities and say that it seriously weakens their argument' but they cannnot see how the proposed selection effect could be important.

Meanwhile J. Richard Gott III of Princeton University, also in the Dec. 10 NATURE, argues further support for Hawking and Gibbons. He acknowledges recent developments that throw doubt on the measurement of the eccentricities of some single-line binaries, but that does not dismay him. Gott points out that the ejection of mass postulated by Gibbons and Hawking would also increase the radial velocity of the binary system (its velocity in the line of sight from earth). Since basic physical laws require that the momentum of the system remain the same, loss of mass entails an increase in velocity. Therefore binaries with black holes should have greater than average radial velocities.

In fact this turns out to be the case, Gott says, for two of the systems cited by Gibbons and Hawking. The light curves (graphs of intensity against time) of the spectroscopic binaries allow their radial velocities to be accurately deduced, he says. Leaving out 201 G Sgr, whose previously quoted eccentricity is now considered totally unreliable, he finds unusually high radial velocities for HD 176318 and HD 194495.　　　　　　　　　　□

Freedom and funding: Skinner support queried

In 1964 B. F. Skinner was awarded a 10-year continuing grant by the National Institute of Mental Health. While receiving this Federal money he wrote and published *Beyond Freedom and Dignity*, a best-seller that has stirred controversy far and wide (SN: 8/7/71, p. 96). This controversy has now reached the floor of Congress.

In a speech to the House last week Rep. Cornelius E. Gallagher (D-N.J.) said that NIMH has granted to Skinner "the sum of $283,000 for the purpose of writing *Beyond Freedom and Dignity*." Gallagher then questioned "whether he [Skinner] should be subsidized by the Federal Government especially since, in my judgment, he is advancing ideas which threaten the future of our system of government by denigrating the American traditions of individualism, human dignity and self-reliance."

This attack on Skinner's principles of behavior modification was apparently designed to gather support for Gallagher's proposal to create a Select Committee on Privacy, Human Values and Democratic Institutions. The proposal has been approved by the Committee on Rules and will be brought to the floor in January. It is "designed to deal specifically with the type of threats to our Congress and our Constituents which are contained in the thoughts of B. F. Skinner."

This committee, says Gallagher's office, would be investigative. It would report to Congress on where Federal research money is going and it would provide a public forum for the evaluation of ideas such as Skinner's. And if it did not have direct control over Federal grants, it would probably have influence on future grants.

A committee like this would not be new to Gallagher. For seven years he headed the Special Subcommittee on
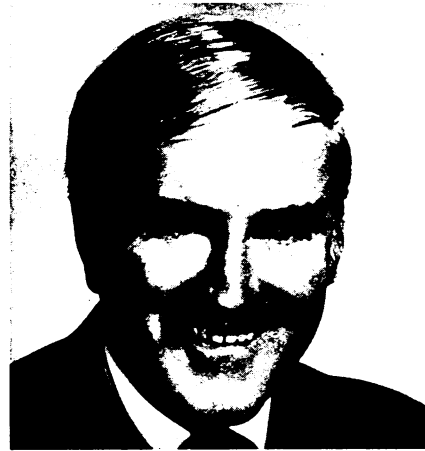
Gallagher: Questions Skinner grant.