Testimony of Stephen Knack
before the Committee on Rules and Administration
United States Senate

March 14, 2001

Good morning, Mr. Chairman and Members of the Committee. I appreciate the opportunity to appear today to testify on voting and election administration issues, which have been a major focus of my research over the last ten years. I am here today to discuss my most recent study, co-authored this winter with Professor Martha Kropf of the University of Missouri-Kansas City.

Following the last Presidential election, a widespread perception emerged that punch card voting equipment was more prevalent in counties heavily populated by minorities and poorer persons. Our study contradicts this belief. We combined county-level demographic data for the mid-1990s with information from Election Data Services on voting equipment used by the counties in the 1998 election. Our results showed there is little support for the view that resource constraints cause poorer counties with large minority populations to retain antiquated or inferior voting equipment.

Among our specific findings:

1. Nationally, racial differences in punch card use are negligible: 31.9% of whites and 31.4% of African Americans lived in counties using this voting technology. Controlling for county size and other variables, counties with larger percentages of African Americans actually have a significantly *lower* probability of using punch cards.

2. African Americans are more likely than whites to live in counties using electronic voting or lever machines, the two types of equipment in which "overvoting" is impossible if the equipment is programmed correctly.

3. Hispanics are more likely to live in punch card counties than blacks or whites, but this disparity is attributable entirely to the use of punch card voting in Los Angeles County. In most states, whites are actually more likely than Hispanics to live in punch card counties.

4. Based on presidential voting patterns in 1996, Democratic and Republican voters were equally likely to live in punch card counties, for the U.S. overall.

5. Because we elect Presidents by the electoral vote and not the popular vote, it's also relevant to make these comparisons on a state-by-state basis. It turns out that in the majority of states where some counties use punch cards and others do not, whites, the non-poor and Republican voters who are more likely to reside in punch card counties than African Americans, the poor and Democratic voters. Unfortunately for Vice-President Gore, Florida happened to be one of the exceptions to this pattern.

6. Public resources don't seem to matter much. Counties with punch card systems actually tend to have higher incomes, higher tax revenues, and larger populations than do

counties with more modern voting equipment. In counties using electronic voting systems--the most expensive type—per capita incomes and property tax revenues are actually lower than in counties using punch card or any other voting technology. Florida is actually one of the best examples of these patterns: the largest and richest counties tend to use punch-card equipment. The Washington Post's claim of November 11 that it is "mainly affluent counties that have switched" to newer technology turns out to be dead wrong.

Our study is intended only to address the question of who uses punch card and other voting systems. It does not explore the question of why punch card voting appears in Florida and elsewhere to be associated with a greater number of invalidated ballots in precincts with larger numbers of poor persons and minorities. Neither does it take a position on any of the other political or legal controversies surrounding the election in Florida.

Because of limitations on the data available, we were forced to consider optical scan systems as a single group. Some counties have scanners at the precincts programmed to inform voters of certain types of mistakes on their ballots, which can reduce substantially the number of invalidated ballots. However, we don't have comprehensive data on which counties use the precinct scanners. Neither can we identify the age of equipment in punch card counties.

We therefore cannot rule out the possibility that among counties using optical scanning the poorer ones are less likely to have the precinct counters. Neither can we rule out the possibility that among punch card counties, the poorer counties have older equipment more prone to generating invalidated ballots. But there's no evidence to support those conjectures, and they could very well turn out to be just as wrong as some of the other popular beliefs about voting equipment.

A recent Cal Tech/MIT study has exposed as false another popular belief. It found that the electronic systems often promoted as the high-tech solution to chad problems actually generate the same rate of invalid presidential votes as Votomatic-style punch card equipment.

Evidence from studies such as these has obvious implications for some of the proposed solutions to problems associated with punch card voting. Our study shows that providing financial assistance to replace punch card technology would not be subsidizing the poorest counties—in most states, including Florida, it would subsidize the richer counties. And replacing punch card technology with expensive electronic systems might not reduce the number of invalidated presidential votes. In fact, it would probably increase it in the short run, because we don't understand yet why electronic systems generate a high rate of invalid votes, so we don't know what to do about it. On the other hand, just about everybody has become well informed about exactly what can go wrong with punch card technology. Next time around, anyone still using punch cards will probably take extra care to insert the card into the slot correctly, punch their selections forcefully, and tear off any hanging chad before turning in the ballot. Poll workers likely will check the vote recorders periodically for chad build up. The error rate for punch card voting will probably fall far below the rates prevailing in recent years for punch cards and electronic systems.

We'll undoubtedly learn more about the performance of different voting systems in the coming months. The Cal Tech/MIT group is expanding their study to examine the effects of using precinct counters in optical scanning systems, and to examine different types of electronic voting systems. Professor Kropf and I are currently studying how ethnicity, education and other factors are related to invalidated presidential votes, and how these relationships differ with different types of voting equipment. For example, we'll be able to show whether racial gaps in the rate of invalidated votes are greater in punch card counties than in counties with other voting technology. There are probably other useful studies currently underway.

Hopefully the findings of these research efforts will not only help inform policy making but also contribute to a more cautious and responsible public discussion of election administration and voting technology reform. The Washington Post and other major newspapers were quick to condemn the television networks for prematurely calling election night contests based on selective and unrepresentative data. But just a few days later these same newspapers were irresponsibly editorializing about racial and class bias in voting equipment, based on nothing more than selective and unrepresentative data. And unlike the networks on election night, they've had plenty of time to get the facts right. Yet as recently as February 25, a Post editorial was still making unsupported claims about how punch card equipment in poorer areas is "older and less well maintained."

We have also heard much talk in recent months alleging massive "disenfranchisement" of voters by punch card technology. This is a loaded term previously reserved for measures such as poll taxes and literacy tests intended to prevent large classes of people from voting. Punch card balloting, despite its recognized flaws, was never intended to prevent anyone's votes from being recorded. The Cal Tech-MIT study found it is no less effective than the touch-screen voting systems in recording votes in presidential contests. Moreover, punch cards were intended to make voting easier. In many large counties it reduced waiting times for voters, as many punch card stations could be provided for the cost of only one lever machine. Although lever machines produce fewer invalidated ballots, it's possible that they would actually generate fewer total votes than punch card equipment, if they are also associated with longer lines that deter some people from going to the polls at all.

The problems affecting the largest numbers of voters in Florida were also the product of good intentions, and were not inherently related to punch card technology. In Palm Beach County, the major problem was a ballot designed to be printed in large type for the benefit of older voters. In Duval County, the major problem was faulty instructions to voters by party workers, that were provided with the intention of reducing roll-off in contests farther down on the ballot. Ballot design and instructions to voters are not issues unique to punch card technology.

I am not trying to defend the use of punch card technology. From the dozens of government reports and academic studies I have read on election administration and voting equipment, it's clear that many elections officials and other experts have been concerned for a long time about the deficiencies of punch card technology. However, we should not be under any illusions that eliminating punch card technology alone is the

technical solution to all voting-related problems. This presidential election happened to be decided in a state in which punch cards were widely used, and in which they produced an unusually high rate of voting errors. The next controversial outcome might turn on some completely different problem, in a state where punch cards aren't even used. As the executive director of the Election Center, R. Doug Lewis, has written:

> "Americans continue to amaze election officials with their creative ability to miscast votes. Give them a marking device with their paper ballot, and they'll take out their own pens instead—and the wet ink from a fountain pen may occlude the lens on the optical scanner. Or they'll use red ink and the infrared scanner won't detect it. Or they'll write notes, which a machine can't read. Give them an ATM-style touch screen, and they'll touch two candidates' boxes at once—and the screen will read neither, or both, or the box in-between."

Of course we should consider reasonable reforms that the evidence indicates might substantially reduce voter error. But voters, as well as party workers and election officials, will always make mistakes, and there will always be the potential for another controversial election outcome. We should not trivialize the denial of voting rights to women and African Americans earlier in this century by defining disenfranchisement downward to include honest mistakes associated with punch card voting.

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Overview

In the aftermath of the 2000 Presidential election and the disputed vote in Florida, differences in voting equipment became a national issue. The public became acquainted with the potential for punch card mechanisms to produce large numbers of invalidated ballots. A Washington Post-ABC News survey found 64% of respondents in favor of (with only 29% opposed) the federal government "outlawing so-called punch-card ballots." An overwhelming 87% favored (with 12% opposed) a law "requiring all states and counties to use one kind of voting machine."

A widespread perception emerged among politicians and in the media that the use of punch cards, and of antiquated voting machinery more generally, is more common in counties with a greater percentage of minorities and poor people. A Washington Post editorial claimed that it is "mainly affluent counties that have switched" to newer technology. Vice-President Gore stated that "the old and cheap, outdated machinery is usually found in areas with populations that are of lower income people, minorities, and seniors on fixed incomes." Senator Lieberman suggested that antiquated voting equipment "may be undermining the electoral rights of many poor and minority citizens." In an opinion article, Jesse Jackson and AFL-CIO President John Sweeney charged that "voters in predominantly minority communities had to vote using antiquated machinesÿ"

Only very limited and selective analyses underlie these assertions, however. A New York Times study reported that in the 2000 election in Florida, 64% of African American voters but only 56% of whites lived in punch card counties. Similarly, Democratic voters were somewhat more likely than Republican voters in Florida to reside in counties using punch cards. A Washington Post article concluded from an examination of the Atlanta and Chicago metropolitan areas that the problem of racial differences in invalidated ballots caused by gaps in voting technology "extended well beyond Florida." Based on this evidence, Washington Post columnist William Raspberry—like many others—has generalized that it is a "fact that the most error-prone machines tend to be in the poorest counties." However, there was no comprehensive study on which such claims could were grounded.

With Professor Martha Kropf of the University of Missouri-Kansas City, I decided to investigate these claims, after learning that Election Data Services, Inc. maintained data indicating the type of voting equipment used in each county across the nation. Our study analyzes the incidence of punch card and other voting equipment by ethnicity, income and other variables, combining county-level demographic data from the Census Bureau with county-level data on voting equipment. We found little support for the view that

resource constraints cause poorer counties with large minority populations to retain antiquated or inferior voting equipment. Nationally, there is very little difference between whites and blacks, between the poor and non-poor, and between Democratic and Republican voters, in the likelihood of living in a punch-card county. In a majority of states in which some but not all counties use punch card technology, whites, the non-poor and Republican voters are actually more likely than African Americans, the poor and Democratic voters to live in punch card counties. Moreover, counties with punch card systems on average have higher personal incomes, higher tax revenues per capita, and larger populations than do counties with more modern voting technology.

Types of Voting Equipment

The choice of voting equipment is determined at the county level in most states. Voting equipment currently in use can be classified into six broad categories: (1) paper ballots, (2) lever machines, (3) punch card systems, including the infamous Votomatic equipment used in Broward, Palm Beach and Miami-Dade counties in Florida, (4) Datavote, a somewhat different form of punch card voting, (5) optical scanning, and (6) electronic systems.

Paper ballots constitute the oldest system of voting still in use. Candidates' names are printed next to boxes, which voters mark. Because they are hand counted, paper ballots remain in use mostly in small counties with few contested offices.

On *mechanical lever machines*, each candidate name is assigned to a lever on a rectangular array of levers on the face of the machines. The voter pulls down selected levers to indicate choices. Levers are connected to a counting wheel, which at the close of the polls indicates the number of votes cast on the lever that drives it. Linkages in the machines are arranged to prevent invalid votes such as overvotes.

Punch card systems employ one or more cards and a clipboard-sized device for recording votes. Information about the ballot choices is provided in a booklet attached to a mechanical holder and centered over the punch card, which is inserted by the voter. To cast a vote, a stylus or other punching device provided is used to punch holes at the appropriate locations on the card, forcing out the inside of a pre-scored area in the shape of a rectangle (the now famous "chad").

Datavote also uses punch technology, but is different enough to warrant a separate category. A stapler-like tool creates holes on the card with sufficient force that pre-scoring of ballot cards is unnecessary. The name and party of the candidates are printed directly on the Datavote card, so it is easier for voters to ascertain after completing their ballot whether they voted as intended. Because fewer ballot choices can be printed on each card, voters typically must vote several cards. This proliferation of cards can slow the counting process substantially (unless extra card-reading capacity is added), so that a large county such as Los Angeles might have difficulty completing their tabulations on election night were it to convert from Votomatic to Datavote.

Optical scanning systems are widely used in standardized testing and other functions besides voting. Optical scanning began to be used in voting at about the same time as punch card systems, although its use spread more slowly until the 1980s. These systems use large ballots similar to those of paper ballot systems, so that information about candidates can be printed directly on the ballot. The ballots are counted by a machine that uses light or infra-red as a sensor to discern which oval or rectangle the voter marked from a set of choices. In many counties, voters can feed the ballot into a reader, which returns the uncounted ballot to the voter if it contains any overvotes or other mistakes, giving the voter a chance to correct the ballot. In other counties, voters drop the ballot in a box and the ballots are all collected and fed into the machines later by election workers.

Direct recording electronic systems are similar to lever machines, and different from other systems, in that there is no physical ballot, and no possibility of overvotes if the equipment is programmed correctly. While votes are tallied electronically using punch card, Datavote, and optical scanning systems, votes are not cast electronically. Electronic voting systems are different from those systems in that voter choices directly enter electronic storage, using touch screens, push buttons or keyboards.

In Maine, Massachusetts, New Hampshire, Vermont, and Wisconsin, voting equipment is determined at the municipal level. In many (but not all) counties in these states, therefore, equipment is not uniform throughout the county. These *mixed systems* were in effect in about 4.5% of counties in 1998, representing about 8% of the population (see Table 1).

Data and Methodology

Following the general election in November of each even-numbered year, Election Data Services, Inc. surveys states and counties to obtain data on voter registration, vote totals, and voting equipment in use, with complete results available the following spring or summer. Thus, the most recent year for which the voting equipment data are available is 1998. Each county is classified in the Voting Equipment Data File as either using paper ballots, lever machines, Votomatic-style punch cards, Datavote, optical scanning, electronic, or mixed. The survey does not ascertain which punch card or optical scan counties provide voters with access to card readers that checks ballots for overvotes or other problems before they are turned in.

We merged the Voting Equipment File with demographic data from USA Counties 1998, a data file available from the U.S. Census Bureau. This file provides estimates of the number of whites, African Americans, and Hispanics (who may be of any race) residing in each county in 1996, and of the number of poor and non-poor persons as of 1993. Personal income per capita and property tax revenues per capita are available for 1994 and 1992 respectively. Data are available in USA Counties on the number of votes cast for the Democratic and Republican candidates (Clinton and Dole) in the 1996 presidential election, which can be used to approximate the partisan distribution within counties.

Detailed Findings

For the U.S. overall, black-white differences in punch card use are negligible: 31.9% for whites and 31.4% of African Americans live in counties using this voting technology. Hispanics are much more likely to live in punch card counties than either whites or blacks. However, this difference is entirely attributable to Los Angeles County, where nearly one in seven Hispanics in the country reside. Whites (27.7%) are more likely than blacks (21.8%) to live in optical scanning counties, but blacks (37.8%) are much more likely than whites (26%) to live in counties using either of the technologies for which overvoting is nearly impossible if machines are programmed correctly: electronic voting and lever machines.

Differences in voting equipment associated with poverty status are very minor. The poor are slightly more likely than the non-poor to live in punch card counties, but also slightly more likely to live in counties with electronic voting.

Based on presidential voting patterns in 1996, Democratic and Republican voters were equally likely to live in punch card counties. Democrats were somewhat more likely to live in counties with "antiquated" equipment, but in the form of lever machines that produce very few invalidated ballots, not punch cards. Republicans were somewhat more likely than Democrats to live in optical scan and electronic voting counties.

In practical terms, these nationwide comparisons are relevant only for the popular vote in the presidential election. Equity in voting technology is better addressed by examining differences across counties within states. The Electoral College system grants a state a fixed number of electoral votes, regardless of the number of valid votes cast in the state. Therefore, differences in voting technology that are purely cross-state cannot disadvantage a state's voters relative to other states. For this reason, it is important to examine differences across counties within states, to exclude purely cross-state differences that can have no electoral impact. Accordingly, we considered separately each of the 29 states in which some but not all counties use punch card technology.

The conventional wisdom regarding racial disparities in voting equipment is contradicted by the state-level comparisons: in 18 of the 29 states, whites were more likely than African Americans to live in punch card counties. The 11 states in which blacks were more likely to live in punch card counties tend to be larger, however, accounting for 191 electoral votes, compared to 162 for the 18 states in which whites were more likely to live in punch card counties.

A similar comparison between whites and Hispanics shows that the former were more likely to live in punch card counties in 21 states (representing 235 electoral votes), while the latter were more likely to live in punch card counties in only 8 states (representing 118 electoral votes).

The conventional view that the poor live disproportionately in punch card counties also turns out to be incorrect for the majority of states. In 21 states, representing 203 electoral votes, it is the non-poor who are more likely to reside in counties using this type of voting

equipment. In only 8 states, representing 150 electoral votes, are the poor more likely to live in punch card counties.

Party differences, as measured by voting in the 1996 presidential election, also contradict popular belief. A greater share of Dole voters than Clinton voters lived in punch card counties in 16 of 28 states. However, the states in which Democratic voters were more likely to live in punch card counties account for slightly more electoral votes (183 to 167).

Economic Factors

The belief that minorities, the poor and Democrats tend to reside in areas using more error-prone voting equipment rests in large part on the reasonable presumption that cost matters. Electronic voting systems are more expensive than punch card systems, and counties with a lower poverty rate (and thereby a smaller share of minorities and Democratic voters in general) may be better able to afford the newer, more expensive technology. On the other hand, larger counties – where minorities and Democratic voters disproportionately reside -- may benefit from economies of scale in purchasing and implementing newer systems such as electronic voting.

Our results found little evidence that the retention of punch card systems, or the adoption of less error-prone optical scanning or electronic alternatives, is heavily influenced by considerations of affordability. Punch card counties in Florida are much larger, wealthier, and more revenue-rich than any other group of counties. It is exactly those counties which should be best able to bear the expense of modern equipment which are the most likely to retain punch cards.

For the U.S. as a whole, punch card and Datavote counties are larger and wealthier on average than those using any other voting system. Paradoxically, counties using electronic voting constitute the group with the lowest incomes on average, and -- by a wide margin -- the lowest property tax revenues per capita.

Similar findings are produced by comparisons across counties for each state separately. For each state in which some counties use punch cards while others use modern (optical scanning or electronic voting) equipment, we calculated simple averages of county size, income, and taxes across the relevant group of counties. For example, we found that in Arkansas, punch card counties on average are larger (mean population of 63,594) than counties with modern equipment (34,139). Similarly, they are wealthier (mean personal income per capita of $16,597 vs. $14,982) and have higher tax revenues per capita (mean of $239 vs. $209 per year).

In 17 of 28 states, punch card counties tend to be larger than counties with modern equipment. Similarly, in 17 of 28 states punch card counties tend to have higher incomes, and higher property tax revenues per capita.

Finally, we ran multivariate tests, using counties as the units of analysis, that include demographic and economic variables together. These tests can determine, for example,

whether counties of a given size are more likely to use punch card systems if they have more minorities. Controlling for other variables, we found that counties with a higher share of African Americans are significantly less likely to use paper ballots, more likely to use lever machines, and *less* likely to use punch card machines. Counties with more Hispanics are less likely to use lever machines, and more likely to use Datavote or optical scanning technology. Higher incomes are associated with a lower likelihood of using paper ballots, but no other significant relationship with income was found. Higher property taxes are associated with a greater use of paper ballots (likely reflecting low population density) and a lower likelihood of using electronic voting. Low population levels strongly predict the use of paper ballots as expected, while large counties are more likely to use punch card or electronic voting systems.

Conclusion

Results from our study contradict the widespread belief that African Americans, the poor, and Democratic voters are more likely to reside in counties using punch card technology, and that the choice of voting systems is largely determined by affordability. Evidence reported in the media on ethnic and party disparities in Florida and in selected metropolitan areas such as Atlanta and Chicago is inconsistent with evidence from most other states and the country as a whole. In fact, in the majority of states with some counties using punch cards and others using alternative systems, whites, the non-poor, and Republican voters are more likely than African Americans, the poor, and Democratic voters to reside in punch card counties. Moreover, there is little evidence that the choice between punch cards and more modern, less error-prone systems is influenced by economic factors. To the contrary, in Florida and elsewhere larger, wealthier and more tax-rich counties are more likely to use punch card technology, and less likely to use electronic voting systems.

Several caveats to our study should be noted. First, it in fact found some evidence of disparities in voting equipment that may disadvantage minority groups. Blacks are more likely than whites to reside in counties using lever machines, which may be associated with longer waits at the polls. Also, Hispanics are much more likely than whites to live in punch card counties, although this disparity would be eliminated entirely if Los Angeles County abandoned its use of punch cards – and the disparity in most individual states is inconsistent with this gap for the nation as a whole.

Second, there are potentially important variations in the way punch card systems operate that we are unable to control for due to a lack of data. For example, we cannot rule out the possibility that poorer counties are less likely to provide voters access to card readers that allow them to check that their ballots accurately reflect their voting intentions. However, the availability of this equipment could just as easily be a function of county size rather than income levels. We also do not have complete data on the number and characteristics of absentee voters in each county and on which system is used for tallying their ballots.

Third, this analysis addresses only the question of who uses punch card and other voting

systems, and does not explore the possibility that minorities or the poor might find it more difficult than other voters to use punch card technology effectively. The New York Times and Washington Post have reported that in Chicago, and in Duval and Miami-Dade counties in Florida, there are far higher rates of invalidated votes in precincts with large numbers of African American voters.

Fourth, the study does not claim that the 2000 presidential election outcome was unaffected by the geographic distribution of punch card voting in the 2000 election. Unluckily for Vice-President Gore, the crucial state in the election happened to be one of the few in which Democratic voters were substantially more likely than Republicans to vote using punch card technology.

Finally, the study is intended solely to investigate the consensus that rapidly emerged in the aftermath of Florida regarding who was more likely to confront antiquated voting technology. None of its findings should be interpreted as arguing for the retention of punch card technology, or that voters are to blame when their ballots are not read in a way consistent with their voting intentions. Neither should our study be interpreted as taking a position on any of the political or legal controversies that arose in Florida following the 2000 election.

In light of the now widely-known problems associated with punch card voting systems, it is easy to second guess decisions to retain punch card systems until now. Lost in all of the publicity regarding Florida, however, are the potential drawbacks of alternative systems. Errors are not unique to punch card systems. As experts have noted, each type of voting system has its own particular vulnerabilities. The executive director of the Election Center, R. Doug Lewis, has written:

> Americans continue to amaze election officials with their creative ability to miscast votes. Give them a marking device with their paper ballot, and they'll take out their own pens instead—and the wet ink from a fountain pen may occlude the lens on the optical scanner. Or they'll use red ink and the infrared scanner won't detect it. Or they'll write notes, which a machine can't read. Give them an ATM-style touch screen, and they'll touch two candidates' boxes at once—and the screen will read neither, or both, or the box in-between.

Counter mechanisms on lever machines may fail to turn, due to a disconnect in the mechanical system or to excessive friction. Unlike the case with punch card systems, there are no independent ballots available for recounting if a lever machine suffers from a rare failure such as this. If the printed strips inserted in a lever machine that identify candidates are incorrect, voters may cast votes for the wrong candidate. If not all of the counters have been set to zero before the polls open, incorrect totals can be produced. Even where lever machines work perfectly, their higher cost may result in an insufficient number of machines, leading to longer waiting times, perhaps deterring some people from voting.

With optical scanning systems, there are instances on record of ballot readers failing to

read inordinately large numbers of ballots. An optical scanning malfunction in Volusia County, Florida caused hundreds of votes to be missed in the 2000 election. The Orlando Sentinel newspaper conducted a manual review of more than 6,000 ballots read by optical scanners as invalid in Lake County, Florida in the 2000 presidential election, and found hundreds of overvotes in which voter intent was clear from attempted erasures or from notes written on the ballots, and several undervotes in which voters had circled a candidate's name instead of filling in an oval.

Most electronic systems in use do not provide re-countable individual records of voter choices, meaning that certain software or other problems in vote tallying may not be correctable. Any system relying on computerized vote tallying, including electronic voting, optical scanning, and punch cards, is subject to both security concerns and the possibility of programming errors.

Punch cards created unusually serious problems in Florida in 2000 for several reasons. First, no punch card counties in that state provide voters with access to card readers to check their ballots for overvotes or other problems; by contrast nearly all optical scan counties in Florida provide this option. Second, Florida's punch card counties appear to be atypical in not having election workers fan the ballot cards, or pull off hanging chad, before machine counting them on election night. Finally, there were problems specific to individual large counties, such as the ballot design in Palm Beach County and confusing instructions provided by Democratic Party workers to their voters in Duval County.

This discussion is not intended as a defense of punch card technology, but to suggest that differences in the accuracy of punch card and other systems was reasonably perceived (until the 2000 election) as a matter of degree, and that the retention of punch card technology was not dictated only by a sheer inability to afford newer systems. In fact, a new Cal Tech-MIT study has found that electronic systems--the most expensive type of voting equipment—generate as many invalidated presidential votes as does punch card equipment.