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DEVELOPMENT AND TESTING OF A MODEL USING COMPUTER TECHNIQUES TO DEVISE ALTERNATIVE DESEGREGATION PLANS FOR URBAN SCHOOLS

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DEVELOPMENT AND TESTING OF A MODEL USING COMPUTER TECHNIQUES TO DEVISE ALTERNATIVE DESEGREGATION PLANS FOR URBAN SCHOOLS

Approved By

Dissertation Committee

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INTRODUCTION

Background and Need

Within the past fifteen years, education in this country has been influenced greatly by political and social changes. Perhaps, no other Supreme Court decision has had the political, social and educational implications of the Brown vs. Board of Education decision of 1954 in which the Supreme Court of the United States held that, "Separate educational facilities are unequal" and that, "in the field of public education the doctrine of 'separate but equal' has no place."[1]

This landmark decision was followed by the second Brown decision in which the Court recognized the possible existence of local administrative difficulties and demanded that school boards "make a prompt and reasonable start toward bringing themselves into compliance with the original order

[1] Brown v. Board of Education of Topeka, 347 U.S. 483, 488 (1954).

of Brown I."[1]

Ten years after Brown I, Congress enacted the Civil Rights Act of 1964. Section 601 of Title VI of the act stated.

> No person in the United States shall, on the grounds of race, color, or national origin, be excluded from participation, be denied the benefits of, or be subjected to discrimination under any program or activity receiving federal financial assistance.[2]

Pursuant to Title VI, the Department of Health, Education, and Welfare issued 45 C.L.R., Part 80, which prohibited discrimination by school districts and other recipients of federal funds.

Despite the historic Supreme Court decision and the later enactments by Congress relating to civil rights, the racial problems of America are still present and in some respects are more severe now than fifteen years ago. Pettigrew recently placed the present day problem in perspective with these words:

> America has had an almost perpetual racial crisis for a generation now. But, the last third of the twentieth century has begun on a new note, a change of rhetoric and a confusion over goals. Widespread rioting is just one expression of this note. The nation hesitates; it seems to have lost its confidence that the problem can be solved, it seems unsure as to even the direction in which the solution lies. In too simple terms, yet in the style of the fashionable rhetoric, the question has become: Shall Americans of the future live

[1]Daniel M. Berman, It Is So Ordered: The Supreme Court Rules on School Desegregation (New York: W. W. Norton and Company, Inc., 1966), pp. 148-149.

[2]Section 601 of Title VI, Public Law 352 of the 88 Congress, The Civil Rights Act of 1964.

racially separate or together?[1]

Given a choice of living racially separate or together, particularly as it pertains to the public school system, the preponderance of evidence and experience overwhelmingly indicates the advisability of desegregated education. Pettigrew suggested the possible alternatives in this statement:

> Racial separatism, then, is a cumulative process; it feeds upon itself and leads its victims to prefer continued separation. Such isolation prevents each group from learning of the common beliefs and values they do in fact share. Consequently, Negroes and whites kept apart, come to view each other as so different that belief dissimilarity typically combines with racial considerations to cause each race to reject contact with the other. Second, isolation leads in time to the evolution of genuine differences in beliefs and values, again making interracial contact in the future less likely.[2]

While millions of white separatists and many black separatists oppose desegregation, most observers of diverse persuasion agree that the achievement of true integration should be the ideal and ultimate goal. If this is true the one course the nation cannot afford is the course of inaction.

The legal implications for educators, however, are frequently cloudy and unclear.

> Does the Constitution require an effort to eliminate de facto segregation? Data abound declaring that

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[1]Thomas F. Pettigrew, "Racially Separate or Together?" Integrated Education, VII (January-February, 1969), p. 36.

[2]Ibid., p. 41.

> the equal protection clause of the fourteenth amendment does not "affirmatively command integration" and forbids only the use of governmental powers to enforce segregation.[1]

It is true that the court, in the landmark Brown vs. the Board of Education decision, was talking about segregation by law. However, in the intervening years, it has become increasingly more apparent that the harmful effects of segregation are not limited to the de jure variety. In a recent decision in Washington, D. C., Judge Skelly Wright stated:

> Racially and socially homogeneous schools damage the minds and spirit of all children who attend them--the Negro, the white, the poor and the affluent--and block the attainment of the broader goals of democratic education, whether the segregation occurs by law or by fact.[2]

The Supreme Court, in a 1968 decision on the validity of a freedom of choice plan, seemed to have in mind this broader objective for desegregation when it stated:

> The Board must be required to formulate a new plan and in light of other courses which appear open to the Board, such as zoning, fashion steps which promise realistically to convert promptly to a system with neither a "white" school nor a "Negro" school, but just schools.[3]

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[1]Will Maslow, "De Facto Public School Segregation," Integration vs. Segregation, ed. Hubert H. Humphrey (New York: Thomas Y. Crowell Co., 1964), p. 155.

[2]Hobson v. Hansen, 269 Federal Supplement, 401 (1967).

[3]Green v. New Kent County School Board, 391 U. S. 430 at 435 (1968).

Regardless of the apparent clarity of the ruling in the Green case, recent happenings and official statements seem to indicate a continuing concern over what the supreme law of the land has ruled relative to de facto segregation. In a recent interview with staff members of U. S. News and World Report, the Secretary of Health, Education and Welfare Mr. Robert H. Finch, reported:

> The Supreme Court has never really said that segregation itself is unlawful--or at least de facto segregation. The court has said if you commit deliberate acts of discrimination, then you are in violation of the law--I don't believe in a 50 percent figure, or a 20 percent figure or any arbitrary figure. We have to look at each school district, with its own profile, and its own "chemistry." We cannot just take arbitrary percentages and still come out with quality education--however, each of us may define 'quality education.'[1]

Administrators and boards of education of school systems in large urban areas are seemingly faced with overwhelming odds when the political, psychological, and physical problems which accompany efforts to limit de facto segregation are added to the dimension of uncertainty regarding the federal guidelines as they pertain to de facto segregation.

The recommendations advanced in the final section of the United States Civil Rights Commission report, Racial

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[1]U. S. News and World Report (March 10, 1969).

Isolation in the Public Schools, represents essential but not complete elements of a strategy for achieving urban school desegregation.

> A congressional uniform standard, firm assignment of state responsibility; sizeable federal fiscal assistance, adequate time, or controlled pacing; and the control recommended over private and public housing and urban renewal, constitute the elements which must be present if the grave problem of urban school segregation is to be remedied.[1]

However, until legal uncertainties on de facto segregation are removed and until action on the part of federal, state and local governments is coordinated and concentrated on solution of the problem, it remains the responsibility of school authorities to initiate and utilize limited techniques to accomplish some if not total school desegregation.

The value of well planned, well implemented yet limited desegregation plans is clearly stated in a report prepared for the U. S. Commission on Civil Rights, Washington, D. C.

> Limited techniques should be continued and extended in all of the largest cities. They can be designed to improve educational opportunity, and they stimulate progressively greater commitment to comprehensive school desegregation programs. It is unlikely that federal, state, or local agencies will take giant steps to remedy a problem unless there has been experience in the small interim steps.

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[1]Report of the United States Commission on Civil Rights, Racial Isolation in the Public Schools I (Washington: U. S. Government Printing Office, 1967), pp. 209-212.

> Limited programs of free choice, grade structure revision, pairing and bussing, also serve to thaw an otherwise frozen complex of local school customs and mores. Quite apart from the challenge of school desegregation, big city school systems face such a host of special changes and rising public expectations that established procedures must be modified in countless ways if alternatives to failure are to be discovered. Well planned, well implemented, yet limited desegregation schemes should be encouraged. Hasty, mechanical experiments should be avoided; they harm some students, and they depress confidence in the desirability of comprehensive school integration.[1]

Given the mandate to put into operation plans for desegregation in large urban schools the school educator has an urgent need for a rational systematic approach to desegregation. What appears to be needed is a realistic, and simplified means by which the geographical location of students can be unitized and computerized along with other student information. Such information should be accomplished with a precise outline of steps to be taken, data to be gathered, criteria to be utilized, restrictions and constraints to be identified and questions to be asked in the application of computer technology to the development of desegregation plans. Ultimately what is needed is an efficient, simplified way to compute several alternatives where each alternative is based on a different set of conditions. This needs to be accomplished in a language the non-computer oriented educator can understand and utilize.

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[1]Robert A. Dentler and James Elsbery, "Big City School Desegregation--Trends and Methods," Report Resume ED 016718 of U. S. Department of Health, Education and Welfare, Office of Education, November, 1967, pp. 1-16.

Numerous studies have been done on participation in decision making, but little has been done to assess the effect of machine decisions regarding desegregation. Dill suggested the need for such a study with this statement:

> Finally, all of the work that has been done on studies of participation in decision-making needs to be extended to take into account the new developments in strategies for making better decisions, especially those which suggest that computers may become important elements in the decision making network of an organization--a third level in our quest for better ways to make decisions in the development of a model which will explore alternatives, evaluate them, and propose a decision which is the equal of what human managers could propose and which sometimes, within the limits of certain assumptions and constraints, can be defined as "optimal."[1]

Weinberg suggested the need for a study that explores the usefulness of the tapes of Block Statistics presently available from the Bureau of the Census. He further stated that the possibilities of increasing the usefulness of the 1970 Census findings for school matters should be probed.

Purpose of Study

The purpose of this study was to devise and test a model for school administrators to utilize in resolving pupil assignment problems related to the desegregation of schools in large urban areas. The study should provide valuable information to members of boards of education and to school administrators in

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[1]William R. Dill, "Decision Making," Behavioral Science and Educational Administration. Sixty-third Yearbook of the National Society for the Study of Education, Part II (Chicago: University of Chicago Press, 1964), pp. 216-218.

planning and implementing desegregation plans.

Statement of Problem

The problem of this study was to develop a computerized model and to determine its applicability for devising alternative plans for reassigning students in an urban school system to achieve a desired pattern of racial desegregation.

Related problems of this study were: (1) to test and modify this model utilizing actual school and demographic data from an urban school system, (2) to develop a set of characteristics desired in the model; (3) to analyze the applicability of the model in terms of these characteristics.

The study attempted to answer the following questions:

1. What criteria should be used by a school system in evaluating a system-wide plan for the desegregation of its school enrollment?

2. What procedures have school administrators utilized to develop school desegregation plans?

3. What demographic and school data are required to develop a computerized model as described in this study?

4. How can the required data for the model be best collected?

5. What is the logical sequence for organizing and assembling the model input data?

6. What difficulties and problems are encountered in the gathering and processing of data for model input?

7. What is the nature of the output and how can it be converted into a form most suitable for use?

Assumptions

It was assumed that an operational approach for devising a desegregation plan is essential for purposes of assisting the school administrator in divorcing facts from emotionalism.

It was assumed that a computer is a potentially useful tool for devising a desegregation plan because of the many variables which must be considered.

It was assumed that large urban schools have an urgent need for simplified ways to analyze large amounts of student and demographic information.

It was assumed that student assignment is an essential consideration in effective school desegregation efforts.

It was assumed that a computerized model will more readily provide for an optimal solution of student assignment than can be attained by utilizing manual methods.

Definition of Terms

Applicability of model means the presence of desired characteristics which make the model feasible for use by professional educators.

Computer is any device capable of accepting data, applying prescribed processes to them, and supplying the results of these processes.

<u>Characteristic of model</u> is a quality desirable in the model.

<u>Computerized model for desegregation</u> is the sum of all the essential procedures required to obtain the desired output.

<u>Constraint</u> is a condition that must be satisfied in seeking a solution to the problem.

<u>Data processing</u> is the rearrangement and refinement of raw data into a form suitable for further use.

<u>De facto school segregation</u> is segregation in the schools resulting from residential patterns.

<u>De jure segregation</u> is segregation in the schools resulting from man-made laws.

<u>Desegregation</u> means the physical mixing of Caucasian and Negro students in a given school by means of assignment.

<u>Input</u> means the process of introducing data into the internal storage of the computer.

<u>Output</u> means the process of transferring data from internal storage of the computer.

<u>Linear programming</u> is the means by which limited resources are allocated among competing activities in an optimal manner.

<u>Optimal solution</u> is the best solution for overcoming a set of constraints to attain a given objective.

<u>Performance of model</u> is the ability of the model to make optimal assignments and to provide the required information for alternative desegregation plans.

Preference factor is the preference given by the investigator to a certain attendance area for assignment to a given school.

Pupil assignment means the assignment of students within a school district to an attendance unit.

Redistricting means boundary change with regard to attendance units within a legal school district or administrative unit.

Delimitations

The investigator recognized, that other than the physical, there were many complex and significant aspects of total desegregation such as the training of the total staff in the concepts and skills related to human relations values and equal educational opportunities, the development of proper interpersonal relationships, the educating of the school community, the fostering of psychological and sociological understandings and the assumption of proper leadership responsibilities.

However, it was reasoned that many of the problems relating to the educational phase of desegregation would not or frequently could not be resolved until physical desegregation occurred. Much of the more vigorous resistance to desegregation manifested itself when the physical aspect was attempted. In fact the ability to handle the more subjective problems associated with desegregation may well depend on the degree to which the school desegregation decision-maker can make a comparative evaluation of many physical alternatives. Therefore, this study was limited to those physical aspects of desegregation which are amenable to scientific, quantitative analysis such as the assignment of students.

It was not the purpose of this study to provide a model for operations research or computer technologists but rather to provide a working model for practicing educators. Therefore, detailed technical explanations of computer usage were omitted and left to experts in that area of concern.

Procedures

The investigator in collaboration with the Consultative Center of the University of Oklahoma initiated this study during January of 1969. After considerable research to determine what had been done in the area of this study, the decision was made to begin the development of a computerized model for purposes of devising alternative plans for school desegregation. The Oklahoma University Computer Center was retained to assist with the technical aspects of the problem. Through consultation with consultants of the Computer Center the general requirements for the model were determined. The student and building data was obtained from a cooperating urban school system while the demographic data was obtained from the U. S. Census Bureau.

The Computer Center assumed responsibility for preparing the data and developing the computer programs for the automated phase of this study according to the guidelines supplied by the investigator. Following the completion of each phase of the model the investigator analyzed the model to determine the degree to which certain desired model characteristics and performance were achieved.

Organization of the Study

The background and problem of the study were presented in Chapter I. Chapter II is devoted to a review of the pertinent literature related to the study. A description of the model will be presented in Chapter III. Chapter IV is devoted to an analysis and evaluation of the model. Chapter V contains a summary of the study, the conclusions based on the findings of the study, recommendations, and suggestions for further research.

CHAPTER II

REVIEW OF SELECTED LITERATURE

This study was primarily concerned with the development and analysis of a computerized model for pupil assignment that was adaptable to the solution of problems related to racial desegregation in urban school systems. A review of the literature revealed relatively few studies which were related directly to the problem. Since the review of the literature presented in this study was intended to deal with practices and procedures related to the physical aspects of pupil assignment for purposes of desegregation, the review was organized into categories which correspond to the major aspects of the study.

Methods Frequently Utilized to Accomplish Pupil Assignment for School Desegregation Purposes

Dentler and Elsbery[1] reported on big city school desegregation. Their investigation sought to understand the current situation with respect to school segregation in the largest central cities of the United States along with the

[1] Dentler and Elsbery, *op. cit.*

least and the most promising techniques for achieving school desegregation in these cities.

These points stood out in the study: (1) Barring new policies, it was expected that by 1975 the twenty largest cities of the nation would be characterized by increasingly extreme residential, and hence, extreme *de facto* school segregation. (2) There was a great difference between a big city school desegregation program that was in operation and one that had been proposed and planned. (3) The only programs in general operation were those involving free choice transfers of pupils, limited open enrollment, or limited change in attendance zones.[1]

Sixty-eight of the one hundred largest school districts in the nation had 75 percent of their Negro students attending predominantly Negro schools in 1969. The extend to which segregation continues in our largest urban schools was further emphasized by the fact that ten of the schools which statistically appeared to have better desegregation records than the sixty-eight referred to above were actually schools with less than 4 percent Negro students in total school enrollment.[2]

Although development of plans to desegregate schools was not new, there had been few successful models for desegregation, particularly, in large city schools. Strictly from

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[1]*Ibid.*, pp. 307-308.

[2]Release by the U. S. Department of Health, Education and Welfare, January 4, 1970.

a numerical basis alone, desegregating schools in a city of 300,000 or more was much different than a similar attempt in a city of 30,000 or less. When the components of complex transportation networks and severe residential segregation were added to the numerical factor, the problem became even more overwhelming.

The first part of this review considered some of the plans, successful or unsuccessful, which had been described with any frequency by medium and large sized school districts.

City-to-Suburb Busing

At least three schools had successful experiences with city-to-suburb busing. Dustin reported on the degree of that success:

> After three years of experience with city-to-suburb busing, schoolmen in Rochester, N. Y., Hartford, Conn., and Boston say that it has substantially benefited both white and non-white youngsters.
>
> Tests show that the academic performance of 135 ghetto youngsters attending school in the Rochester suburbs of West Irondequoit and Brightton is dramatically higher than youngsters left behind in the city. The Boston area program has been similarly successful. Witness its expansion from an original 225 pupils to nearly 1,000 youngsters, who are bused out to 28 surrounding school districts. The busing of youngsters from Hartford to suburban West Hartford has been so successful that the number of inner city youngsters has more than doubled.[1]

Some other schools had proposed a city-to-suburb busing plan which had met strong resistance from school patrons.[2]

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[1]Martin Buskin, "City-to-Suburb Busing What Next for Great Neck?" School Management (April, 1969), p. 60.

[2]Ibid., pp. 58-65.

<u>School Closing</u>

One of the more frequently used methods in school desegregation was that of closing a school or schools and incorporating the attendance area of the closed school into the attendance areas of one or more adjoining schools. Frequently students were bused from the closed school to peripheral schools to attain a better racial distribution throughout the district. School administrators commonly found it more practical as well as politically feasible to close schools in the inner-city area. The closed schools frequently tended to be Negro schools.

The closing of three predominantly all-Negro vocational schools with students reassigned to general high schools was one of twelve techniques proposed for the desegregation of the public schools of Chicago by Weinberg.[1]

The Wichita, Kansas school district likewise used the closing of a predominantly Negro school as the basis of a recently implemented school desegregation plan. The plan provided for the closing of a predominantly Negro junior high school. The Negro students from specified geographical areas were then assigned to particular schools outside the Negro community.[2]

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[1]Meyer Weinbert, "Techniques for Achieving Racially Desegregated, Superior Quality Education in the Public Schools of Chicago, Illinois." <u>Report Resume No. ED03157 of U. S. Department of Health, Education and Welfare</u>, Office of Education, November, 1968.

[2]Interview with Dr. Dean Stucky, Deputy Superintendent of Schools, October 9, 1969.

Grand Rapids, Michigan, converted a majority Negro high school to a junior high dispersing the students to the other three high schools in the district.[1]

Clusters or Complexes

The educational complex was a much discussed but little utilized concept for school desegregation. Aside from the Baltimore school system which made an effort to cluster elementary schools, there were few if any such plans in operation as of this writing except for a few that could be termed complex or cluster modifications.[2]

The Oklahoma City school board submitted a cluster plan which was approved by the school system and the courts The plan called for the grouping of city senior high schools into a northside and a southside cluster of facilities. Students, according to the plan, were to attend their neighborhood school only for certain electives and extra-curricular activities, and were to be transported during the day to other schools in the cluster for specialized subjects.[3]

Educational Parks

The feasibility of educational parks in large cities

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[1]Grand Rapids Board of Education Meeting, May 27, 1968

[2]Dentler and Elsbery, op. cit.

[3]Daily Oklahoman, January 7, 1970, p. 1.

will be tested only when several have been created and operated for some time in more than one city.[1] Large city schools such as New York, Philadelphia, Baltimore, Washington, Syracuse, and Rochester, as well as a host of smaller towns had educational park plans on their drawing boards or were actively exploring what such parks could do for them.[2]

In what is termed by the planners as "the furthest reaching integration plan of any city in the country" the Pasadena, California school district presented to the courts a plan which reorganized the district's elementary schools and established an "educational park" which contained three individual high schools at a cost estimated at $9.2 million for the first phase.[3]

Condoli created a modified model of the educational park where it would provide supplementary services for all the students and citizens of the community. He suggested

> The park would provide an integrating center for all segments of the Grand Rapids community; the public and non-public schools, the inner city and the peripheral residential areas, the white and non-white elements, the wealthy and the low income segments, the culturally deprived and the culturally advantaged, the old and the young.[4]

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[1]Dentler and Elsbery, op. cit., p. 313.

[2]Max Wolff, "Position Paper--The Educational Parks," (Paper presented at the Conference on Education and Racial Imbalance in the City, Hartford, Connecticut, March 2-3, 1967), p. 3.

[3]The Daily Oklahoman, February 19, 1970, p. 5.

[4]I. C. Candoli, "A Feasibility Study of the Community College's Potential Role in Combating the Effects of Cultural Deprivation in Metropolitan Areas" (unpublished Ph.D. Dissertation, Michigan State University, 1967), pp. 96-100.

Changing Attendance Boundaries

Changing attendance zones or boundaries either alone or in combination with some other technique probably represented one of the most frequently used methods employed by schools to effect school desegregation.

One of the first cities to attempt districtwide desegregation was Washington, D. C. The hope for the success of the plan was apparent in this description of its plan:

> On September 13, 1954, desegregation occurred in Washington, D. C., a community with 105,000 students, 62% of whom were Negroes. Dr. Hobert M. Corning, then superintendent of the District of Columbia, gave leadership to the development of the plan now bearing his name. It called for complete desegregation of all schools, to be accomplished with the least possible delay.[1]

Other schools had incorporated boundary changes as one of several techniques.

The Oklahoma City school system paired four junior-senior high schools in 1968. As a result of the pairing two of the schools became three-year high schools while the other two became junior high schools. In order to achieve a better racial balance for the 1969-70 school year and to prevent resegregation, boundary lines were changed and extended to include a greater number of Caucasian students from other predominantly white student attendance areas.

The Atlanta Public Schools were projecting a rezoning

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[1]Herbert Wey and John Corey, Action Patterns in School Desegregation (Bloomington, Indiana: Phi Delta Kappa, 1958), p. 276.

plan to become effective during the 1970-71 school year. The changing of boundaries in keeping with the neighborhood school concept was to increase by seven percent the number of Negro students who would attend desegregated schools.[1]

The Portland public school system proposed a plan whereby the school district was to be divided into three subdivisions. Each subdivision would be plotted in a manner to insure that no more than 25 percent of the student population of a given school would be Negro. Each subdivision was to contain approximately four high schools and have a superintendent.[2]

Pairing

Where there were two or more nearby schools, one or more serving Negro or minority students, and one or more serving white students, pairing had been utilized to achieve a better racial mix. This method was first adopted in Princeton, New Jersey, and shortly thereafter in Willow Grove, Pennsylvania, and Benton Harbor, Michigan.[3] Pairing of schools was the nucleus of the court-ordered desegregation plan instituted in the Oklahoma City school system in 1968.[4]

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[1]Interview with J. F. Merrill, Director of Data Processing, April 3, 1970.

[2]Interview with Dr. Dougherty, Director of Research, April 3, 1970.

[3]Arnold Rose, The Negro in America (New York: Harper Torchbooks, 1964), pp. 215, 280-289.

[4]Daily Oklahoman, op. cit., p. 1.

The Minneapolis school system proposed the pairing of two elementary schools for 1971. One of the schools to be paired was mostly composed of Caucasian students while the other school in the projected pair had an enrollment of approximately 61 percent Negro. The objective in this case was to attain a more acceptable racial mix.[1]

Supplementary Centers

Part-time desegregation would be one outcome of supplementary centers, established to provide selected educational services to a portion of all of a district's students. Depending on the plan, a child might spend a part of each day, part of a day per week, or a few days a year at such a center.[2]

The Cleveland Public School System provided special educational programs for all the 14,000 sixth grade students from public and parochial schools in such a center. Each day about 400 students attended the center with racial balance maintained.[3]

The Cleveland Plan allowed each sixth grade student to spend one full day four times a year at the center. Educational experiences of a nature and depth not duplicated in

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[1]Interview with Dr. Williams, Deputy Superintendent, April 3, 1970.

[2]Howard W. Hickey, "Development of Criteria for Evaluating Alternative Patterns to Reduce School Desegregation in the Inner City," (unpublished Ph.D. dissertation in Educational Administration, Michigan State University, 1968), p. 68.

[3]*Ibid.*

individual schools were provided at the Supplementary Center.[1]

The "Area Program of Enrichment Exchange" (APEX) found in the Los Angeles public schools was an example of a supplementary center. The project essentially consisted of specialized subject field centers distributed among five senior high schools in West Area D of the Los Angeles district. An abbreviated version was offered to ninth graders in eight junior high schools in the same area. In each center a wide variety of courses was offered in that subject field. Many of these were available only in APEX centers; for example, anthropology, data processing, jazz workshops, mass media, writing, psychology and small animal care, to name a few.[2]

While participation in the APEX student exchange was voluntary the end result was that a significant amount of integration occurred as a result of having eight of the ten centers placed in predominantly Negro schools.[3]

Busing

Busing does not always constitute a separate alternative. School closings, changing attendance boundaries, as well as other suggested methods for obtaining a better racial

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[1]Interview with Dr. Tanner, Deputy Superintendent, October 9, 1969.

[2]Jean Gregg, "APEX: Quality Integrated Classes in Los Angeles High Schools," Integrated Education, Issue 36 (November-December, 1968), pp. 19-20.

[3]Ibid.

mix, quite frequently include an additional element of busing. Busing as related to desegregation plans usually had one of two identifying features. One identifying feature was the busing of students from school attendance area (A) to a receiving school (B) with no reciprocal busing of students from the receiving school (B) to the sending school (A). This was usually referred to as one-way busing in most desegregation plans and involved the busing of minority group students to predominantly Caucasian schools.

The second type busing was identified by a reciprocal busing arrangement whereby students were bused from school (A) to school (B) and from school (B) to school (A). Usually this implied that Caucasian students would be bused from white-majority schools to Negro-majority schools.

Berkeley, California, with a school district of approximately 16,000 students was the first school district of this size, containing a substantial minority population, to successfully use two-way busing on a comprehensive scale. Two-way busing was used to desegregate two junior high schools in 1964. In 1968 buses again rolled in both directions to carry some 3,500 elementary school children to new schools outside their traditional neighborhoods.[1]

Los Angeles, California, was under a superior court's

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[1]Thomas D. Wogaman, "Desegregation in Berkeley: Some Applicable Lessons," (unpublished paper, Berkeley, California, 1969).

order to integrate fully its approximately 600 schools by September, 1971. It was estimated that 240,000 children would need to be bused to meet the court requirement. Two-way busing appeared a necessity if the court order was to be implemented by 1971.[1]

Manual Means Frequently Employed to Develop Desegregation Plans

The data required for desegregation plans and the use of the data were two major considerations in the mechanical development of a desegregation plan. Perhaps the first and most comprehensive attempt to describe a step-by-step process for planning the complete physical desegregation of a school system was compiled by the U. S. Office of Education.

Following is a brief summary of the information the report suggested needed to be accumulated:

Student enrollments by school, grade, race
Staff assignments by school, position, race
Capacity, age, location and adequacy of all school facilities
Curricular and extracurricular offerings in each school
Demography and geography of the community
Distances between schools and between population centers
Transportation facilities available
Organization and current policies of the school district
Projected figures for student population over the next 5 years
Information on changing housing patterns.[2]

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[1]The Daily Oklahoman, February 15, 1970.

[2]U. S. Department of Health, Education, and Welfare, Office of Education, Planning Educational Change: Technical Aspects of Desegregation, Vol. 1 (Washington, D. C.: U. S. Government Printing Office, 1969), pp. 1-21.

Listed below, in part, are the working materials the report suggested the planners should have in their possession as they developed the desegregation plan.

1. Pupil location maps prepared by local school officials for each school.
2. School and school site maps.
3. Demographic smear map.
4. Transportation maps.
5. Acetate overlays sufficiently large to cover the maps being used.

Some idea, regarding the explicit instructions given the planners, can be gleaned from the following excerpt.

1. Plot the location of the students in the lowest grade of every school in the area. For example, if the school system is set up as 6-3-3, three pupil locator maps should be prepared. The first map would locate every student in the 1st grade, the second map would locate every student in the 7th grade, and the third map would locate every 10th grade student.

2. As a reference guide, the following symbols and colors will provide easy identification:

   White students--red dots
   Negro students--green dots
   Elementary schools--blue circles
   Intermediate schools--blue triangles
   High Schools--blue squares
   Zone lines--black

3. In most cases, it is advantageous to start with the elementary schools. Place a sheet of acetate overlay over the school locator map and mark all elementary schools on acetate with a blue circle. Either on the edge of the acetate or on a separate sheet of paper place the following information for each school:

   a. Name of school
   b. Date of construction

c. State rated capacity
d. Current enrollments
e. Number of portable classrooms, if any.

4. Using zoning and other techniques, establish on the acetate a plan for elementary schools which is educationally sound and administratively feasible.

5. Repeat steps for the intermediate schools.

6. Repeat steps for the high schools.[1]

Date Processing Techniques as Related to Desegregation

The literature described several attempts made by school districts to utilize some form of data processing in the development of school desegregation plans. At least two publications sponsored by the U. S. Office of Education dealt, on a hypothetical basis, with the application of electronic computer techniques to desegregation in school systems. The models outlined in the aforementioned publications are described in this review.

In most studies the standard transportation problem was the mathematical formulation employed when data processing was utilized to develop desegregation plans. When the school desegregation problem was placed in the context of a standard transportation problem, areas of student residents became sources, the schools became destination points, and each

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[1]*Ibid*., pp. 1-4.

ethnic group became a commodity.[1] The term, areas of student residents, as used in the standard transportation formulation implied a problem need to deal with groups of students rather than with individual students. Frequently the U. S. Census block was used as the primary geographic base for grouping students. Technically it would be more correct to speak of grouping addresses rather than students.

Once the desegregation problem was formulated as a standard transportation problem, the computer, through the use of a linear programming procedure was given the task of assigning students to schools to attain a given ethnic mix by the most desirable means possible.

Clarke and Surkis were among the first researchers to formulate the school desegregation problem in the context of a standard transportation problem where the areas of student residences were sources, the schools were destination points, and each ethnic group was a commodity. Cost was computed on the basis of the amount of time it took to transport students from each tract to each school.[2]

Brooklyn was chosen as a test case for the system developed by Clarke and Surkis because of its extreme

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[1]Stephen H. Clarke and Julian Surkis, "Application of Electronic Computer Techniques to Racial Integration in in School Systems," Report Resume No. ED 018526, Department of Health, Education and Welfare, Office of Education, and Welfare, Office of Education, Bureau of Research, November, 1967.

[2]*Ibid.*, p. 5.

residential segregation. Census tracts were used as the geographic unit of student ethnic distribution. The Brooklyn problem proved difficult to solve mainly because of its size and no final output was ready at the time of this publication.[1]

A study was made by Fulkerson, et. al.[2] in Los Angeles as part of a proposal to alleviate overcrowding and de facto segregation in elementary schools. This was done by means of free and voluntary bus transportation of children from overcrowded schools to schools in other parts of the city with unused classroom space. A "network flow" procedure was used for the assignment of students from overcrowded schools to schools with unused classrooms.

O'Brien and Lyle[1] in 1968 developed and described an urban education model. The central orientation of the model was to plan the location and enrollment size of elementary and secondary school plants. Four sub-models comprised the urban education model. One sub-model, termed the urban sub-model, determined attendance area boundaries by assigning pupils to schools so as to achieve given objectives. A school sub-model estimated space and staff requirements per school. A cost sub-model estimated the cost implications

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[1] Ibid., p. 25.

[2] "A Transportation Program for Filling Idle Classrooms in Los Angeles," R nd Report P-3405, July, 1966, "cited by" Stevens H. Clarke and Julian Surkis, "Applications of Electronic Computer Techniques to Racial Integration in School Systems," Report Resume No. ED 018516 of U. S. Department of Health, Education and Welfare, Office of Education, Bureau of Research, December, 1968, p. 27.

of attendance area boundary changes. An effectiveness submodel made possible predictions of student achievement for schools newly formed through combining computer selected groups (blocks) of students.[1]

O'Brien and Lyle succinctly established the limitation of the model:

> . . . the model does not yield a "solution." It provides an array of measures which, hopefully, is meaningful to the school administrator and upon which a decision may be based.[2]

In another series published on the urban education model, O'Brien presented a model for determining required school attendance areas when restrictions had been placed on the racial and/or social composition of each school plant.[3]

The model defined the location of the students by geographical units such as census tracts and in its application to the school systems level, the model served as an evaluation technique in the location of school plants.[4]

O'Brien suggested the model may give answers to the following questions:

> What size schools are required to achieve given and/or social composition levels?
> What geographical units and governmental units are required to cooperate in such planning?

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[1] *Ibid.*, pp. 2-4. [2] *ibid.*, p. 7.

[3] Richard J. O'Brien, "A Model for the Determination of School Attendance Areas under Specified Objectives and Constraints," *Report Resume No. ED 018859, U. S. Department of Health, Education and Welfare, Office of Education*, January, 1968, pp. 1-7.

[4] *Ibid.*, pp. 1.

What resource use in terms of student travel, time or travel cost is required to achieve given social or racial compositions?
What are the trade-offs or exchange rates between student travel time or cost or distance and racial or social composition?
What is the assignment of students to schools, under stated constraints on the composition of the school attendance areas, that will result in minimum student travel time or cost or distance?[1]

Levy[2] described the application of a model based on the standard transportation problem formulation, to the Boston elementary schools.

Levy encountered several difficulties in the application of his model to the Boston elementary schools. Computational difficulties occurred as a result of the problem's size--it was too large to be stored in the computer's memory. A solution was found through the utilization of a combined standard transportation procedure and a decomposition procedure. In practice the problem was made manageable by solving a series of transportation problems each based on the same children, neighborhoods and schools but each with a different set of costs. In this way each problem was solved to minimize the total cost of assignment without regard to racial consideration.[3]

Levy found the major difficulty in any school

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[1]Ibid., p. 2.

[2]Frank Levy, "The Racial Imbalance Act of Massachusetts," (unpublished Ph.D. dissertation for Department of Economics, Yale University, 1969), pp. 175-190.

[3]Ibid., pp. 178-183.

redistricting project was the assembling of a data base. His comments in this regard are noteworthy.

> . . . most school systems have had no need to analyze large amounts of residential information, and so much information is usually highly decentralized. Most often, children's addresses are only available on their permanent record cards which are kept in the individual school offices. . . . In Boston, maps existed showing the outline of elementary school districts (each district contained an average of three elementary schools), but school attendance zones within each district had to be obtained from individual principals. . . the best that could be done was to find attendance (by race) of each school, the boundaries of its attendance zone, and use assumptions of a uniform population distribution within the zone. Even in this case the building of an adequate data base was long and tedious.[1]

Two other problems had a significant bearing on the results derived through the application of the model to the objective of desegregating the Boston elementary schools. One problem arose as the result of imposing too rigid constraints such as the requirement that all students should be assigned to schools within walking distance and secondly that all school districts should have reasonable shapes. Levy reasoned that the value of the model, in assisting school administrators to determine objective decisions, was curtailed to the degree that alternative solutions were limited.[2]

Finally Levy suggested that the model did not

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[1] Ibid., pp. 185-186.

[2] Ibid., p. 189.

adequately represent the school administrator's problem.

> The model redistricts under a set of constraints so as to maximize the compactness of the resulting districts. The school administrator is maximizing a much more complex function, which involves compactness, bad street crossings, utilization and under-utilization of particular school buildings, and a number of other individual problems which cannot be easily expressed in a simple linear programming problem objective function.[1]

Heckman and Taylor[2] defined a standard transportation problem approach for establishing attendance boundaries to obtain a racial mix. They discussed technical aspects of their approach, such as problem formulation, alternative constraint possibilities, techniques to avoid splitting neighborhoods, and improvement of speed execution.

Some of the major points emphasized in the Heckman-Taylor study were summarized as follows:

1. It is crucial that the approach used allows for the computation of optimal solutions under a variety of racial balance assumptions so that one can examine the trade off between integration achieved and the cost of doing so.

2. In the early stages of examining alternatives it is probably more practical to attain rough approximations than to strive for more definite options.

3. Reasonable computer run times were obtained by subdividing the entire city into smaller sub-cities.

4. In subdividing the city, certain rules were followed, among them: (a) divide along

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[1]Ibid., p. 189.

[2]Leila B. Heckman and Howard M. Taylor, "School Rezoning to Achieve R cial Balance: A Linear Programming Approach," Journal of Socio-Economic Planning Sciences (Great Britain: Pergmon Press, 1969), pp. 127-133.

> geographical barriers whenever possible; (b) have each sub-city contain about the same fraction of Negroes as the city as a whole; (c) have other minority populations reasonably distributed among the sub-cities; and (d) have the school capacity in each sub-city greater than the number of children in that sub-city.[1]

Heckman and Taylor concluded with the statement--"our overall belief is that linear programming may make a contribution to the problem of school redistricting to achieve racial balance."[2]

A procedure developed by Weaver and Hess,[3] utilizing computer techniques to apportion and district political units, appeared to have some relevancy to the problem being explored in this study. They suggested a "mechanical formula" and pre-determined general principles to limit discretion as absolute requirements for dealing with highly sensitive, political issues such as judicial apportionment and districting.[4]

Weaver and Hess identified compactness as a potential principle which, when combined with contiguity and equal population, could produce a non-discretionary districting procedure. They defined compactness "as a measure of population as well as geographic concentration." They suggested that by using

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[1] _Ibid._, pp. 131-133. [2] _ibid._, p. 133.

[3] James B. Weaver and Sidney W. Hess, "A Procedure for Non-Partisan Districting: Development of Computer Techniques," _Yale Law Journal_, LXXIII (1963), pp. 288-308.

[4] _Ibid._, p. 290.

their compactness formula districts of maximum compactness could be located around centers of population, whereas under prior definitions, "compact" districts often divided population centers.[1]

Weaver and Hess basically used standard transportation problem formulation, with modification, to determine compactness and suggested its applicability to other problems such as school districting.[2]

Several additional attempts have been made by medium and large-sized school districts to apply the technology explored above to the problem of redrawing school attendance boundaries for purposes of achieving a better racial mix within schools of the district.

One of the first school districts in the United States to apply computer technology to the problem f reestablishing attendance boundaries, which subsequently became the basis for a desegregation plan, was the school district of Evanston, Illinois. The Evanston public school district had a student population of approximately 16,000 students of whom about 21 percent were Negro. The school district had a land area of 8.75 square miles abutting the northern edge of Chicago.[3]

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[1] Ibid., p. 292.

[2] Ibid., p. 308.

[3] Ernest H. Wakefield, "The Computer Helps Desegregate School," (Report by the president of the board of education).

The program developed for the Evanston school board was based on solving the standard transportation problem. In order to make the program more useful some modifications were made in the transportation procedure and the following constraints were applied.

1. School capacity was considered to be the number of classrooms multiplied by 27.

2. The walking distance to school was not to be more than one mile for any child.

3. The number of Negro children in each school was to be no more than 25 percent.[1]

The raw data supplied to the computer was gathered by the neighborhood school principals who listed the school, grade, sex, race, birthdate, and location by city block, of each child. This pupil data then was keyed to the geographic block locations and transferred, with school capacity and location data, to a computer file suitable for generating TV-style displays on IITRI--Illinois Institute of Technology Research Institute--developed computer system. The data from the 731 Evanston city blocks was then condensed into 170 areas averaging four blocks per area. This decrease was necessitated by the limited data storage capacity of the computer associated with IITRI's "Electrosketch" system.[2]

A very unique feature of the Evanston model was the use of the "Electrosketch," an IITRI developed device, which

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[1] Ibid., p. 4.

[2] Ibid.

allowed an operator to draw lines, circles, arcs, and arbitrary contours such as map boundaries. These were stored in the computer's memory and displayed immediately on an oscilloscope--a device which displayed in graphic form the results.

Liveright concluded with the statement "The success of the Evanston project suggests that similar computer techniques could be used in many other areas."[1]

The New Haven, Connecticut public school system contracted with the General Learning Corporation of New York to redistrict the three New Haven high schools in 1967. The three high schools had a combined enrollment of approximately 5,300 students of which approximately 2,000 were Negro. The percent of Negro students in each school prior to the study ranged from 51 percent in one school to 32 percent in another.[2]

The following priorities of objectives were established by the board:

1. Load balance
2. Racial balance
3. Comprehensive balance
4. Minimize number of students affected.
5. Minimize decontiguities of boundaries.
6. Consider alternative ways of phasing into new districts.[3]

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[1]Mike Liveright, "Computers Aid School Redistricting," Spectra, III, Research Institute, 1967.

[2]The New Haven Register, March 19, 1968.

[3]Final Report to the New Haven Public School Board by the General Learning Corporation on the School Redistricting Project. March 8, 1968, p. 2.

The address, grade, race, and school of each student in grades 5 through 11, along with the curriculum for students in grades 10 and 11, was punched on Hollerith cards by the students of one of the high school classes. Student addresses were later matched with a dictionary containing census tracts/blocks and x y coordinates. The standard transportation problem was used in the New Haven study to determine a "best" solution to the problem.[1]

A unique feature of the model developed by the General Learning Corporation was the Man-Computer System which was used to evaluate the effects of changing from one district to another. The Man/Computer System provided an instantaneous feedback to requests for the following actions from the computer:

1. Evaluate your alternative
2. Forecast the high school population for an area.
3. Tell you which school the areas are assigned to.
4. Change the school assignment of area.
5. Change the forecasted high school population of an area.[2]

Five alternative plans were presented to the board all of which improved loading and racial imbalance and at the same time reduced the average distance of students from their schools. All in all the New Haven school board requested and received seven plan modifications before finally arriving at a decision for plan adoption.[3]

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[1] Ibid., pp. 80-85. [2] ibid., p. 86.

[3] Ibid., p. ii.

Probably the most comprehensive study completed to date on school redistricting utilizing computer technique was the study done for the San Francisco Unified School District by the Science Research Institute of Menlo Park, California. In September, 1966, the San Francisco Unified School District contracted with the Stanford Research Institute to study alternative means by which racial balance in San Francisco's public schools might be improved.[1]

The objectives of the study were that the Institute develop and evaluate several alternative patterns of pupil attendance which would result in a racial composition of individual schools more nearly reflecting the districtwide racial distribution. Also the educational implications, feasibility, and cost-effectiveness of each alternative were to be evaluated.[2]

The San Francisco Unified School District was composed of approximately 89,000 students in 1966. The city had a high residential concentration of minority groups. Unlike many cities it had a large population of orientals and "Spanish surnames" in addition to the white and Negro ethnic groups.[3]

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[1]William J. Platt and Robert A. Harker, "Improving Racial Balance in the San Francisco Public Schools," Research Memorandum No. 8--Summary Report, Stanford Research Institute, Menlo Park, California (May, 1967), p. ii.

[2]*Ibid.*, p. ii.

[3]*Ibid.*, p. 4.

The science Research Institute formulated the problem as a standard transportation problem similar to those reported in other like studies in this review. Twelve computer programs were developed or used in the total model.[1]

Programs 3, 11, and 12 were unique to this particular model and merit a brief description.

Program 3 matched street names and addresses in the class list file with street names and addresses in a master San Francisco street index tape. This program was developed by the Bay Area Transportation Study Commission (BATS) and was incorporated without modification into the San Francisco Unified School District System.[2]

Program 11 was developed to measure the magnitude of the deviations of the racial percentages in the individual schools about the city-wide averages. In effect, this program permitted an analyst to measure changes in racial balance resulting from implementation of a pupil assignment plan.[3]

Program 12 was developed for the purpose of forecasting student populations. The program contained two options that allowed the user to incorporate known or anticipated changes

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[1]Benjamin Lefkowitz, "Computer Programs to Help Analyze Pupil Assignment Plans," Working Paper No. 1, Prepared for San Francisco Unified School District (Menlo Park, Calif.: Stanford Research Institute, March, 1967), p. iii.

[2]Ibid., p. 10.

[3]Ibid., p. iv.

into the forecast, i.e., new housing additions or the removal of houses in a slum clearance project. The second option permitted the program user to substitute an average annual change for a computer annual change, i.e., where changes in a tract's ethnic composition in one time period differed markedly from a projected time period.[1]

A total of twelve alternative plans were developed for the San Francisco Unified School District. The methods suggested for redistricting and reassigning students in the twelve plans included changing attendance boundaries, one-way busing, two-way busing, reorganization of grade patterns, pairing, closing schools and building and enlarging schools. Not all the methods were included in any one plan.[2]

Three alternatives were selected by the Board for further study. Jenkins reported:

> . . . it is the consensus of the staff that none of the options provides a single, comprehensive solution to the problem of imbalance in San Francisco schools . . . Each of the series B, C, and D, however, offers an approach that merits further consideration.[3]

The Charlotte-Mechlenburg School System in North Carolina used computer techniques to restructure attendance

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[1]*Ibid.*, pp. iv-v.

[2]Robert E. Jenkins, "Report No. 1--Program Alternatives," Report submitted to Board of Education of San Francisco Unified School District, December, 1967, pp. 14-15.

[3]*Ibid.*, p. 21.

lines for purposes of achieving a better racial mix throughout the school system. This system had a student population of 83,000 students and was ranked 43rd in size among school administrative units throughout the United States. It covered an area of 550 square miles.[1]

In 1969 the school system contracted with System Associates, Inc., of Charlotte, North Carolina in an attempt to desegregate all schools in the system using only the technique of "attendance line restructuring" to the ratio of 70 percent white, 30 percent black or as near that ratio as possible. Systems Associates, Inc. was requested to preserve compact, contigous "neighborhood" school attendance areas wherever possible.[2]

Grids approximately 2,500 feet square were used as the geographic base. Student population data for each grid was provided by the school. Other data indicated the capacity, location, and present student body population for each of the 104 schools in the system.[3]

A set of three computer programs was written to determine which schools could be desegregated. In order for a

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[1]"Background Information on the Charlotte-Mecklenburg School System, Charlotte, North Carolina" (mimeographed copy available from the school).

[2]Section I, Exhibit VIII of report by Systems Associates, Inc., Charlotte, North Carolina, p. 1.

[3]Ibid., pp. 1-2.

combination of "grids" to be considered acceptable they had to

1. Contain only grids contiguous to one another on at least one full side.
2. Contain only grids contiguous to one another and at least one had to be contiguous on the full side to the grid in which the school was located.
3. Not contain the "home grid" of another school.[1]

The restructuring of attendance lines was 90 percent effective with regard to the total number of schools. Ten of the 104 schools remained predominantly Negro under the method described.[2]

"Suitable field-tested techniques that can be used by all types of school systems in their effort to achieve a unitary nonracial system" was the stated goal of a computerized desegregation model being developed and tested at Florida State University.[3] The project was co-sponsored by the Florida State Department of Education, the Florida School Desegregation Center, and the Orange County School System. It was financed through a $125,000 grant from the U. S. Office of Education.

The model was being developed for the Orange County, Florida School System. The school district was 35 miles long and 35 miles wide and had a student population of 82,000, of

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[1] Ibid., p. 3.

[2] Letter from John W. Weil, Vice-President, Systems Associates, Inc., Charlotte, North Carolina, March 17, 1970.

[3] Peter Phlaum, "Description of Orange County Project," (Report presented to Conference on Computer Applications to Desegregation, Tallahassee, Florida, November 5, 1969).

which 18 percent were Negro.[1]

One feature of the Orange County model, which differed somewhat from the other models reviewed, was the method by which students from several census block areas were assembled to a point (node) on a transportation artery.[2] It was hoped that such aggregation would facilitate the development of a transportation system. The project had not been completed at the date of this writing.

Summary

The review of the literature revealed the more prevalent methods being used to desegregate schools.

The inappropriateness of manual methods for developing desegregation plans for large urban school systems was underscored through an examination of the manual procedures outlined by HEW.

A review of past and current efforts to apply computer technology to the problem of school desegregation revealed considerable progress in the technical aspects of the problem.

Four of the studies reviewed were developed using hypothetical situations and consequently did not concern themselves with a more important aspect of the problem--data collection and preparation.

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[1]Joe Hall, "Background Information," (Report presented to the Conference on Computer Applications to Desegregation, Tallahassee, Florida, November 5, 1969).

[2]Phlaum, op. cit.

Two of the studies were limited in applicability to the problem as a result of the constraints placed on the model formulation by the school systems. Both the Evanston, Illinois, model and the New Haven, Connecticut, model had some interesting features but were deficient in the exploration of problems that may have been associated with data collection and preparation. The Evanston model used a much larger geographical aggregation base because of computer limitations, while the New Haven model was able to capitalize on prior census use studies done in New Haven.

The San Francisco model, although quite comprehensive, did not deal with the problem of data collection and preparation to a significant degree. Furthermore, the study was facilitated by the availability of the geographic base program developed by the Bay Area Transportation Study Commission--a benefit not currently shared by many school districts.

The Orange County model promised to be comprehensive but had not been completed at the date of this writing.

Perhaps most significant for this study was the fact that relatively strong emphasis had been placed on programs and mathematical formulations in most of the models. The line of communication generally was with the computer technician rather than the educator.

CHAPTER III

DEVELOPMENT OF THE MODEL

Introduction

Several attempts with the manual manipulation of student data in the development of effective school desegregation plans for medium-sized school districts provided sufficient motivation to seek more practical and efficient methods to accomplish this difficult task. To physically manipulate large amounts of data in the development of alternative plans for desegregation is tremendously time consuming and it is relatively impossible to determine the degree to which each alternative is an optimal solution.

Experience further indicated that what was needed was a methodology and system which would enable the school administrator and school board to readily generate many alternatives to the mechanical (physical) aspects of school desegregation in an urban school. Having generated the alternatives the system should provide a ready means for plan evaluation and modification.

Although other models of this nature have been developed, as indicated in the review of the literature, their basic orientation has tended to be on a hypothetical plane or one of heavy emphasis on the mathematical formulation of the problem. The language in most of the studies reviewed tended to be that of the operations research specialist or the computer technician rather than that of the educator. Few, if any, studies had explored the application of data processing techniques to the problem of school desegregation from the point of view of the school administrator. None had clearly emphasized the practicing educator's role in the gathering, recording, and processing of student information for data processing purposes. Neither had the studies thoroughly explored the problems and advantages of grouping together all the individual addresses of a grid or block so as to form a unit of addresses (geographic base). In most cases the computer model was tested under rather rigid constraints and according to predetermined objectives. Several of the researchers suggested that such conditions tended to limit the value of the computer model when applied to the problem of school desegregation. What is needed, they suggested, is a methodology, flexibility, rough approximations, along with many choices. Then and only then, they concluded, could the real value of the model be attained through the iterative process. Finally, none of the studies contained a review of the other studies to a significant degree.

As a consequence, the decision was made to develop and test a working model to apply computer technology to the school desegregation problem and to describe the model in non-technical terms. The aim was to develop a computer model which would devise alternative suggestions for school attendance units and student assignment and which would also incorporate some of the characteristics to be described in this chapter.

An urban school, forty-sixth in student body size nationally, was selected as the real life entity on which the model could be developed and tested. (X) school district had a student body of approximately 75,000 students of which 22 percent were Negro. Representation of other minority groups in the school was minimal and this factor was not considered separately in the problem. (X) school had a geographical area of 185 square miles and was surrounded by other school districts which were part of the total metropolitan area and predominantly Caucasian in student composition.

A significant and difficult feature of (X) school was its extreme residential segregation. The large Negro community was circumscribed on three sides by other than (X) school districts. See Appendix A. The only other Negro residential area of significant size was located in a section of the school district which was not contiguous with the larger school district.

The decision was made to limit the study to the eight contiguous senior high schools which constituted the larger attendance area of (X) school system. The combined student enrollment for the eight schools was approximately 14,100 students. The ethnic composition of the student body was 2,218 Negro and 11,882 Caucasian or other students. One 10-12 senior high school was predominantly Negro in student population while another had a Negro population of approximately 50 percent. The organizational structure of six of the eight high schools was grades 10-12. The other two high schools had an organizational structure of grades 9-12.

The capacity for each attendance unit was calculated from a base of twenty-eight students per teaching post. In those cases where the space in special learning areas such as shop and science deviated from the average space per student in all the high schools, a correction figure was multiplied times the base of twenty-eight students per teaching post. As a result the number of students assigned per teaching post varied from twenty-six in some attendance areas to thirty in other attendance areas. Using the formula described above the combined student capacity for the eight senior high schools was 15,458.

With the exception of one predominantly Negro junior high school and a predominantly Negro junior-senior high school the physical plant of the entire system was considered satisfactory. The one predominantly Negro junior high school was located in an Urban Renewal area and was scheduled to be closed for the beginning of the 1970-71 school year.

General Model Description

The computerized model for desegregation of this study was previously defined as the sum of all the essential procedures required to obtain the desired computer output. Four distinct phases were deployed in the development of the model. Each phase is first briefly identified and then subsequently more fully described. A schematic diagram of the model is presented in Appendix B.

Phase 1. Data Collection and Preparation--This phase was concerned with the gathering and verification of the data to be utilized in the problem. The desired end result was a master file containing all pupil/block information and all school plant information necessary to solve the problem. See Appendix C.

Phase 2. Problem Data Preparation--This phase was concerned with selection of the proper data needed for any desegregation alternative based on the conditions submitted in the request to the computer. See Appendix D.

Phase 3. Problem Solution--This phase was concerned with the actual mechanics of solving the given problem.

Phase 4. Problem Solution Preparation--This phase was concerned with the communication of the problem solution to the system user. See Appendix E.

Data Collection

Once the model objectives were formulated and the desired characteristics outlined the next priority was the collection of data. Undoubtedly, the establishment of a data base, which was in a logical, useable format for computer purposes, was the most fundamental aspect of the model development.

An analysis of predetermined goals and objectives for the model, along with a survey of desired characteristics revealed the need for the following data:

1. A list, by grade and race and school currently attending, of all students, grades 8 through 11.

2. The addresses of all students in grades 8 through 11.

3. The location and enrollment capacity of all senior high schools along with the one junior-senior high school.

4. The capacity of other school facilities, if any, that could possibly be used as a junior or senior high school.

5. The physical condition of the facilities under consideration.

6. A list of secondary school facilities currently under construction or being planned for immediate construction.

7. A list of schools where immediate changes in organizational patterns or remodeling were contemplated.

8. A summary of acquired sites for future school construction.

9. The number and current location of portable classrooms.

10. School maps showing secondary school locations and attendance areas.

11. A map or grid system which divided the school district into small units or areas along with the information needed to geographically define each unit or area.

12. A measuring device or means to indicate relative distances between each small area (census block) and each school.

Student information such as grade, race, and address by school was collected by school (X) through normal enrollment channels and was available in computerized form from the school's Data Processing Center. The enrollment capacities of all the schools in (X) system along with their physical condition was made available from the Director of Buildings and Grounds. Also available from the same source was the number and location of portable classrooms throughout the system as well as information regarding current or porposed construction and acquired school sites. School maps showing the location and attendance areas of all the schools was obtained from the Office of the Assistant Superintendent in Charge of Instruction.

It should be noted at this point that although information was collected regarding acquired building sites and long-range building proposals this data was not considered essential to the initial development of the model unless it was to be achieved immediately.

The collection of data relating to geographical units and measurements of relative distances (items 11 and 12) posed a much more complex problem than did the collection of school related data. Problem number one was the matter of a decision regarding the basic unit or area to which individual students and/or residences would be grouped (aggregated). In the standard transportation problem formulation used in this study it was relatively impossible to consider each student and/or address separately. To have done so, for instance, would have meant measuring the distances of each separate address to all the junior and senior high schools under consideration. This, in turn, would have necessitated computing only small sections of the total problem at one time as the available computer could not have handled all the data under those circumstances.

In making the decision regarding the geographical unit (base) to be used to group students and/or addresses together, some initial consideration was given to using a grid system developed by the Association of Central Oklahoma Governments. In this arrangement the entire metropolitan area was divided into ten acre squares or grids. It became readily apparent that the big drawback with ten acre squares was their lack of conformity to existing street patterns. This had the obvious disadvantage of creating unnatural lines of demarcation. Further, the grid pattern did not lend itself to the production of maps easily recognizable with current street maps should mapping be required.

Two other alternatives were explored as a basis for arriving at a decision regarding the nature of the geographic base that would be used in the model. One alternative considered was the possibility of developing a geographic base which was unrelated to any past efforts or designs. This alternative was rejected on the basis that it was untimely and too costly.

The alternative which was finally agreed upon was the U. S. Census tract/block. A census block was a geographic unit designated by the U. S. Census Bureau for purposes of collecting and defining census data. The census block was generally coterminous with city blocks meaning of course that the block boundaries were mostly determined by streets or other natural boundaries. The census tract represented a larger unit to which several blocks were aggregated.

The census block/tract was selected as the basic unit or geographic base to which students would be aggregated for reasons which appeared sound at the time the decision was made.

Some of the reasons for the selection of the census tract/block as the geographical base to which individual students would be aggregated were:

1. Census blocks were small enough that they did not constitute too large an aggregation of students. On the

other hand, to be much smaller would create problems similar to those discussed if individual addresses were to be used.

2. Census blocks were usually surrounded by streets or other natural boundaries. This permitted ease of identification on maps.

3. The census tract/block, which the Census Bureau used as a basic unit for collecting and defining census data, suggested numerous possibilities for enriching the data base of the model being developed if the same units were used as geographic bases in the model.

4. Each block and tract was identified by a number.

5. Perhaps the most important feature of the census tract/block was the address coding guide developed by the U. S. Bureau of the Census. The address coding guide is a listing of block faces, which are, as the name suggests, sides or "faces" of blocks. The range of addresses for each block face is given in the guide. A block face record in the address coding guide contains the following information:[1]

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[1]Donald F. Cooke and William H. Maxfield, "The Development of a Geographic Base File and Its Uses for Mapping," Papers from the Fifth Annual Conference of the Urban and Regional Information Systems Association (Kent State University Publication: Urban and Regional Information Systems, 1967), pp. 207-218.

SAMPLE OF A BLOCK FACE RECORD IN ADDRESS CODING GUIDE

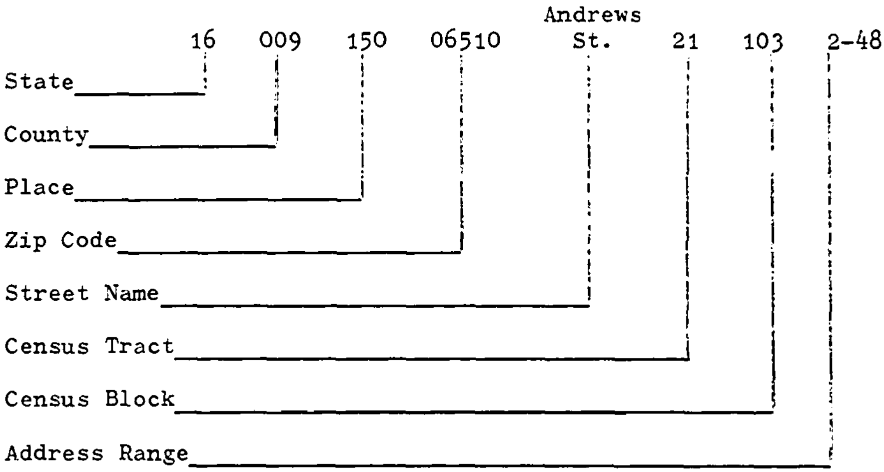

Figure 1.

An address coding guide for the total Standard Metropolitan Statistical Area (SMSA) which included the area occupied by (X) school district along with other adjoining areas was obtained from the U. S. Bureau of Census, in microfilm form for the sum of $80.00.

Maps of Census tract/blocks for the (X) school district were obtained from the Association of Central Oklahoma Governments. These maps contained census tract/blocks for the entire metropolitan area. The maps that were available at the time the project started were larger maps than the census block maps published by the Census Bureau. The problems this posed will be discussed later in this study.

A system of measurements (x y coordinates) was not included in the Address Coding Guide. The method by which this was accomplished will be discussed under the section entitled Data Preparation.

Data Preparation for Computer

As suggested previously, the address coding guide obtained from the U. S. Bureau of the Census contained information for the entire metropolitan area. Consequently, the first step in data preparation was the identification of those census blocks contained in (X) school district only. The necessary information was then keypunched from the address coding guide and put in standard form for computer use.

After the information from the address coding guide was standardized and put in machine readable form a program was developed to match student information to the proper tract/block. Developing a program to match addresses to census blocks was necessary in this project as the ADMATCH program was not completed at that time. ADMATCH is a program recently completed by the Census Bureau that matches records geographically identified by street address to a geographic base file such as a census block.[1]

When an attempt was made to match the student data with the tract/blocks it was found that many addresses did not match with a block. This necessitated the editing of the data from both the student information file and the address coding guide to determine the cause for no match and/or mismatch. After several editing attempts a computer tape was developed which contained tract and block identification along with the name, grade and race of all students located in a particular block.

The reason for matching students to blocks and consequently considering the assignments of blocks rather than individual assignments of students was discussed earlier in this chapter. However, one of the reasons given for grouping students to the block level was the necessity to establish measurements from each point, be it a block or an individual address. The task of measuring distances on maps and establishing x y coordinates is usually accomplished with the aid of a machine called a digitizer. Unfortunately, in this project a large enough digitizer was not available for use with the maps containing the census blocks. This necessitated a time-consuming hand measurement of all the distances from block centers and schools to the reference point. A state planemetric map provided a reference point so that x and y coordinates could be recorded for each block center and school. The adding of x and y coordinates for each block center and school provided the information the computer needed to compute distances between tract blocks and schools, as well as the distances from school to school.

The last step in the phase of data preparation under discussion here was the development of a computer program to assign blocks to schools according to the school attendance area in which the blocks were located. In essence this

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[1]For more complete information on ADMATCH see Heidi Cockran, "Accress Matching," Papers from the Sixth Annual Conference of the Urban and Regional Systems Association (Kent State University Publication: Urban and Regional Information Systems, 1968), pp. 67-72.

program merely assigned students to schools they were currently attending by blocks rather than by individual address.

Problem Data Preparation

In the statement of the objectives of the system it was stated that flexibility was desired so that assignments could be made by single grade or groups of grades. Flexibility was also desired so that the problem could be attacked using the entire school district or any part of the school district.

Flexibility was attained through the use of the GIPSY System which provided for the computerized selection of areas, grade or grades to be utilized in any given problem. The GIPSY Retrieval System thus eliminated the necessity to write a specific program to accomplish each selection of objectives.[1]

Another way in which flexibility was attained was by dividing the input into the system into several separate components. Separate components (files) were developed for each race. Each race component had two sub-components (files). One sub-component contained student information while the other contained the identification and enrollment capacity for each of the schools available for scheduling.

Problem Solution

The standard transportation procedure was the basic

[1]For additional information regarding GIPSY see: University of Oklahoma, Information Science Series, Monographs II and IV.

mathematical formulation used in the solution of this problem. In the original standard transportation problem the planner was concerned with the allocation of homogeneous goods from warehouses (supply points) to stores (demand points). He (the planner) was faced with a given number of warehouses, each of which had a stock of goods for distribution to a given number of stores. The goal was to draw a shipping schedule which would fill all demands at the stores with goods from the warehouses at a minimum overall cost. Cost was considered to be the distance traveled which was converted to a dollar and cents value.[1]

In the model described in this study the standard transportation formulation described above was applied to the school assignment and redistricting problem. The goods to be shipped (either by walking or busing) were children. The warehouses were replaced by neighborhoods each with some number of student residents. (Throughout this study a neighborhood was considered the number of students of a given age or grade living within a given census block area.) The stores were replaced by schools each with some capacity (demand) The cost was interpreted as the distance from any neighborhood to any school.[2]

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[1]Levy, op. cit., p. 176.

[2]This programming interpretation is derived from the work of James Weaver and Sidney Hess, "A Procedure for Non-Partisan Districting: Development of Computer Techniques," Yale Law Journal, LXXIII (1968), 288-308.

To simplify the explanation, a single race--the Negro race--and a single grade--the fifth grade was considered.

For each school two numbers were known: (1) The present number of Negro fifth graders, (2) The desired number, or quota, of Negro fifth graders. Using the standard transportation formulation the computer initially fills the school's quota of Negro fifth graders from the blocks (neighborhoods) nearest that school because such assignments require little or no transportation. After completing the assignments of all Negro fifth graders who live near a school, each school will have a net surplus of Negro fifth graders if many of that grade and race live near the school--a deficit of Negro fifth graders if few of that grade and race live near the school. The problem then is to assign the surplus Negro fifth graders to other schools having a deficit of Negro students so as to:

1. Exactly utilize all net surpluses
2. Exactly fill all net deficits
3. Do this at the least transportation costs which is measured in pupil-miles.[1]

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[1]This programming interpretation is derived in large measure from the work of Benjamin Lefkowitz, Working Paper No. 1: "Computer Programs to Help Analyze Pupil Assignment Plans," in a report prepared for the San Francisco Unified School District, March, 1967.

To compute pupil-miles the computer must know the distance between all blocks (neighborhoods) and schools and between all schools involved in student transfers. To develop this data x-y coordinates were assigned to each block center. A state planemetric map was used as the reference point for the x-y coordinates.

Problem Solution Preparation

This final phase of the system was concerned with the output--display of the problem solution and attendant information to the system user. The results or solutions to the problem were designed to provide the following data:

1. A list of tract/blocks assigned to each school.

2. The enrollment, present and past, for each school.

3. The percent capacity assigned as a result of the problem.

4. The number of miles in the district requiring busing times the number of students attending the school.

5. The number of busing miles required.

6. The cost of busing per school.

7. The ethnic composition of each school on a percentage basis as a result of the new assignment.

Specific Model Objectives

Primarily what was desired of the model was an automated method of selecting neighborhoods (blocks) of students for assignment to a given school to attain a prescribed racial mix. In addition it was desired that the computer would make the necessary assignments in the most optimal way possible. Optimal implies an ability to take the needed students from the closest available surpluses and to use the least total distance possible to accomplish the task.

It was further desired that the computer should provide the user, in a minimum time, the plan alternatives in a form both readable and subject to interpretation without decoding.

Information Desired of Computer

1. A list of blocks assigned to each school.

2. The name of the school from which the blocks were taken.

3. The enrollment by grade before and after the change, for each school.

4. The percent of the capacity being utilized in each school as a result of the assignment.

5. The total number of miles students will be bused.

6. The cost of busing per school.

7. The ethnic composition of each school on a percentage basis as a result of the new assignment.

Characteristics and Qualities Desired in Model

One of the aims for the model was that it have characteristics and qualities which could add to both its performance and applicability. The four characteristics decided upon were:

1. Flexibility--Determined by the ability of the model to provide different alternatives without necessitating extreme modifications. More specifically, it was desired that it have flexibility to:

a. Make assignments on both an individual and/or a grade grouping basis.

b. Redistrict or realign attendance unit boundaries of individual schools and retain their grade structure or redistrict and change their grade structure; e.g., make certain schools 7-8, others 9-12.

c. Designate likely sites for new school locations.

2. Responsiveness was determined by the ability of the model to respond quickly, and with little modification, to a new set of conditions presented by the planner. The degree to which the model possessed this characteristic was determined by the amount of time it took the model to respond to a different set of conditions.

3. Adaptability was determined by the potential of

the model to provide information other than that related to changing boundary lines. More specifically, the quality of adaptability was judged on the basis of the ease with which other data such as academic or socio-economic data could be added to the existing data to gain additional insights into the school.

4. Reliability was determined by the degree to which the model performed as expected and exhibited the desired characteristics.

Input Data

It was considered essential that the input data should be correct, complete and manageable. The correctness of the input data was determined by the degree to which the data was free of errors. The completeness of the input was determined by the presence or absence of essential informational details as well as by the ready availability of the data. The degree to which the data was manageable was determined by form, standardization and legibility.

Output Data

Clarity and completeness were the two qualities desired in the output data. Clarity was determined by the degree with which the output could readily be interpreted and understood without an intermediate step of decoding. The degree to which the data was complete was determined by the presence or absence of the desired information as outlined under specific model objectives.

Suggested Criteria for Evaluating Alternative Plans

The evaluation of alternatives as perceived in this study is the evaluation which relates to the weighing of physical attributes resulting from a comparison of several alternative plans. One might, for example, compare the amount of physical desegregation attained in one plan per student busing mile with the amount of physical desegregation attained per student busing mile in other plans. Other evaluations may depend on the comparative utilization of building facilities or a comparative analysis of safety factors.

It is recognized, however, that school decision-makers must consider other factors such as the political, sociological, educational and psychological, along with the physical aspects of desegregation. On this scale the most extensive research known to this investigator relating to criteria for plan evaluation is the work done by Hickey[1] at Michigan State University entitled "An Instrument to Evaluate Alternative Patterns for School Desegregation." Hickey's instrument provided for the evaluation of four broad aspects of school desegregation:

1. Assessment of current status of the community.
2. Examination of alternative plans.
3. Commitment to a plan of action.
4. Implementation of the plan.

[1]Hickey, *op. cit.*

CHAPTER IV

ANALYSIS AND EVALUATION OF MODEL

Basis of Analysis and Evaluation

This study was concerned with the development of a computerized model and subsequently the determination of its applicability for devising and evaluating alternative plans for redistricting and assigning students in an urban city school for purposes of desegregation.

The study proposed to test and modify the model, utilizing actual student and demographic data from an urban school, and to develop a set of model characteristics as a basis for analyzing and evaluating the model performance and applicability to professional educators. The purpose, therefore, of this chapter is to analyze and evaluate the applicability and performance of the model on the basis of the objectives and characteristics described in Chapter III.

Basis of Analysis and Evaluation (Applicability)

To some extent applicability is dependent on performance for unless the model provides the desired output it undoubtedly lacks applicability. Applicability, however, encompasses more than performance. It implies the presence of desired characteristics and qualities in the model which make it feasible to use and understandable to professional educators who must work with it.

Consequently, the applicability of the model was analyzed and evaluated to the degree the stated characteristics and qualities were present.

The four characteristics and qualities desired were:

1. Flexibility
2. Responsiveness
3. Adaptability
4. Reliability

In addition it was considered essential to the model that the input data be correct, complete and manageable and that the output data have the qualities of clarity and completeness.

In some instances the characteristics desired in the model were subject to quantitative analysis, i.e., flexibility by the number of alternatives provided or responsiveness by the amount of time that elapsed until the model responded to requests based on a new set of conditions.

For the most part, however, the analysis of characteristics of the model was subjective, that is, subject to evaluation based on experience with the model and on additional enlightenment gained from the time the study was initiated.

Alkin and Duff[1] suggested a like subjective analysis of a model.

> . . . the purposes of a system study, therefore are twofold: (a) to provide information for rational administrative decision-making in order to improve the real world system and (b) to continually re-examine and modify the argument of the model in order to improve the model and analysis.

Basis of Analysis and Evaluation (Performance)

The analysis of model performance was based on model ability to automatively select and make optimal assignments of Census tract/blocks to given school attendance areas for purposes of attaining a prescribed racial mix. An optimal assignment, in this case, was dependent on the ability of the model to take needed students from the closest available surpluses to the most appropriate new station. To the extent that an optimal solution was the result of a mathematical manipulation the results were subject to manual verification. However, such analysis is time consuming and costly and was not undertaken in this study. It was assumed that optimality was inherent in the linear formulation of the problem as used in the model, so long as the restraints were such that a solution was attainable.

The analysis of model performance was further based on model ability to provide the decision-maker with the

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[1]Marvin Alkin and William L. Duff, "Some Data Problems in Systems Research," Research and Data Problems in Big-City Schools; A Symposium, edited by William G. Monahan (Iowa City, Iowa: Center for Research in School Administration, Iowa University, 1968).

following information relative to each alternative plan for desegregation:

1. A list of tract/blocks (neighborhoods) assigned to each school.

2. The name of the school from which the census block is taken.

3. The enrollment by grade before and after the change for each school.

4. The percent of the capacity being utilized in each school as a result of the assignment.

5. The total number of miles students will be bused.

6. The cost of busing per school.

7. The ethnic composition of each school on a percentage basis as a result of the new assignment.

Several additional possibilities through which model performance could be assessed were considered. It was possible, for example, to compare suggested model developed desegregation plans with predetermined desegregation criteria and/or to compare cost per unit of desegregation achieved through a model plan with the cost per unit of desegregation achieved previously by School (X). However, for purposes of this study, it was reasoned that an evaluation of alternatives was not essential to a determination of model performance. The emphasis of the investigation was the development of a model capable of providing a relatively simple way to attack the mechanical aspects of the problem through automation. A principle concern for plan alternatives was not that they be the solution but rather that they provide a rational basis for decision-making.

Analysis of Input

Basically, three kinds of informational input were required for the model developed in this study. They were student information data, school data, map data, and other geographical data. It was considered essential to the success of the model that the input data would be correct, complete, and manageable. It is on the basis of the presence of these three desired qualities that the input data to the model was analyzed.

Analysis of Student Information (Input)

The student information for the model was obtained from the data processing center of School (X). It was obtained in a form ready for computer processing. The information requested and the information received regarding each student in grades 6 through 11 was the student's name, street and home address, grade, and race along with the name of the school the student was currently attending.

A factor which quickly became apparent regarding the student information was the absence, at the time the data was collected, of an objective to put the data to the use for which it ultimately would be used in this study. Leu stated the problem well.

> . . . a major barrier to securing adequate educational data is our current inability to define what educational and external data are significant or relevant to our planning.[1]

As a result of using student data which was not originally collected with the objective of using it for the purposes of this study many errors were found. Such errors may have been of little consequence had the data been used only for the purposes for which it was originally collected.

The most frequent error found in the student data was misspelled street names. Other errors frequently found were the wrong use of abbreviations, and the sometimes erroneous interchange of street designations such as avenue, street, court and place. The irregular form in which street and avenue names were regarded also posed a problem.

The frequency of errors on the first run was a ratio of about one error for every three students. This was reduced to a ratio of one error for every nine students on the second run.

Correcting the number of errors encountered in the

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[1]Donald J. Leu, "Toward Adequate Educational and Sociological Cultural Data for Continuous Educational Planning in Large School District," in Research and Data Problems in Big-City Schools: A Symposium, edited by William G. Monahan (Iowa City, Iowa: Center for Research in School Administration, Iowa University).

student data took an additional 220 man-hours of labor.

Generally the form and structure of the student data was considered good. However, had the objectives and purposes for which the data would be used been clear at the time the data was collected, much time would have been saved through the process of putting the student data on magnetic tapes originally to correlate with the form to which the data would be matched.

The two most crucial areas in developing a reliable student information file, then, were those of early identification of objectives and procedures and the subsequent collection of required data to achieve those purposes. Although most schools collect the basic student information required for a study of this nature, it is usually not collected in the form or with the degree of accuracy required when data processing techniques are to be employed.

Should the decision to utilize student data for a study of this nature be made prior to the time of data collection, it would seem that several simple measures could well save numerous man-hours of labor and improve the reliability of the data. Some of these steps are:

1. All school personnel who are responsible for students at the time data is being collected should be alerted to the needs and requirements of accurate data.

2. Students should be encouraged to write legibly and spell accurately.

3. A list of acceptable abbreviations such as St., Terr., Pl., and Ave. should be placed on the form and the proper one underlined or encircled.

4. The words north, south, east, and west should be written on the form and underlined or encircled when applicable.

5. In case of doubt students should be encouraged to check convenient reference sources such as city maps or telephone directories for proper street spellings or seek help from a supervising adult.

6. The forms should provide ample space for legible writing and should be structured for information in a logical order for future data processing use. Should the previously determined procedure call for the use of ADMATCH, the information should be structured so that it could readily be put into a machine sensible format to be used with ADMATCH.

As an intermediate step for improving the reliability of the collection of data the school could create and maintain a street name file. Such a file lists the acceptable names of streets in the urban community. In addition, it contains acceptable commonly used abbreviations as well as some of the very common misspellings of street names. By employing a file of this nature the student generated information is first checked against the street name file to insure the validity of the street name prior to processing the student information with the Address Coding Guide. This step allows for greater flexibility in the collection of data from the student.

Incorrect, unreliable basic data tends to make the model inflexible to change. The original student data was obtained from School System X at the close of the 1968-69 school year. Prior to the time the data could be processed and all the programs which constitute the model could be developed, the 1969-70 school year was in progress. It was estimated to require approximately 125-150 man-hours of labor to update the student data to 1970. As a result of the large amount of time required to update the student data, the decision was made to continue with the 1968-69 student data. Had the original student data been correct and in a more manageable form, updating would have been a relatively cheap and simple process.

Analysis of School Data

School data, as used in this study, was that data which defined school capacities, described the physical conditions of buildings, gave the location of portables and provided information on land areas and projected school sites. The school data generally met the standards desired in the input data.

However, a slight inconsistency was found between the rated capacities per school submitted by the Director of Buildings and Grounds and those submitted by the Department of Research and Statistics of School (X). To compensate for this inconsistency, a formula was devised to determine the capacities of the nine senior high schools. Through the use of the formula the square feet per student mean was formulated for each teaching area. The + or - deviation from this mean was then multiplied by 28 to determine the student capacity for each area. The cumulative average of all the teaching areas became the capacity per teaching area assigned to a given school. The students assigned per teaching post had a range of 26-30 as compared with the 31 per teaching post uniformly assigned by the Department of Research and Statistics.

Analysis of Geographical Data

Once the census tract/block had been established as the basic geographic level the next step was to acquire the address coding guide and produce a standard coding guide for that portion of the urban area containing the school district.

Approximately six weeks elapsed from the time the guide was ordered from the Census Bureau until it was received in microfilm form.

The microfilms posed some problems. The information on the microfilm could not be read until it was magnified. Consideration was first given to magnifying the information for photographic reproduction. However, the expense was considered prohibitive so the decision was made to rent microfilm readers. This, too, posed some problems as microfilm readers were at that time available only on a daily or a yearly rental basis. The total for thirty days rent was equal to one-year rent on a yearly basis. Three microreaders were rented on a yearly basis for a total of $505.00. The actual time required to keypunch the information from the microfilm was 40 days, or a total of 960 man-hours.

Among the problems encountered with the address coding guide were those of misspelled street names, inconsistency of the use of street and avenue, poor legibility in some instances, and incomplete information for the entire school district area.

In retrospect a major problem with geographic data was that of timing. This study was started in January, 1969. The new address coding guides for the 1970 census had not been published and were not available until December, 1969. This necessitated using the 1960 guide which, unfortunately, had not been updated since that date. A second factor associated with timing was the ADMATCH program developed by the Census Bureau. The ADMATCH program, which automates the matching of students to census block/tract, was not available until January, 1970. Again, the end result was a time-consuming development of a similar ADMATCH program.

The use of an address coding guide in 1969, which had been developed in 1960, created problems which were time consuming as geographical data of new additions had not been recorded. Also, recent changes occurring in the developed areas, such as deleted streets and new streets, were not reflected.

Many additional problems were encountered with the address coding guide. Numerous errors in spelling and street namings along with poor legibility and format added hours to the programming and editing process. Approximately 10,000 errors were detected in 30,000 notations during the first run. One hundred and twenty man-hours were required to standardize the method of recording street names and to strip off that part of the Standard Metropolitan Statistical Area (SMSA) which did not apply to the redistricting problem.

In view of the many problems encountered the advisability of using the address coding guide as a geographic base was questionable. However, it should be recalled that a primary concern of this study was to develop a model that had future as well as present applicability to the problem of student assignment and school redistricting. The applicability of the address coding guide as a geographic base for the future appears more promising. Voight[1] reported that the U. S. Census Bureau is in the process of establishing an ongoing update program for the address coding guide. The objective of this program is to correlate national and local

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[1]Interview with Robert B. Voight, Special Assistant to the Associate Director of Research and Development, U. S. Bureau of the Census, April 20, 1970.

efforts in an annual update cycle. The updating process is designed to register all street additions and changes occurring in a SMSA within a given year.

The second feature of the updating process will be a basic change in the address coding guide to incorporate new techniques developed through the Dual Independent Map Encoding (DIME) process.[1]

The DIME geographic base file is essentially a file of boundary segment records, where a typical segment is a portion of a street length defined by intersecting streets or boundaries. The term "Dual Independent" refers to the fact that each boundary segment is described by specifying its two end nodes (intersections) and its right and left blocks. With each node and block uniquely numbered, the computer can then construct two independent networks and match them to insure that the existing network is completely represented and all land accounted for.[2]

Principally, DIME provides information about a block segment as does the address coding guide. The geographic

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[1] Ibid.

[2] Robert A. Totschek, "A Computerized Shelter Allocation Process for Los Angeles County," (Kent State University Publications, Urban and Regional Information System, Service Systems for Cities. Papers from the Seventh Annual Conference of the Urban and Regional Information Systems Association, Kent State University, Akron, Ohio, 1969), pp. 316-335.

base is not only more definitive with the DIME technique but also provides much more flexibility and accuracy in editing and updating the geographic base file.

It is possible that a school system, deciding to develop a complete geographical coding system, will discover more feasible sources than the address coding guide. The character and type of a geographical coding system for school planning purposes will depend upon the need and the resources available to that particular school system. Pflaum[2] has developed the idea for three basic types of geographical systems ranging from fast, cheap non-sophisticated systems to highly accurate, relatively expensive systems.

Analysis of Maps

Two kinds of maps were basically used in this study. The one map was provided by the school district and showed school locations along with their attendance areas. These maps were generally accurate and readily interpreted.

The second map was a census block map showing census blocks and census tracts. Here again timing was an issue as

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[1]Donald F. Cooke and William H. Maxfield, "The Development of a Geographic Base File and Its Uses for Mapping" (Kent State University Publication: Urban and Regional Information Systems for Social Programs. Papers from the Fifth Annual Conference of the Urban and Regional Information Systems Association, Kent State University, Akron, Ohio, 1967), pp. 207-218.

[2]Peter E. Pflaum, "Computer Applications to the Problem of Desegregation," (unpublished paper, Florida State University, Tallahassee, Florida, 1970).

regulation census block maps were not available at the time this study was originated. The census block map available was larger than the regulation size map. This constituted a problem in assigning XY coordinates to block centers as no digitizer was available for the larger map. This necessitated figuring all XY coordinates manually--a time-consuming task of 200 man-hours with approximately 6,000 census blocks.

Regulation size census block maps were obtained from the Census Bureau in December, 1969, along with the new address coding guide, and these were later used in the study.

Analysis of Applicability of Model

The applicability of the model was determined by the degree the stated characteristics of flexibility, responsiveness, adaptability, and reliability were present.

Analysis of Model Flexibility

Flexibility in the model was determined by the ability of the model to provide different alternatives without necessitating extreme modifications. The specific alternatives by which flexibility was to be tested were:

1. The ability of the model to make assignments on both an individual grade and/or a grade grouping basis.

2. The ability of the model to redistrict or realign attendance unit boundaries of individual schools and retain their grade structure or redistrict and change their grade structure, e.g., make certain schools 7-8, others 9-12.

The first test of flexibility was a test of ability to make assignments on a grade-grouping basis. For this test the combined attendance areas of all eight high schools which comprised the larger contiguous area of School (X) were considered. The eight high schools had an adjusted capacity for 15,458 students. The combined area was composed of 3,305 census blocks in which 10,364 Caucasian students and 2,578 Negro students in grades 9, 10, and 11 were geographically located. The stated test objective was that the model assign to each school sufficient numbers of Negro students so that the enrollment at each of the eight high schools would be 20% Negro. The assignment of 20 percent Negro students to the enrollment of each of the eight high schools was made in computer time of one hour and forty-four minutes. The computer time required to select the proper data for the test was ten minutes. A total of 1,966 assignments and reassignments (iterations) were made by the computer in the process of achieving an optimal solution to the problem. In all, a total of 610 census blocks, in which 2,578 Negro students resided, were assigned during the test.

The second phase of test I was similar to the first phase except that Caucasian students were assigned to complete the total enrollment for each school. Some problems were encountered in the second phase of test I as a result of the large number of census blocks (2,695) located in the area identified as Caucasian. Following some adjustments to provide computer accomodation to the size of the problem, phase II of test I was successfully completed. The assignment of 80 percent Caucasian students to the enrollment of each of the eight high schools was made in computer time of five hours and thirty minutes. The computer time required to select the proper data was fifteen minutes. A total of 2,356 iterations were made by the computer in the process of achieving an optimal solution to the problem under consideration. A total of 2,695 census blocks, in which 10,364 Caucasian students resided, was assigned.

The second test of flexibility was a test of model ability to make individual grade assignments for purposes of changing the racial composition of the ninth grade in selected schools. The stated objective for test II was to assign to each school a sufficient number of Negro ninth grade students to achieve a ratio of 20 percent Negro in the ninth grade enrollment of each school under consideration. The assignment was to be made in the most optimal way possible. In addition, it was expected that the model could provide for the selection of the ninth grade from the tenth and eleventh grades without additional program modification.

To conserve computer time only four high schools in the inner-city area were considered in test II. The census tracts, from which 1,284 census blocks could be assigned, were delineated by the planner. This step was necessary to avoid the iterative process whereby the computer would have been forced to select from the total 3,305 blocks in the eight school area rather than from the prescribed 1,284 census blocks in the four school area. As in test I the assignment of Negro students was made separate from the assignment of Caucasian students. The assignment of 20 percent Negro students to the ninth grade enrollment of each of the four high schools was accomplished in computer time of seventeen minutes. The computer time required to select the proper data was six minutes. A total of 991 iterations was made by the computer in the process of achieving an optimal solution to the problem. Four hundred twenty-three census blocks, in which 869 Negro ninth grade students resided, were assigned.

The Caucasian students were assigned in the second phase of test II. The assignment of 80 percent Caucasian students to the ninth grade enrollment of each of the four high schools was accomplished in computer time of twenty-nine minutes. Computer selection time for this phase of the problem was nine minutes. The number of iterations required was 1191. A total of 761 census blocks, in which 1,214 Caucasian ninth grade students resided, was assigned.

The third test of flexibility was a test of model ability to select, at the planner's request, the students in a prescribed geographic area and to assign the students in a way that students in each of three high schools were students of a single grade to be represented by 20 percent black students and 80 percent white students. Thus, all ninth grade students of the area were to attend school A, all tenth grade students were to attend school B, and all eleventh grade students were to attend school C. Each of the three grades, as well as the Negro and Caucasian students, was assigned separately.

The assignment of 20 percent Negro ninth-grade students to school A required a computer selection time of one and one-half minutes and an assignment time of ten minutes. The number of iterations required was 785. A total of 330 Negro ninth-grade students out of 869 available students was assigned to school A.

The assignment of 80 percent Caucasian ninth-grade students to school A required a computer selection time of one and one-half minutes and an assignment time of seven minutes. The number of iterations required for an optimal assignment was 756. A total of 1,320 Caucasian ninth-grade students out of 1,320 available students was assigned to school A.

The assignment of 20 percent Negro tenth-grade students to school B required a computer selection time of one and one-half minutes and an assignment time of seven minutes. The number of iterations required was 608. A total of 319 Negro tenth grade students out of 757 available students was assigned to school B.

The assignment of 80 percent Caucasian tenth-grade students to school B required a computer selection time of two minutes and an assignment time of six minutes. The number of iterations required was 755. A total of 1,276 Caucasian tenth-grade students out of 1,276 available students was assigned to school B.

The assignment of 20 percent Negro eleventh-grade students to school C required a computer selection time of two minutes and an assignment time of seven and one-half minutes. The number of iterations required was 698. A total of 280 Negro eleventh grade students out of 818 available students was assigned to school C.

The assignment of 80 percent Caucasian eleventh-grade students to school C required a computer selection time of two minutes and an assignment time of twenty-nine and one-half minutes. The number of iterations required was 1,595. A total of 1,120 Caucasian eleventh grade students out of 1,235 available students was assigned to school C.

Analysis of Model Responsiveness

Responsiveness in the model was determined by the ability of the model to respond quickly, and with little modification, to a new set of conditions presented by the planner. The degree to which the model possessed this characteristic was determined by the amount of time it took the model to respond to a different set of conditions, along with the ability of the model to select the needed data without external modifications.

The time required and modifications needed to test the flexibility of the model were the criteria used to evaluate model responsiveness. Table I is a comparative presentation of the time required and of the tasks performed during the three test runs.

TABLE I

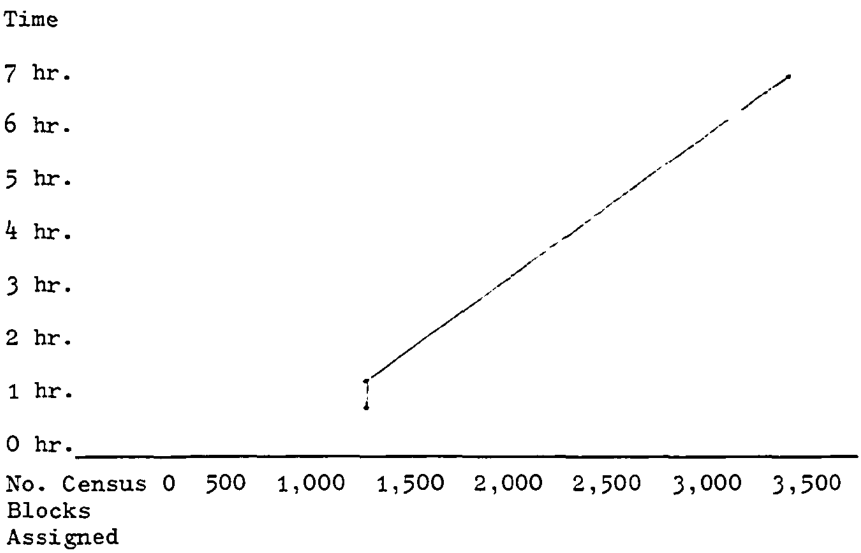
A COMPARISON OF COMPUTER TIME AND TASKS PERFORMED ON THREE TESTS OF MODEL FLEXIBILITY

Test	Selection Time	Assignment Time	No. Iterations	No. Census Blocks Affected	No. Students Assigned
1	25 min.	7 hr., 15 min.	4,322	3,306	12,882
2	15 min.	46 min.	2,182	1,284	2,083
3	10 1/2 min.	67 min.	5,277	1,284	4,645

Selection time represents the amount of computer time required to select the proper data for the test. Assignment time represents the actual computer time used for problem solution. The number of iterations represents the possibilities considered by the computer prior to arriving at an optimal solution. The relationship of computer time and the number of census blocks affected is graphically presented in figure 2.

FIGURE 2

RELATIONSHIP BETWEEN COMPUTER TIME AND THE NUMBER OF CENSUS BLOCKS ASSIGNED



<u>Analysis of Model Adaptability</u>

Adaptability of the model was determined by the potential of the model to provide information other than that related to changing boundary lines. Although a test was not run to determine this characteristic the performance of the model along with results of other studies of this nature led to the conclusion that the model is adaptable to other types of information. O'Brien and Lyle[1] outlined an urban education model with four sub-models. The central orientation of the model was that of planning the location and size of elementary

[1]O'Brien and Lyle, *op. cit.*

and secondary school plants. A School Sub-Model enabled educators to estimate total space and total staff needed for a given student body. A Cost Sub-Model provided an estimate of costs for a new school or school addition. An Effectiveness Sub-Model provided an estimate of student achievement in a projected school situation based on actual student achievement and socioeconomic factors. The urban sub-model determined attendance area boundaries by assigning pupils to school so as to achieve given objectives.

Stanford Research Institute[1] developed a sub-model to present estimates of projected enrollments by race, grade and census tract for each school over a five-year period.

If adaptability, as described, is desired in a model, it is essential that decisions regarding such objectives be made prior to the time data is collected and processed for model input. The adaptability of the model is dependent to a considerable extent on the nature of the additional input data which is processed along with the student geographical data.

Analysis of Model Reliability

Reliability was determined by the degree to which the model performed as expected and exhibited the desired characteristics. A high degree of reliability was characterized in the performance of the model. Although all the

[1]William F. Powers, "Research Memorandum No. 2--Population Projection to 1971," March, 1967, pp. 1-50.

desired characteristics were identifiable the model was limited in its responsiveness to the planner to the extent that the time required to respond to a given request was somewhat detrimental to the effective evaluation of alternatives through the iterative process. The nature of the output placed additional limitations on the ability of the model to function as desired. Nevertheless, the experience of the investigator indicated that the model provided optimal alternatives much more rapidly than could be done manually.

Analysis of Model Performance

Model performance was the ability of the model to automatively select and make optimal assignments of census tract/blocks of students to given school attendance areas for purposes of attaining a prescribed racial mix. The model was to provide certain information regarding such assignments as a test of ability to perform as stipulated.

The information desired and the degree to which the information was provided is listed and analyzed below.

Objective #1. and Analysis	The model should provide a list of census tract/blocks assigned to each school. This objective was accomplished.
Objective #2. and Analysis	The model should provide the name of the school from which the census block was taken. This objective was accomplished.
Objective #3. and Analysis	The model should provide the enrollment by grade before and after the change for each school. This objective was accomplished.
Objective #4. and	The model should provide the percent of capacity being utilized in each school as

Analysis — result of assignment made by the model. This objective was accomplished.

Objective #5. and Analysis — The model should provide the total number of miles students will be bused for each alternative plan. An aggregate number of miles was recorded. However, the total miles recorded reflected the combined distances from block centers to all the schools to which students were assigned. The distance from each block center to a school represented the shortest distance between these points irrespective of travel routes. Thus, the miles provided by the model had comparative rather than real value.

Objective #6. and Analysis — The model should provide the cost of busing students for each attendance area or school. The nature of the aggregate miles given, as previously described, preclude an accurate basis for figuring busing costs. However, provided a cost value was assigned per busing mile a comparative evaluation of busing costs per alternative would be possible.

Objective #7. — The model should provide the ethnic composition of each school on a percentage basis as a result of the new assignment. The ethnic composition of each school as a result of an assignment was available as a result of the request given the model for a specified racial composition.

Analysis of Model Output Data

Clarity and completeness were the two qualities desired in the output data. Clarity was determined by the degree output data could readily be interpreted without an intermediate step of decoding. The completeness of output data was determined by the ability of the model to produce the desired information. An analysis of model information output was made in the previous section Analysis of Model Performance.

Four separate programs provided output in the following forms:

Output Program #1

School Name Total Capacity Total Enrollment

Negro Enrollment % total capacity
% total enrollment

Caucasian Enrollment % total capacity
% total enrollment

Output Program #2

Census tract/block School to which tract/block was assigned

School to which tract/block is assigned

Output Program #3

Number of census blocks changed/unchanged in assignment	Number Caucasian students with changed assignments	Number Caucasian students with same assignments
Number of census blocks changed/unchanged in assignment	Number Negro students with changed assignments	Number Negro students with same assignments

Output Program #4

Total Number of Busing Miles

Total Number of Students Bused

Total Cost of Busing

Output data which does not require an intermediate step for decoding purposes was the desired objective. Although sufficient information was generated for the planner to plot school attendance areas, the absence of immediate output showing attendance areas in graphic form constituted a rather serious model limitation.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to devise and test a model for school administrators to utilize in resolving pupil assignment problems related to the desegregation of schools in urban areas. Several studies were reviewed which attempted to devise models for desegregation. The emphasis in most studies was on the technical aspects of the problem with little value given to the more practical administrative responsibilities of gathering, recording and processing student data. None of the studies reviewed treated the problems related to using U. S. Census tract/blocks as a geographical base in depth. Many of the studies tested the models under severe constraints which it was thought tended to limit the value of the computer model.

Consequently, this study attempted to describe all the procedures involved in the developing and testing of the model and to present the description in non-technical terms. School data was obtained from an urban school and used to develop and test the model. The model was tested and analyzed to determine its performance and applicability to the problem for which it was designed. The basis for analysis was certain prescribed characteristics desired in the model and its ability to perform in terms of delivering the desired output. In the final analysis the model was judged on its ability to respond quickly without modification to a planner's request and to present the solution in readily interpreted form.

Findings of the Study

The major problem encountered in the development of the computerized model resulted from the use of data which was not originally collected nor processed to be used for the purposes to which it was used in this study.

A similar problem with U. S. Census data was, to some extent, a result of timing. However, recently published, properly updated census information should provide one logical method for geographically locating students.

The model did accomplish the objective of devising alternative desegregation plans and did provide the desired information. However, some of the information, i.e., number of miles students were bused, lacked implicitness as a result of the problem formulation.

The model was flexible and responsive to requests from the planner. The GYPSY selection process, along with other model designs, enabled the model to select without external modification, and to respond as directed. The time factor for responsiveness varied from a time of 46 minutes to 7 hours, 15 minutes depending on the size of the problem.

The model did not supply output in a readily interpreted form. Although all information was concisely assembled, the immediate visual embodiment was absent, necessitating a rather prolonged effort on the part of the planner to assemble data in a manner in which it could be visually interpreted.

Conclusions

The following conclusions were derived from the experiences attained during the model development and are based on the analysis of the model.

It is possible to develop a working computerized model for purposes of developing physical desegregation alternatives.

The decision to develop and use a similar model to devise desegregation plan alternatives, in an urban school system, should be made prior to the collection of the student data to be used in the model.

All model objectives should be carefully formulated prior to the data collection phase of model development.

The model probably should be planned and developed only when the school system can utilize the model for purposes in addition to the development of desegregation plans.

Each school system should carefully analyze the status of U. S. Census Address Coding Guide information prior to finalizing a decision to use the address coding guide as a geographical base.

As a result of the longer response time required by the model for the larger problem as compared with the response time required for the smaller problem it appears the model was most effective when the total problem was subdivided into smaller problems.

The model developed in this study has its greatest application in those situations where numerous options for physical desegregation are available to the decision-maker. There is probably less need for the model if desegregation options are limited from the beginning.

The computerized model does not consider all of the factors and/or elements in a desegregation plan but rather provides rough approximations of student assignments which should be meaningful to the decision-maker and provide a basis upon which a decision may be made.

Recommendations

The following recommendations are presented as a result of this investigation:

1. Further research is needed to explore cheap and simple means whereby school data can be collected and periodically updated to comply with data processing demands and

purposes.

2. Attempts should be continued to develop simple ways to aggregate students to geographic locations.

3. School systems should cooperate with other agencies of the urban area in the development of needed data.

4. School systems considering the use of a computerized model for devising school desegregation plans should carefully investigate the practicability and cost of plotting distances to coincide with available transportation patterns. The shortest distance between two points was used in this study.

5. Further research is needed to explore additional ways in which a model of this nature can be supplemented with other informational input, such as U. S. Census data, to attain a wide assortment of objectives.

6. School systems, in developing desegregation plans. should consider the use of a computerized model together with the careful development of other factors fundamental to an effective total plan for school desegregation.

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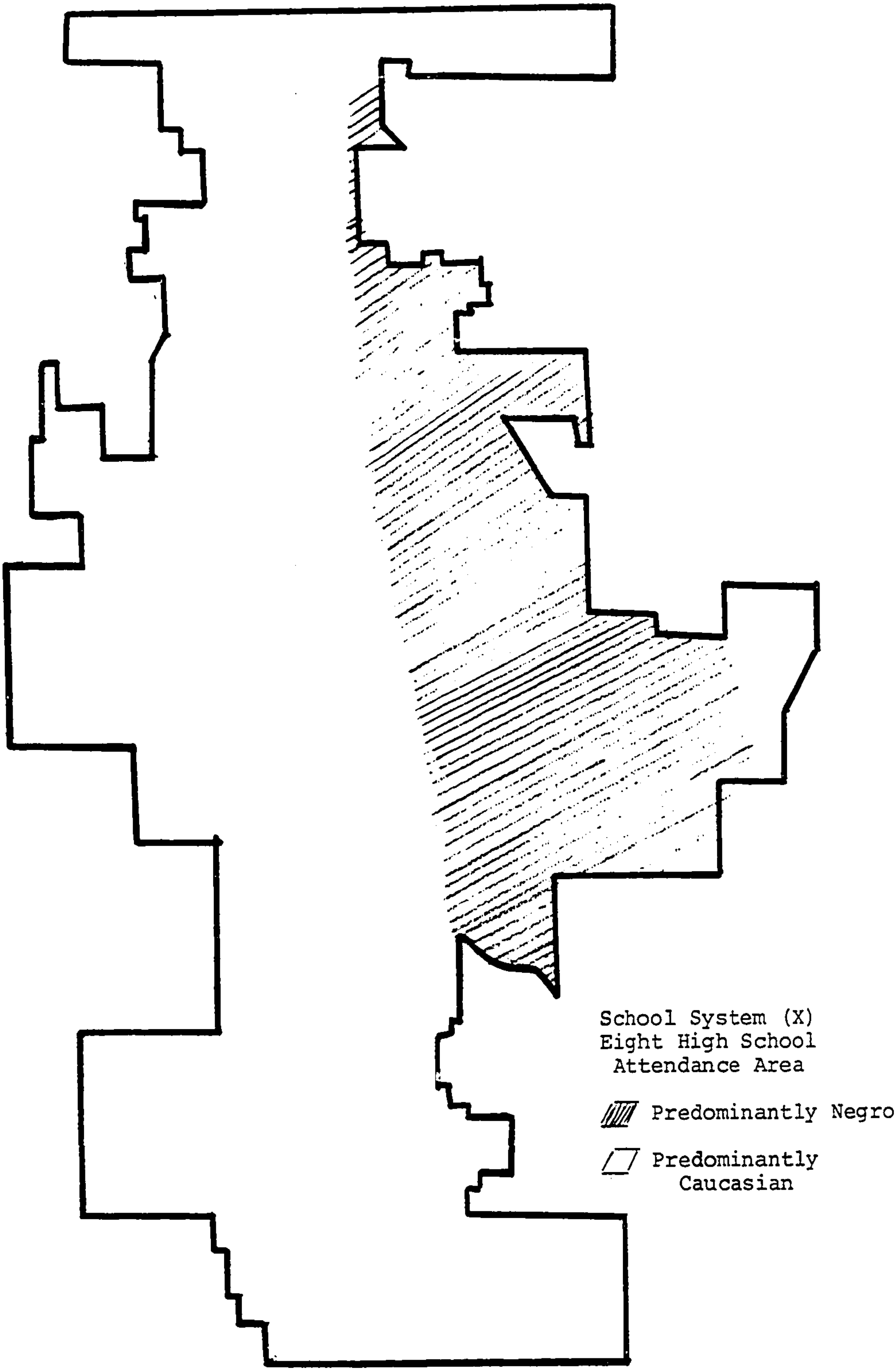
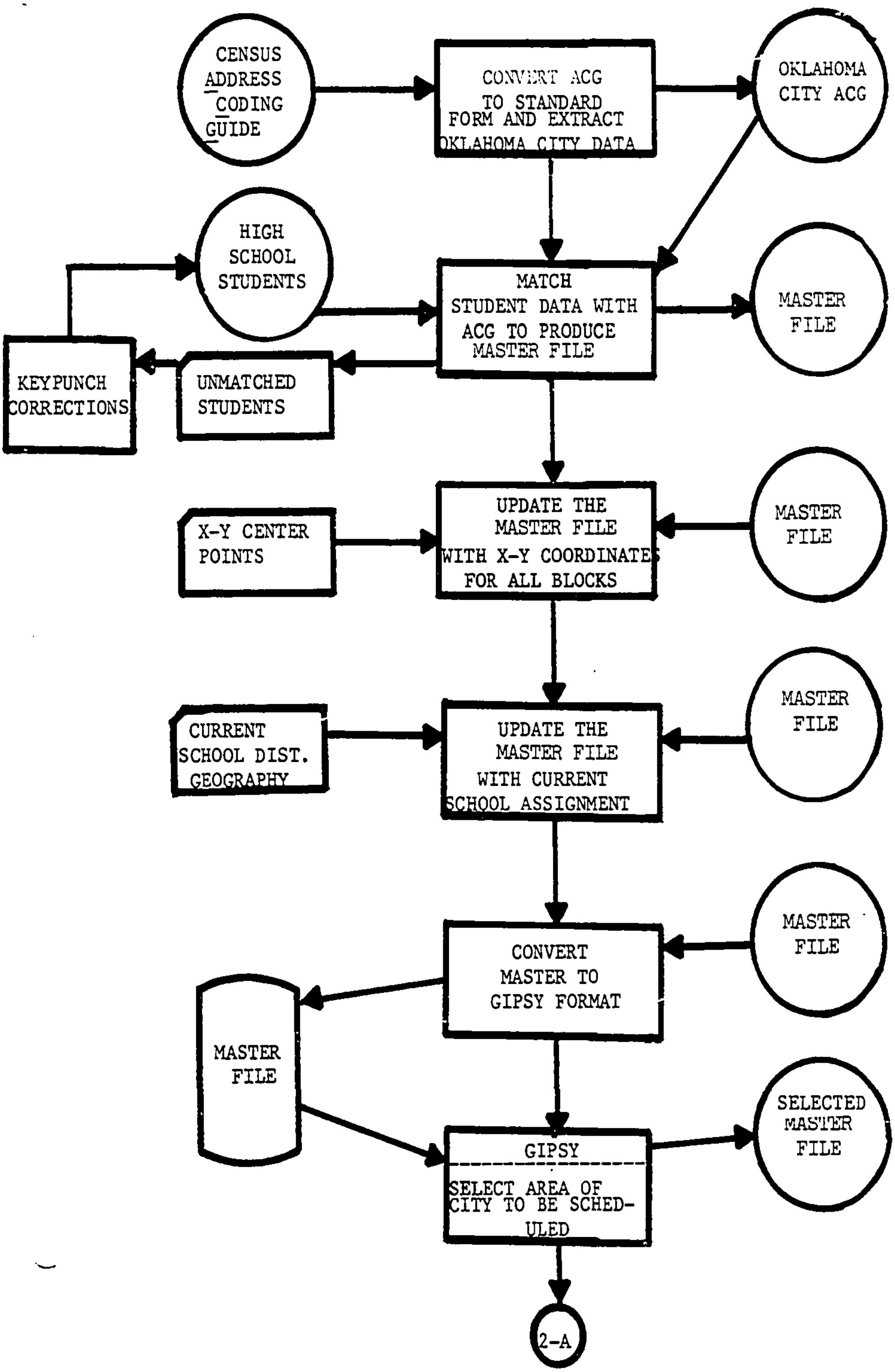
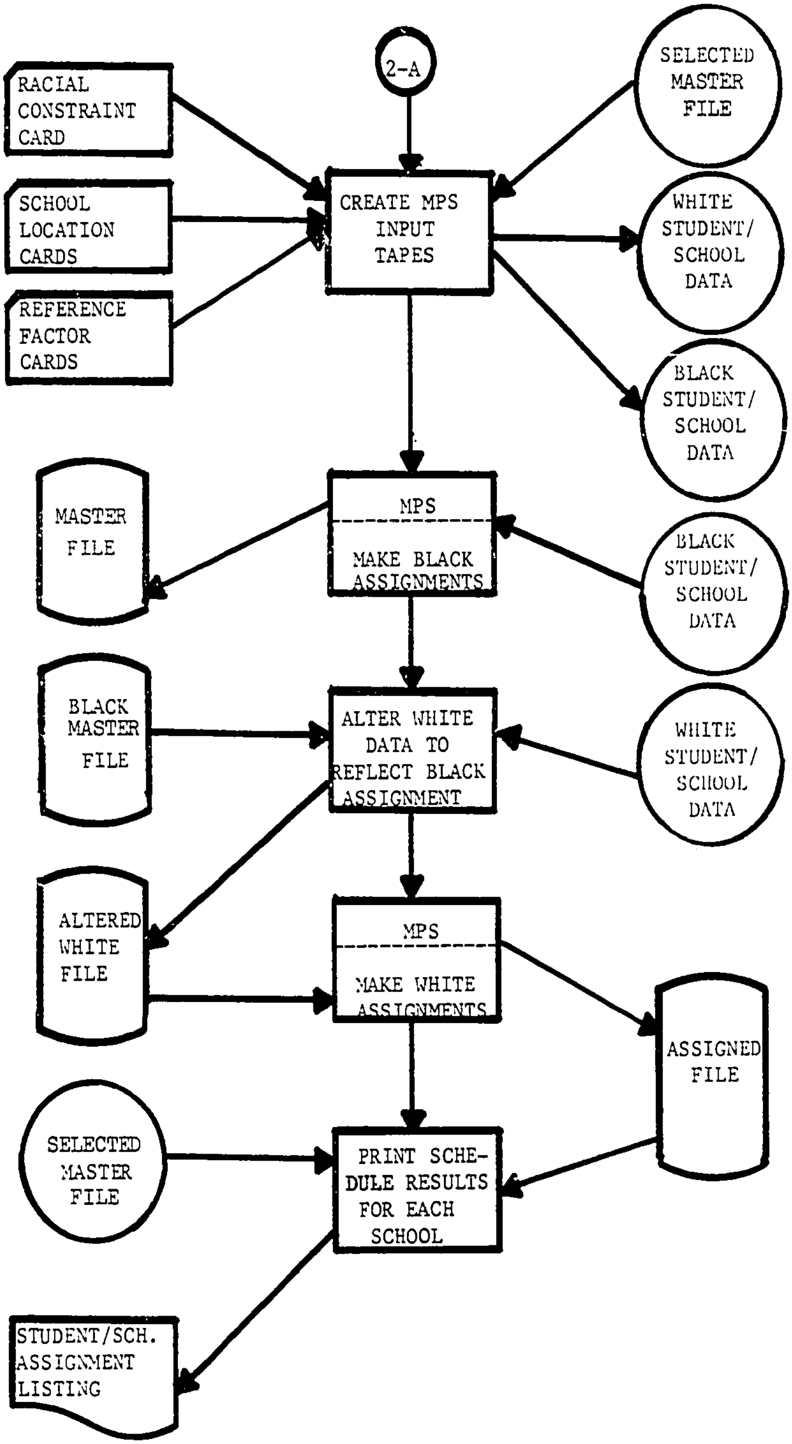
APPENDIX A


School System (X)
Eight High School
Attendance Area
Predominantly Negro
Predominantly
Caucasian

APPENDIX B

SYSTEM FLOWCHART: STUDENT ASSIGNMENT SYSTEM




2-A
RACIAL CONSTRAINT CARD
SCHOOL LOCATION CARDS
REFERENCE FACTOR CARDS
CREATE MPS INPUT TAPES
SELECTED MASTER FILE
WHITE STUDENT/ SCHOOL DATA
BLACK STUDENT/ SCHOOL DATA
MASTER FILE
MPS
MAKE BLACK ASSIGNMENTS
BLACK STUDENT/ SCHOOL DATA
BLACK MASTER FILE
ALTER WHITE DATA TO REFLECT BLACK ASSIGNMENT
WHITE STUDENT/ SCHOOL DATA
ALTERED WHITE FILE
MPS
MAKE WHITE ASSIGNMENTS
ASSIGNED FILE
SELECTED MASTER FILE
PRINT SCHEDULE RESULTS FOR EACH SCHOOL
STUDENT/SCH. ASSIGNMENT LISTING

APPENDIX C

PROGRAM DESCRIPTION

MPS DATA PREPARATION PROGRAM

The MPS Data Preparation Program was designed to accomplish the following tasks:

1. Create the student (supply) MPS input for black and white students by:
   a. Computing the squared distance from each tract/block to each school available for assignment.
   b. Summing all the students by race from each tract/block in grades to be scheduled to create a total, by race, for each tract/block to be assigned.
   c. Locating, for external preference factor, the assignment, affected tract/block and making the noted assignment.
2. Create school (demand) MPS input by altering the stated school capacities from the school location card by the inputted racial percentage found on the racial constraint card.

Inputs to the Data Preparation Program were:

1. A master student file containing the following information:
   a. The identifying tract code and block number.
   b. The x-y coordinates.
   c. The student population for a block broken down by race and grade.
   d. The identification of current school assignment broken into elementary, junior high and senior high.

2. The racial constraint in grade assignment card containing the following information:
   a. The percentage of black students to be assigned throughout the system.
   b. The number of grades to be submitted for assignment.
   c. A list of those grades to be used in the assignment allocation.

3. The school location card containing the following information:
   a. The alpha character school code.
   b. The school name.
   c. The enrollment for that school.
   d. The x-y coordinate of the school.

4. The preference factor assignment card containing the following information:
   a. The numerical factor to be assigned.
   b. The tract code and block number to which the assignment was made.
   c. A list of the schools to which this preference factor from this tract/block will be assigned.

The program began by reading the racial constraint card and setting up the percent of black students to be assigned in the system and creating a list of grades to be used in the assignment process. The program then read the school location cards and built a matrix containing the school code, the x-y coordinates of the school's location and finally the enrollment of the school broken down into a black enrollment and a white enrollment. This breakdown was determined by the percentage of black students retained from the racial constraint card (the total enrollment times the percentage of black students equals the black enrollment; the total enrollment minus the computed black enrollment equals the white enrollment). The program then began to read the master record and the preference factor assignment cards when appropriate. When there were preference factor assignment cards the program sought those master records to which the assignment was to be made. Once those records were found the preference was then applied to each of the schools listed on the preference factor card. If there were no preference factor assignments to be made to an individual block the output records were created using a preference factor of the squared distance only.

The output from a program consisted of two major files of eleven character records. Each of these major files contained two sub-files. The sub-files were composed of a student supply file and school demand file. The student supply file contained all the information pertaining to the assignment of a given tract/block to a given school. This information included the number of students available for assignment in this tract/block and the preference factor for that block to a given school. The records were created on the basis of one record per race, per block/school assignment. The school demand file contained information identifying each of the schools available for assignment and the adjusted capacity of the school based on the racial constraint.

The assignment of external preference factors was accomplished on a block level and was made in one of the following manners:

1. Assigning a factor of zeroes to a given block school relationship which forced preferred assignments to a

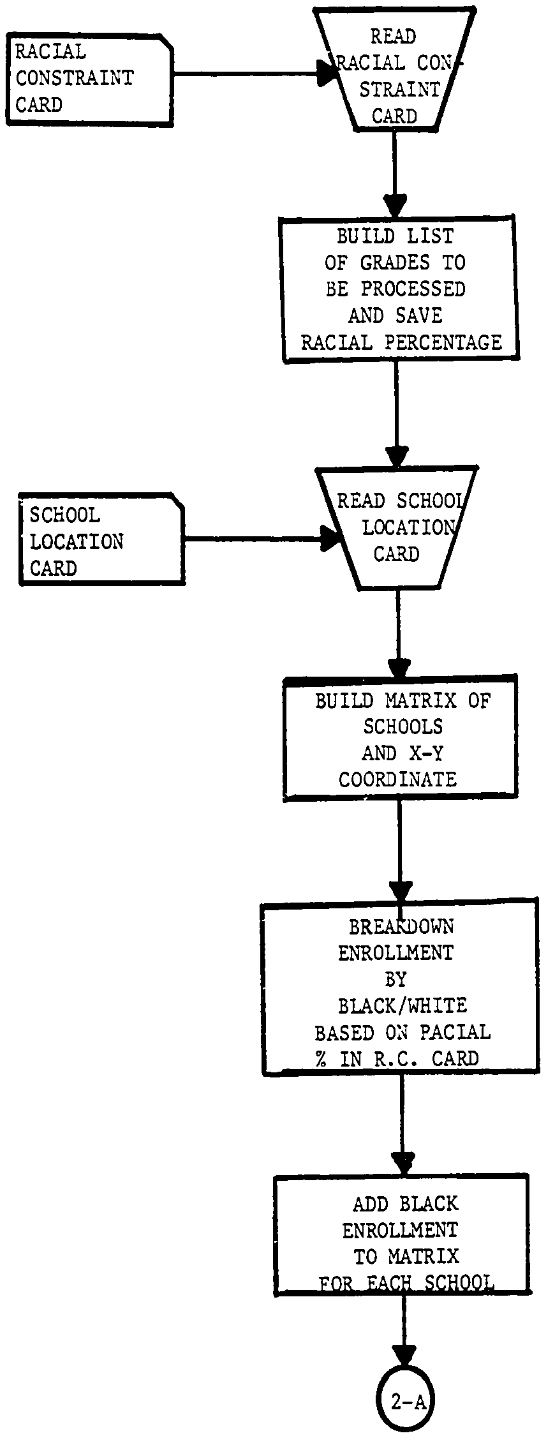
given school.

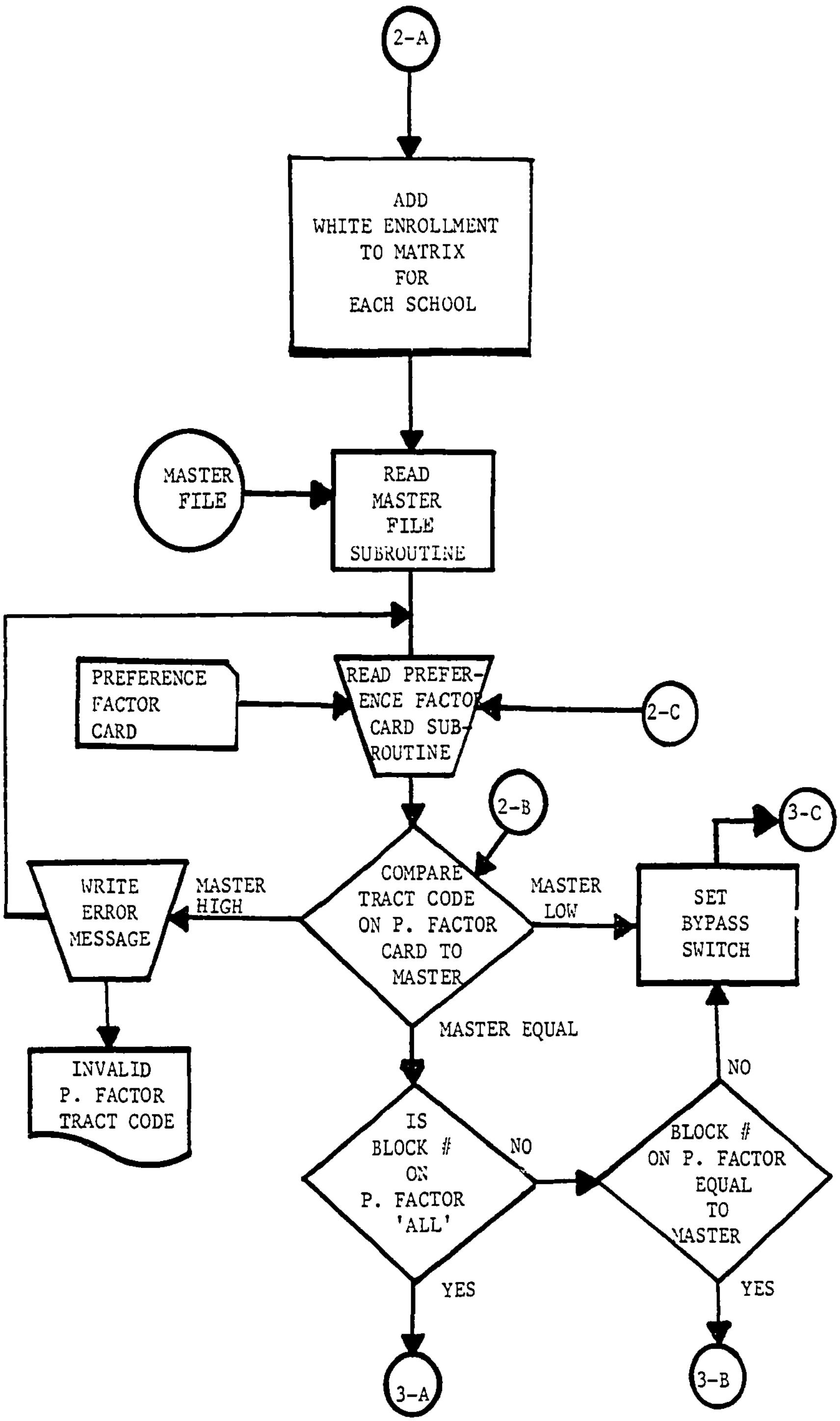
2. An assignment of all 9's for a given block school relationship to force assignment away from the school.

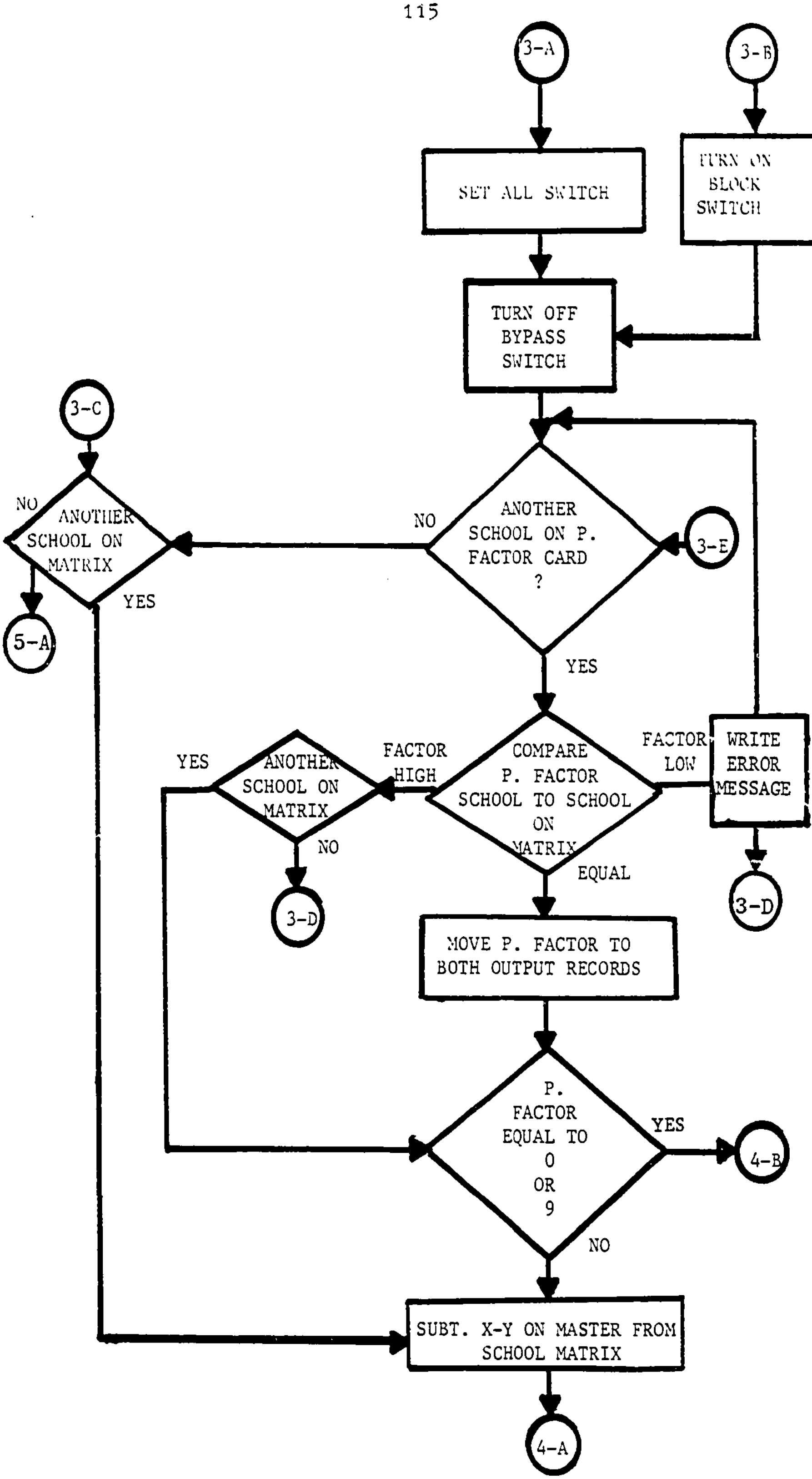
3. The assignment of a numerical preference factor to be added to the computed preference factor. (These constraints are developed by the consultant based on such criteria as may be necessary.)

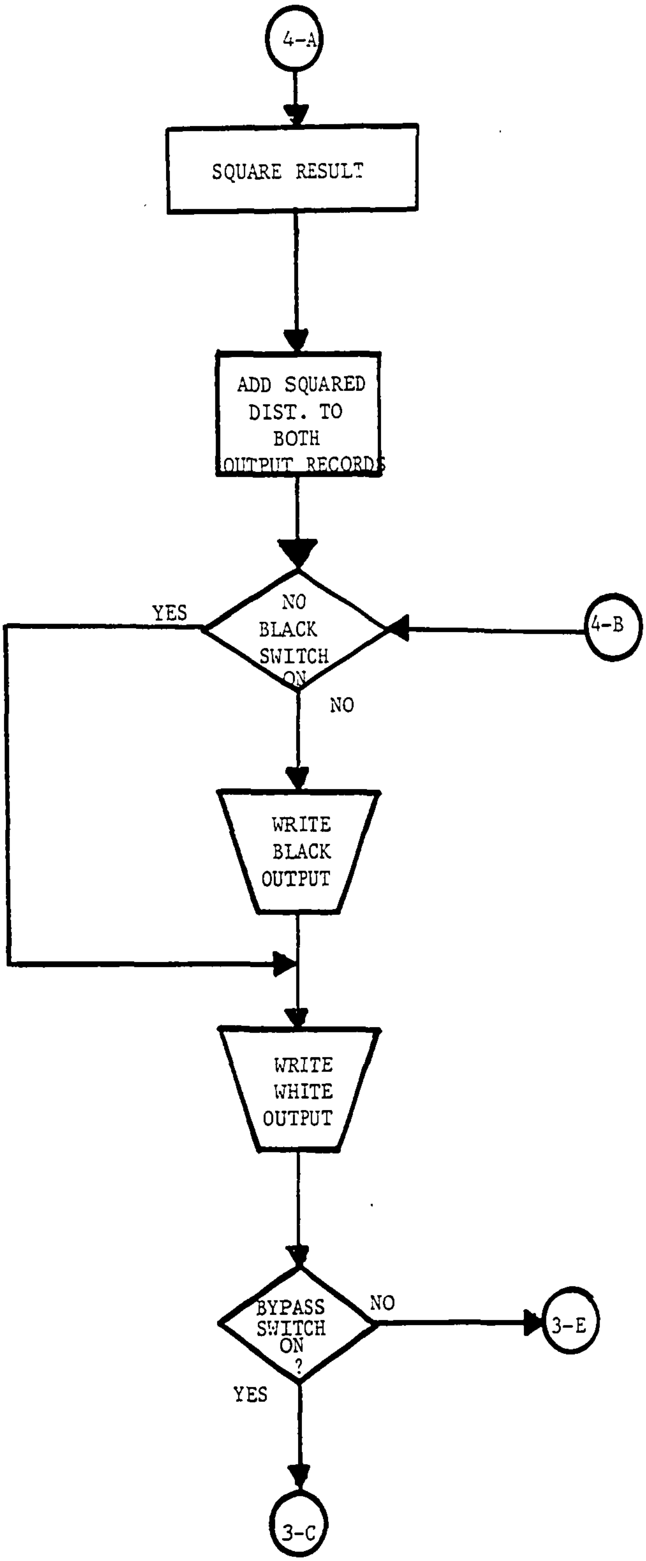
The zero or nine assignment replaced the squared distance in the preference factor field and represented the only factor to be used. Any number other than zero or nine was added to the squared distance to develop a single preference factor.

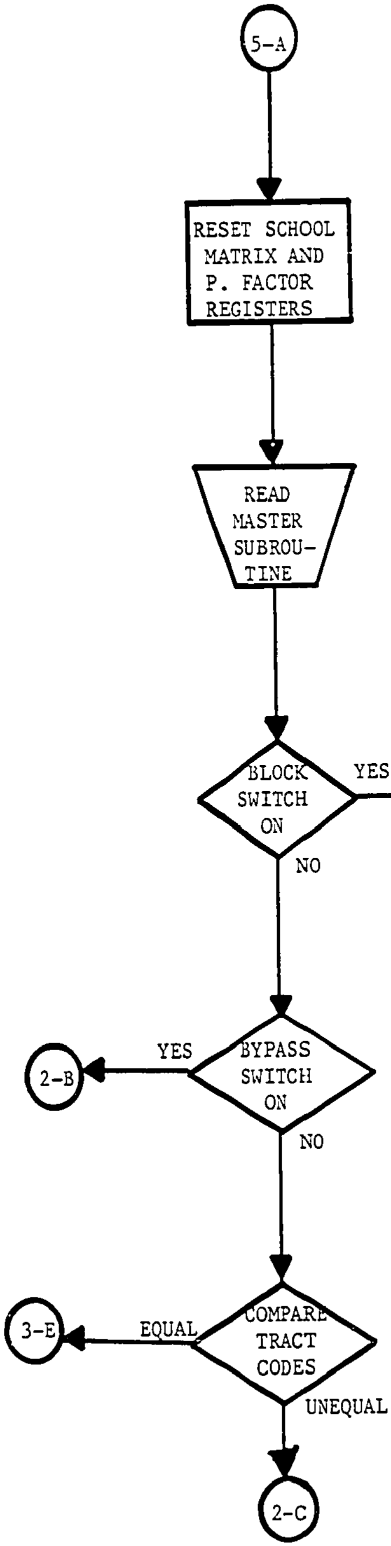
PROGRAM FLOWCHART: MPS DATA PREPARATION PROGRAM



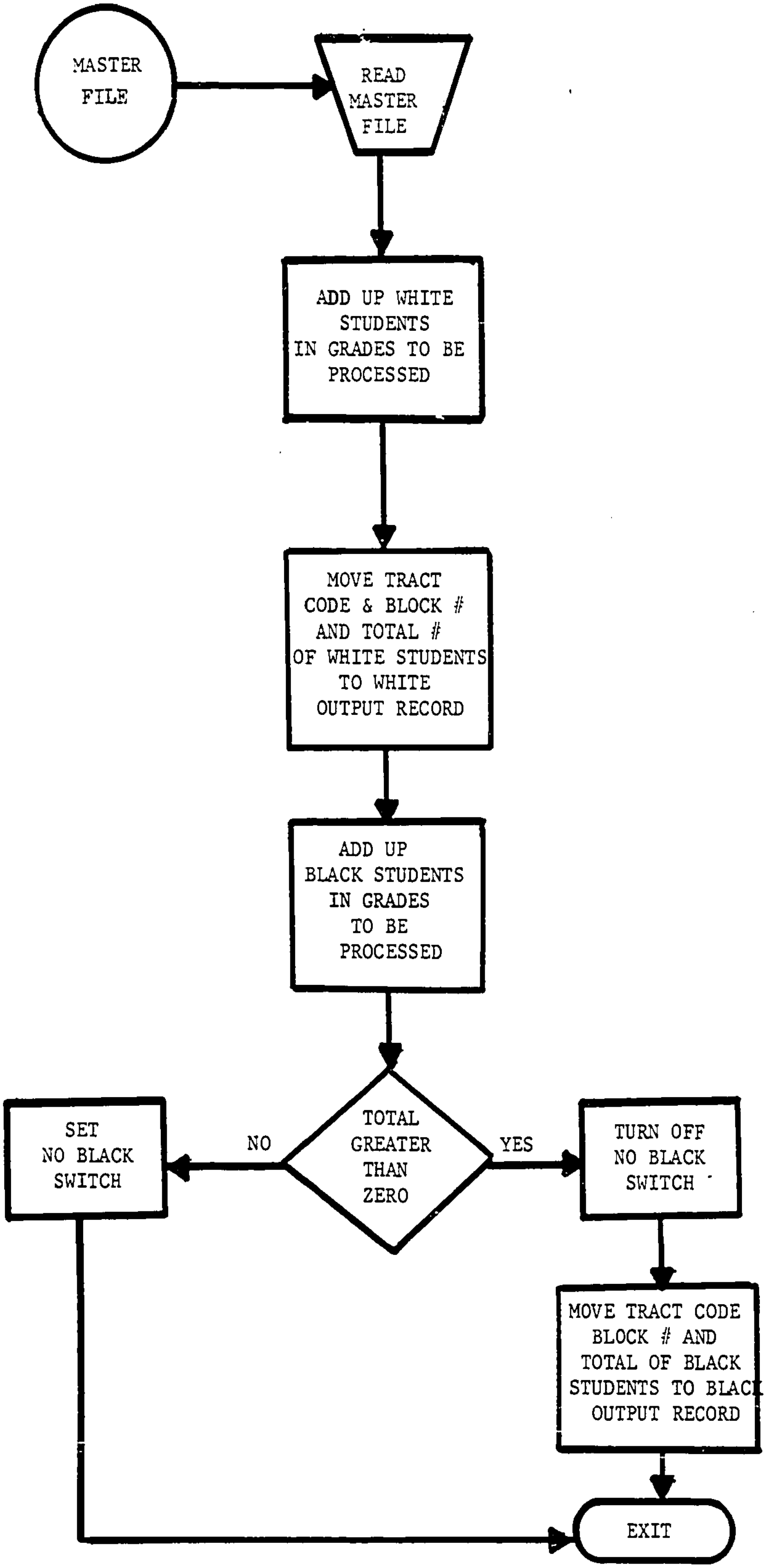

2-A
ADD
WHITE ENROLLMENT
TO MATRIX
FOR
EACH SCHOOL
MASTER
FILE
READ
MASTER
FILE
SUBROUTINE
PREFERENCE
FACTOR
CARD
READ PREFER-
ENCE FACTOR
CARD SUB-
ROUTINE
2-C
2-B
3-C
WRITE
ERROR
MESSAGE
MASTER
HIGH
COMPARE
TRACT CODE
ON P. FACTOR
CARD TO
MASTER
MASTER
LOW
SET
BYPASS
SWITCH
MASTER EQUAL
INVALID
P. FACTOR
TRACT CODE
NO
IS
BLOCK #
ON
P. FACTOR
'ALL'
NO
BLOCK #
ON P. FACTOR
EQUAL
TO
MASTER
YES
YES
3-A
3-B


3-A
3-B
SET ALL SWITCH
TURN ON BLOCK SWITCH
TURN OFF BYPASS SWITCH
3-C
NO
ANOTHER SCHOOL ON MATRIX
YES
5-A
NO
ANOTHER SCHOOL ON P. FACTOR CARD ?
3-E
YES
YES
ANOTHER SCHOOL ON MATRIX
NO
3-D
FACTOR HIGH
COMPARE P. FACTOR SCHOOL TO SCHOOL ON MATRIX
FACTOR LOW
WRITE ERROR MESSAGE
3-D
EQUAL
MOVE P. FACTOR TO BOTH OUTPUT RECORDS
P. FACTOR EQUAL TO 0 OR 9
YES
4-B
NO
SUBT. X-Y ON MASTER FROM SCHOOL MATRIX
4-A

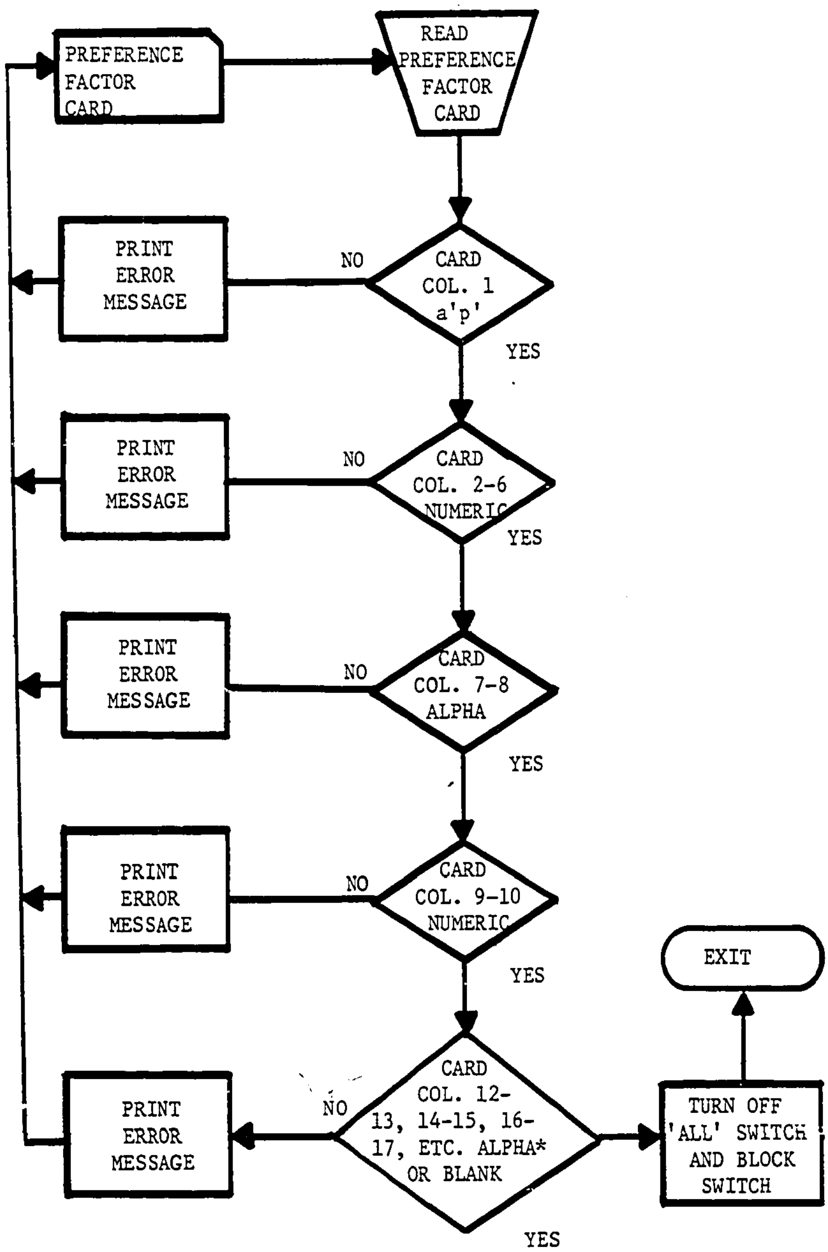

4-A
SQUARE RESULT
ADD SQUARED DIST. TO BOTH OUTPUT RECORDS
NO BLACK SWITCH ON
YES
NO
4-B
WRITE BLACK OUTPUT
WRITE WHITE OUTPUT
BYPASS SWITCH ON ?
NO
YES
3-E
3-C


5-A
RESET SCHOOL MATRIX AND P. FACTOR REGISTERS
READ MASTER SUBROU-TINE
BLOCK SWITCH ON
YES
2-C
NO
BYPASS SWITCH ON
YES
2-B
NO
COMPARE TRACT CODES
EQUAL
3-E
UNEQUAL
2-C

READ MASTER SUBROUTINE

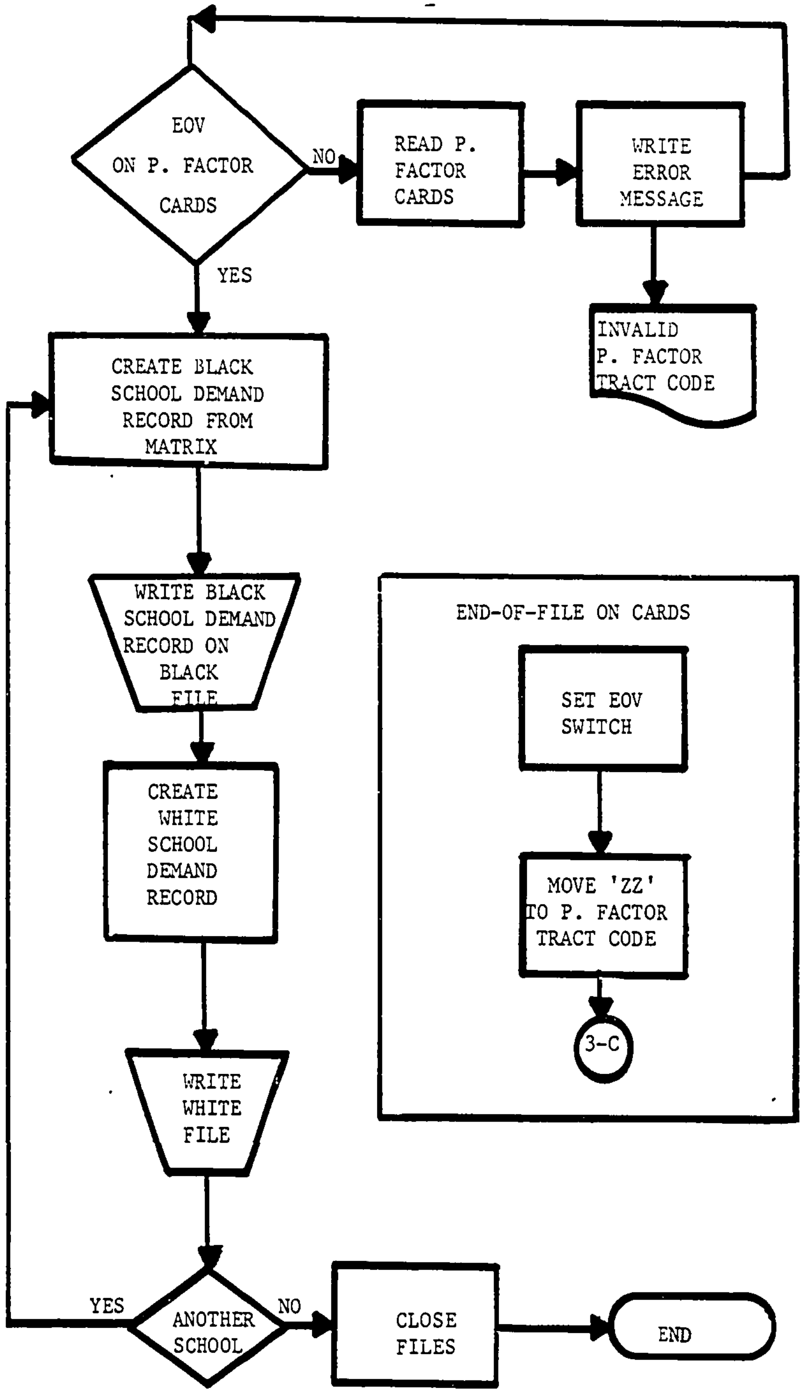


READ PREFERENCE FACTOR CARD SUBROUTINE



* STARTING WITH A OR B OR C

AT END-OF-FILE ON MASTER



PROGRAM DESCRIPTION

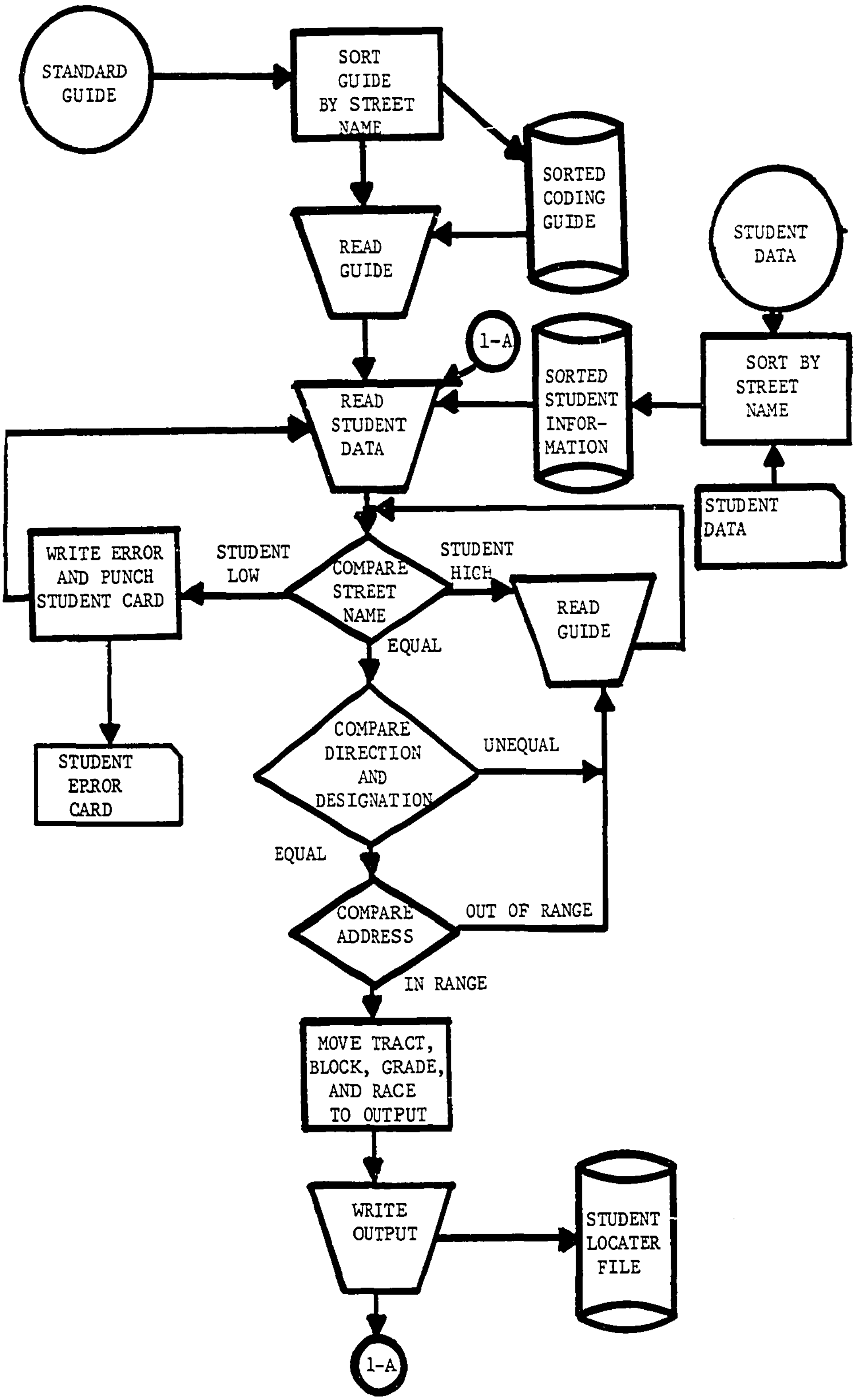
STUDENT MATCHING PROGRAM

The Student Matching Program was designed to match the pupils attending school in the urban area to a census tract/block neighborhood. This was accomplished by comparing the address in the student record to the address coding guide which referenced all addresses in the urban area to a given census tract/block. During the matching process the program punched student records that it was unable to match. Experience indicated that many mismatches were caused by only minor errors or discrepancies in the student records which were corrected with a small amount of keypunching.

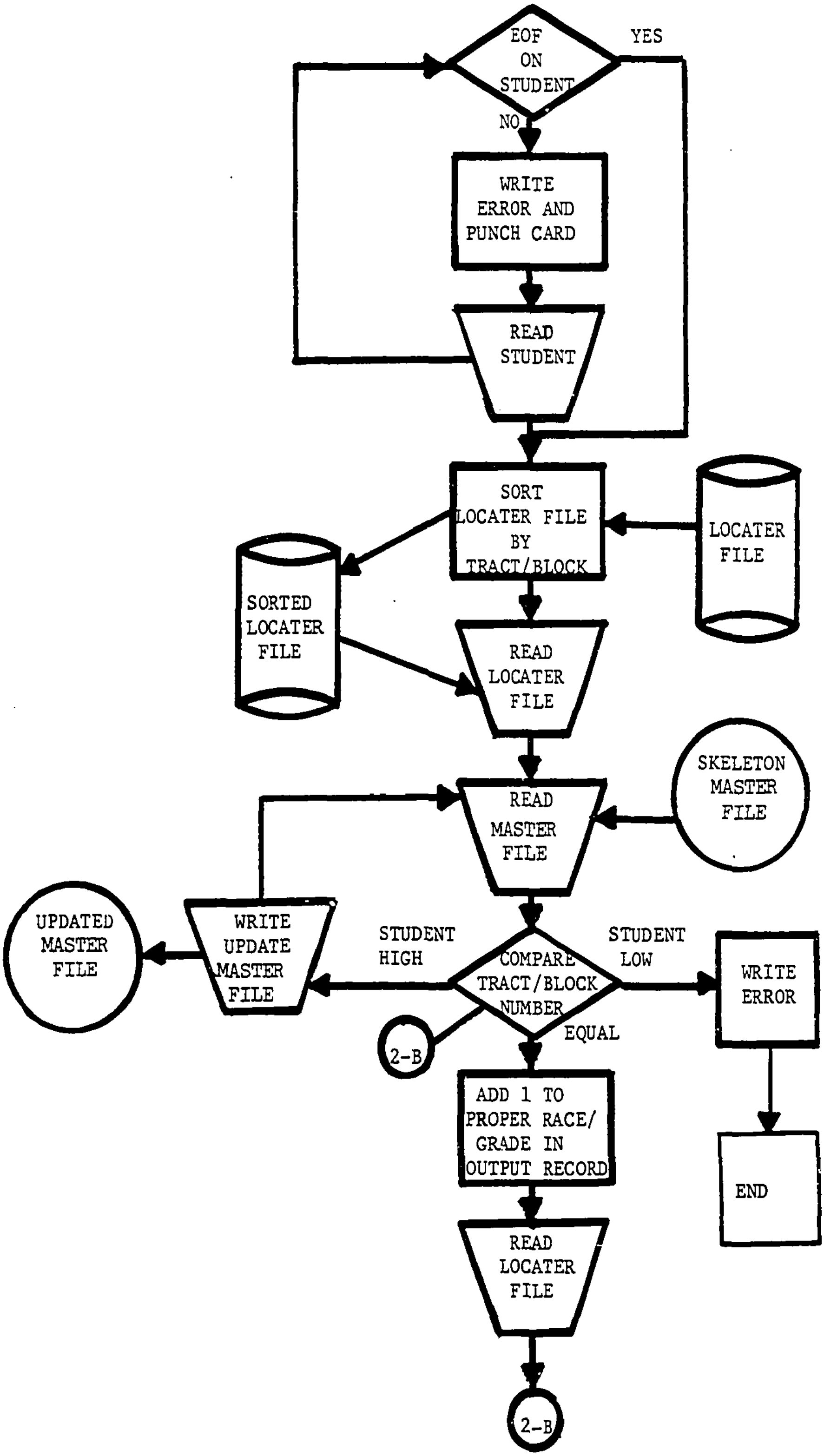
To complete the task of matching the students to neighborhoods this program also read the skeleton master and updated it with the students located in each of the neighborhoods. This update was accomplished by creating an intermediate file, the student locater file. This file was then sorted to tract/block sequence and a simple update routine was programmed to compare the tract/block on the locater file to the skeleton schedule master created in the previous program. When a match was found one student was added to the appropriate grade for his or her race in the master record.

This program may be rerun with the punched output as input until all the student records have been updated to the master tape.

PROGRAM FLOWCHART: STUDENT MATCH



AT END OF FILE ON GUIDE

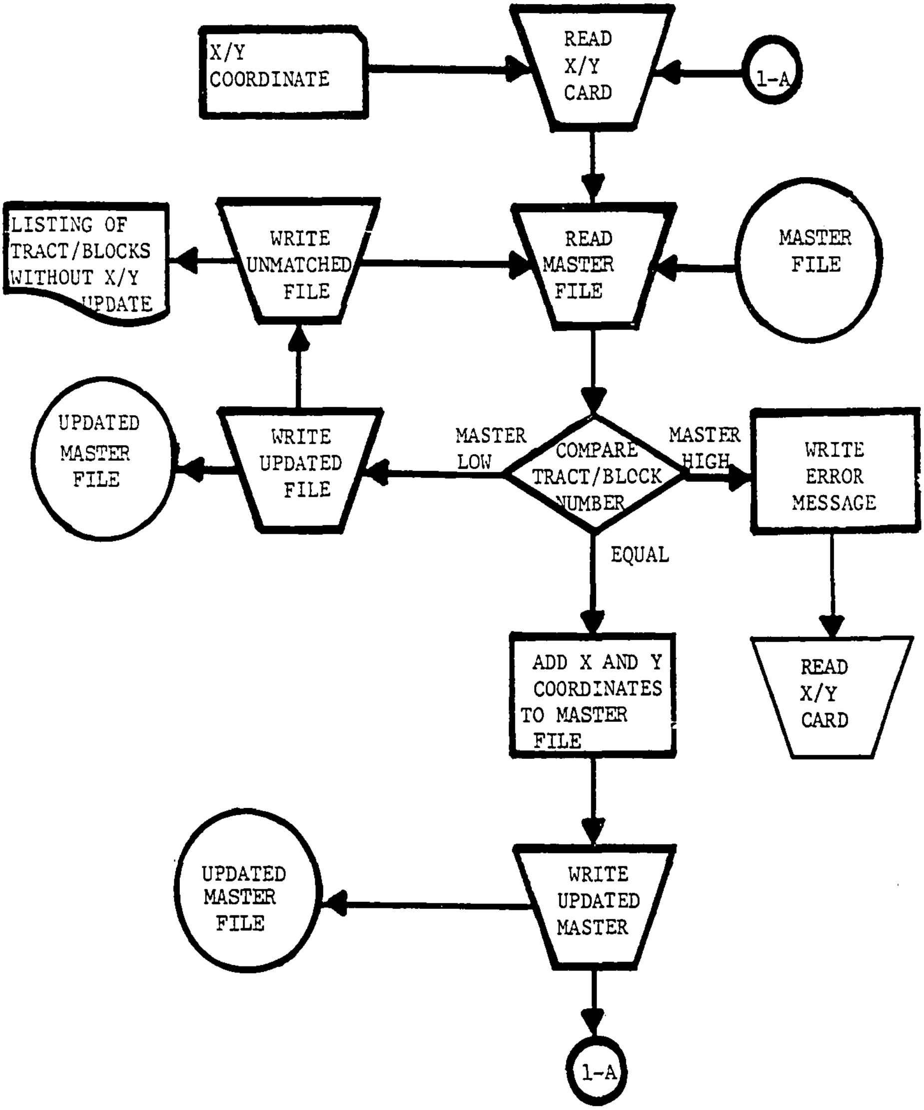


PROGRAM DESCRIPTION

X/Y COORDINATE UPDATE PROGRAM

This program was designed to place in the Master File the x-y centroid coordinate index for each tract/block. These coordinates were digitized from census maps and the information placed on punched cards. The card input file contained the tract/block number and the x and y coordinate numbers. The program read the master file and the x/y coordinate file and updated the appropriate master record with the x/y coordinates. Output from the program was an updated Master File and a listing of all tract/blocks that had not yet been updated with x/y coordinates. This listing was then used to insure all tracts and blocks had been recorded or digitized from the census map.

PROGRAM FLOWCHART: X/Y UPDATE



PROGRAM DESCRIPTION

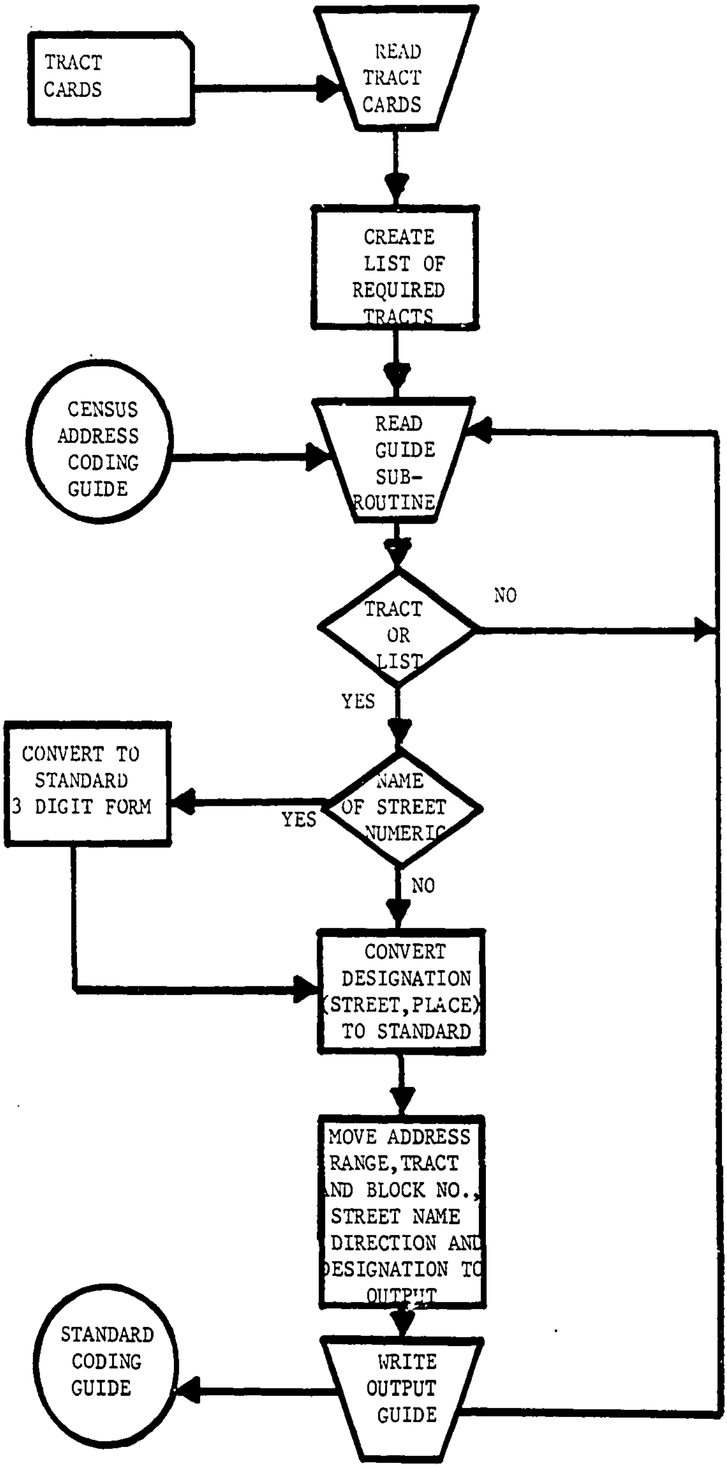
ADDRESS CODING GUIDE CONVERSION PROGRAM

The Address Coding Guide Conversion Program was de-designed to take the Bureau of the Census Coding Guide and create a standardized street name, street designation reference. It reduced to a standard of three characters, zero filled, all numeric street names, stripped off the th and st on street names such as 21st and 20th and converted to a two character field the street designation, such as st for street, pl for place, bl for boulevard, etc. This standardization program was necessary to reduce the data from school (X) to uneable fashion. It was also necessary to check for errors remaining in the coding guide available from the Census Bureau.

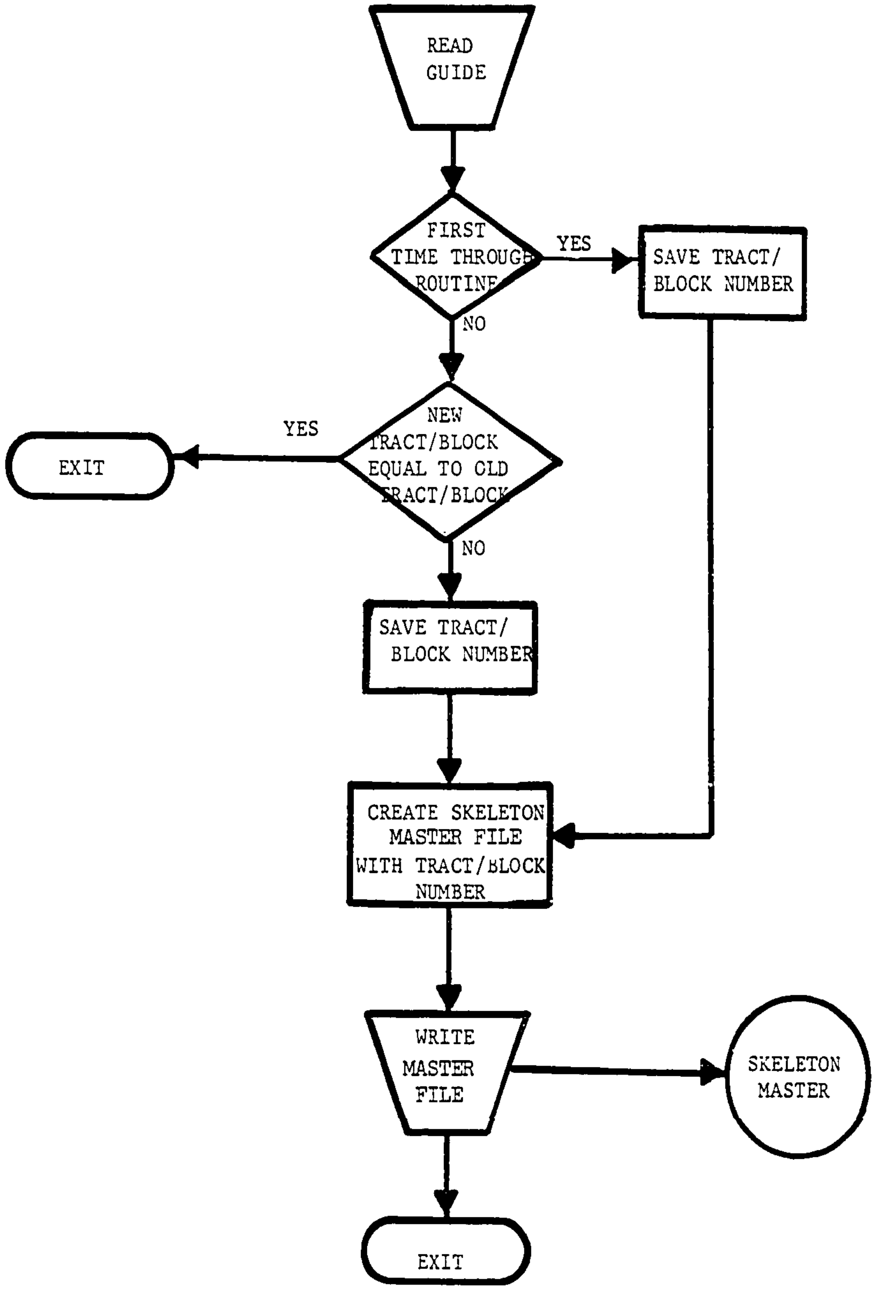
In addition to creating a standard guide form this program reduced the entire census guide to that geographic area needed for the school redistricting problem. Rather than maintain the entire standard metropolitan statistical area in the coding guide it was decided to reduce it to only the geographic area required for the problem.

The final task accomplished by this program was to create the skeleton master file. The program was created, on tape, one record per tract/block in the form of the final master record. At this point only the tract number and block number were completed in the master record, the rest of the information was updated in subsequent programs. The creation of the skeleton master in this program insured one master file record for each tract/block in the area regardless of whether there were pupils resident in the tract/block.

PROGRAM FLOWCHART: ACG CONVERSION



READ GUIDE SUBROUTINE



PROGRAM DESCRIPTION

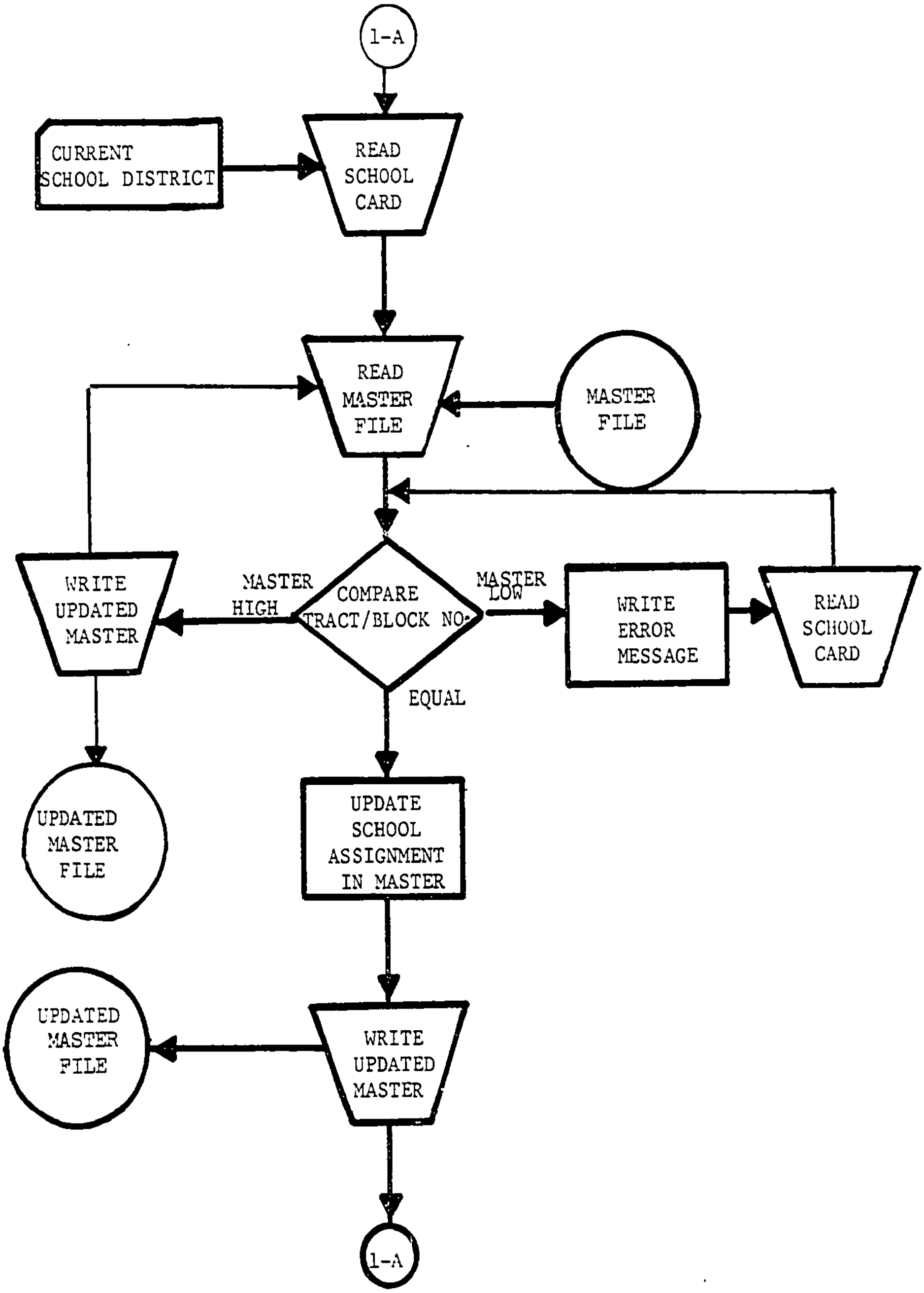
SCHOOL ASSIGNMENT PROGRAM

The purpose of this program was to update the Master File with the current school assignment. That is, each neighborhood or tract/block was assigned to a school at the elementary, junior high and senior high level. This assignment reflected the schools attended by the pupils in that neighborhood.

Input to the program consisted of a card file, containing reference to the neighborhood and its school assignment, and the Master File. Output was in the form of an updated Master Tape.

The program was run a minimum of three times, once for each level of school. The card input file identified the tract and block to which a school district was assigned. The school was identified by a two character code and the type of school by a one character identification. This information was updated to the Master File. Each run was made with only a single type of school and required a minimum of three runs to complete the update process. (Additional runs are frequently needed to update error records detected during previous runs or to add further information to the file.)

PROGRAM FLOWCHART: SCHOOL ASSIGNMENT PROGRAM



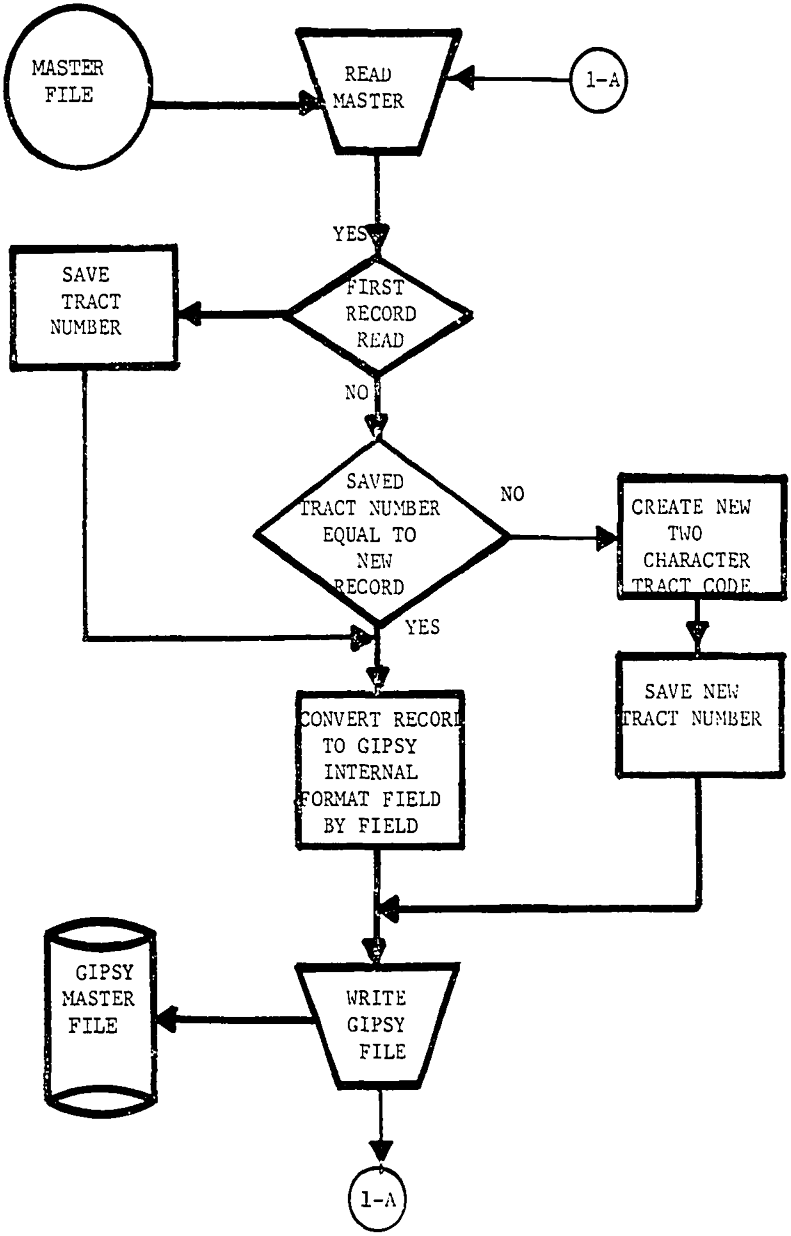
PROGRAM DESCRIPTION

GIPSY CONVERSION PROGRAM

This program was written to convert the Schedule Master Tape to the internal format required for use in the GIPSY Retrieval System. In addition, this program added to each record a two character tract code which was unique to each different census tract in the geographic area. This code was added to the file to be used in the MPS program in place of the longer six character census tract number.

The program read the Schedule Master, added the two character trace code to the master record, and then performed the conversion process with the output placed on a direct access file.

PROGRAM FLOWCHART: GIPSY CONVERSION PROGRAM



APPENDIX D

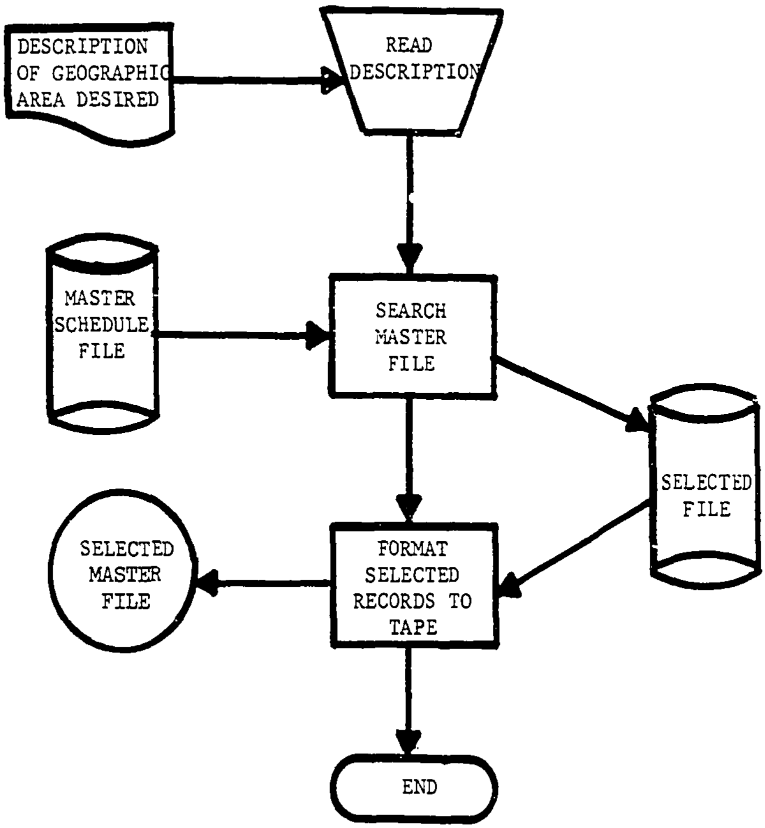
PROGRAM DESCRIPTION

GIPSY PROBLEM SELECT PROGRAM

This program is really a single GIPSY run. It was used to create the input file for the redistricting problem. The GIPSY programs were employed to select from the master file a subset of neighborhoods as described in the GIPSY input. Output was created by the GIPSY program in a fixed field, fixed length format.

Further information describing the operation and characteristics of the GIPSY system may be found in the University of Oklahoma Information Science Series Monograph II and Monograph IV.

PROGRAM FLOWCHART: GIPSY PROBLEM SELECT PROGRAM



APPENDIX E

PROGRAM DESCRIPTION

PROBLEM SOLUTION PRINT PROGRAM

This program was designed to read the MPS solution file and prepare the print out for the redistricting problem. In addition, it performed some minor computations to provide further quantitative information on the redistricting solution.

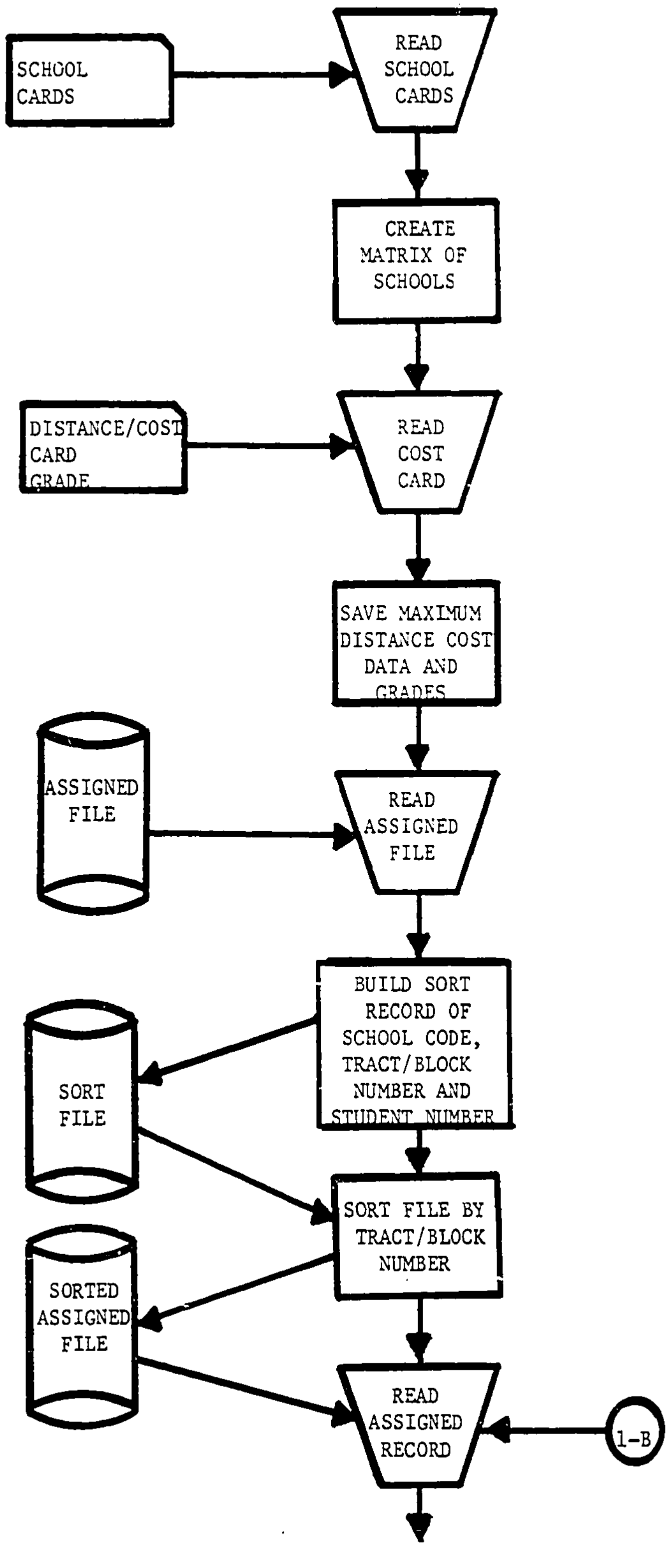
The program initially read the school cards used as input to the MPS Data Preparation Program and created a matrix of information on each school. This matrix contained the school code, school name, x-y coordinate location and enrollment capacity. The program then read the distance/cost card which contained the maximum distance the pupils walked to school, the cost of busing (if known) and the grades that had been considered for assignment. This data was saved by the program for future reference.

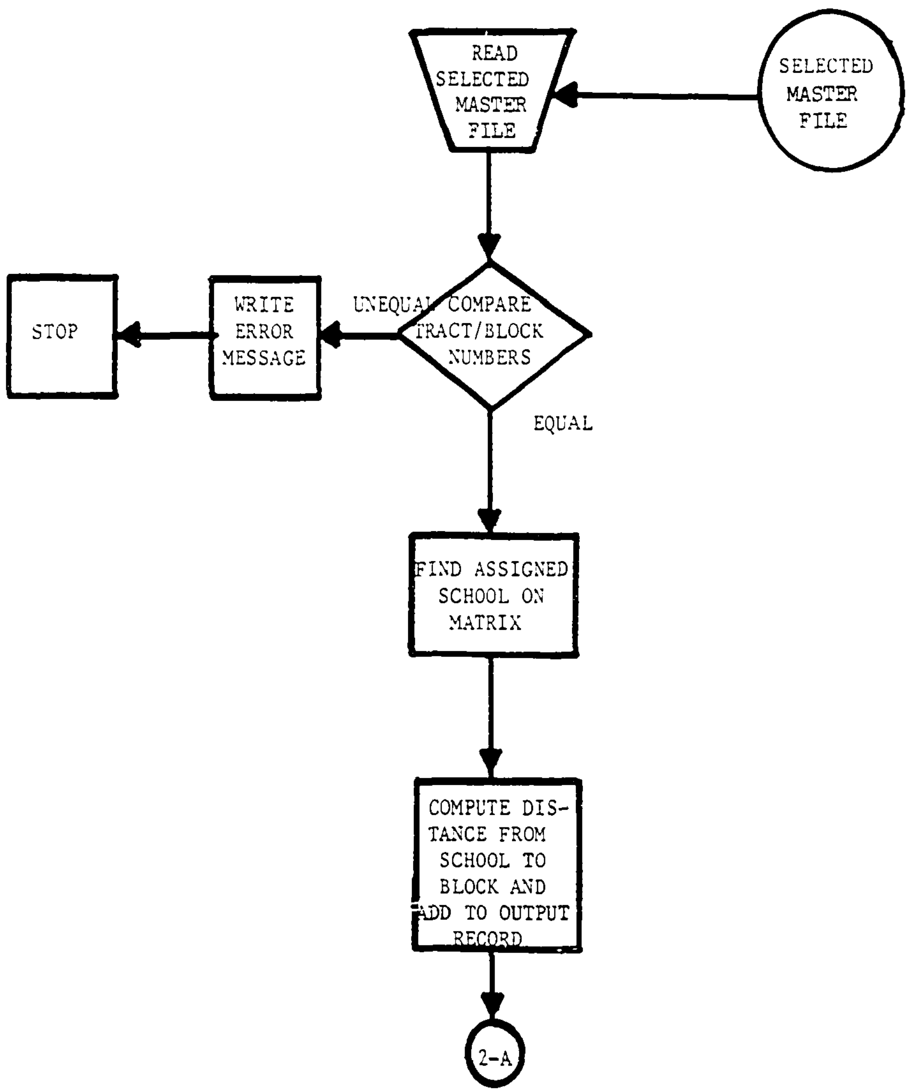
The MPS Assignment File was read and a sort record created and sorted by tract/block number. This sorted file was read and compared with the selected Schedule Master created by the GIPSY program. This comparison was used to create a file in which each of the assigned neighborhoods had a distance computed from it to the school of assignment. The selected schedule master was used to pickup the x-y coordinate for each of the assigned neighborhoods. The distance computation then became a matter of subtracting the x-y location of the neighborhood from the x-y location on the matrix for the proper school assignment.

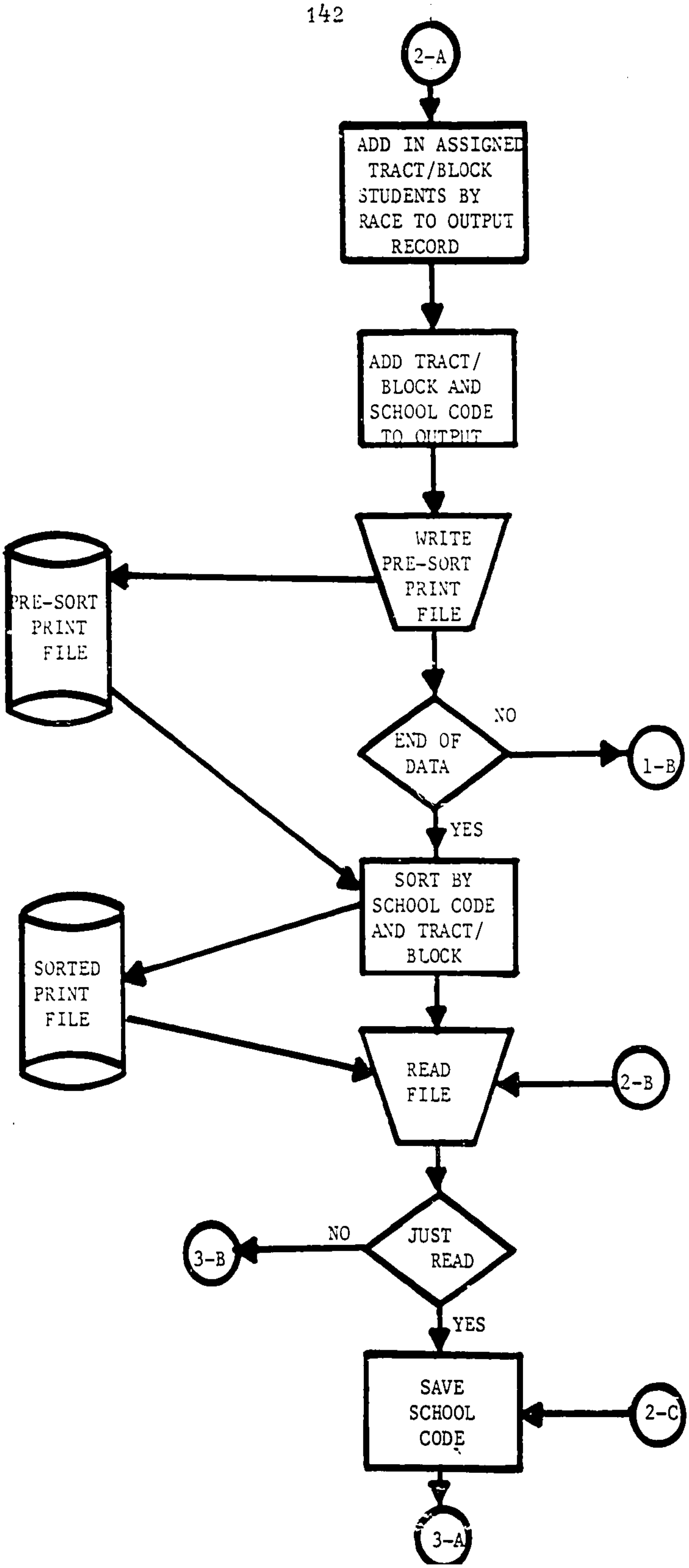
This information was then added to a second intermediate file which was used for printing purposes. This file contained the computed distance from the neighborhood to the school, the tract/block number and the school code and the number of students by race resident in the neighborhood. When the entire assignment file was processed this second intermediate file was sorted by school code. After the sort was completed the program read the file and created the printed output. This output contained.

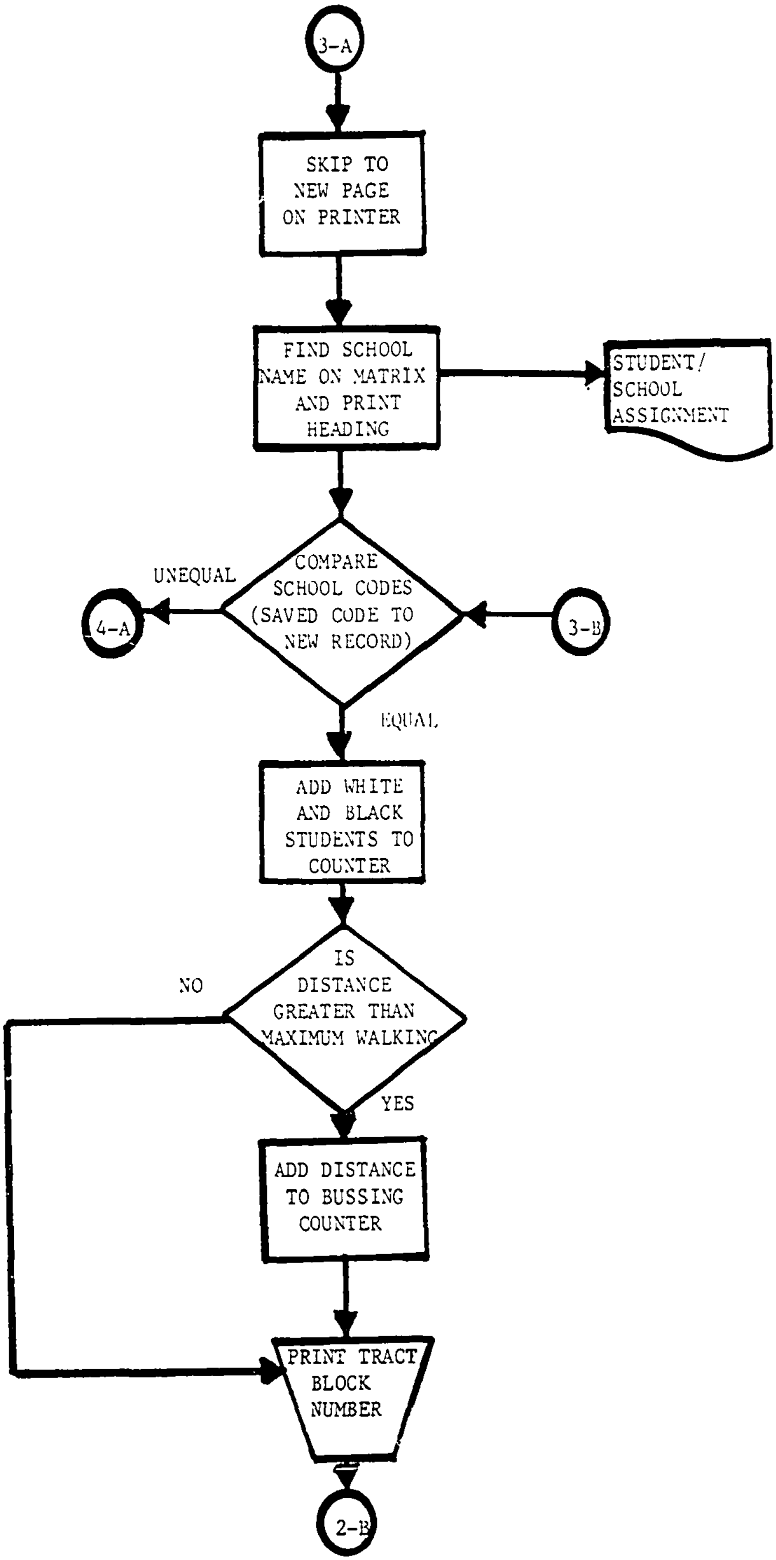
1. The name and current enrollment of the school
2. The tract and block of the neighborhoods assigned to the school
3. The new total enrollment and the enrollment by ethnic group
4. The ethnic composition of the school
5. The total busing distance for this school
6. The total busing cost for busing children to the school.

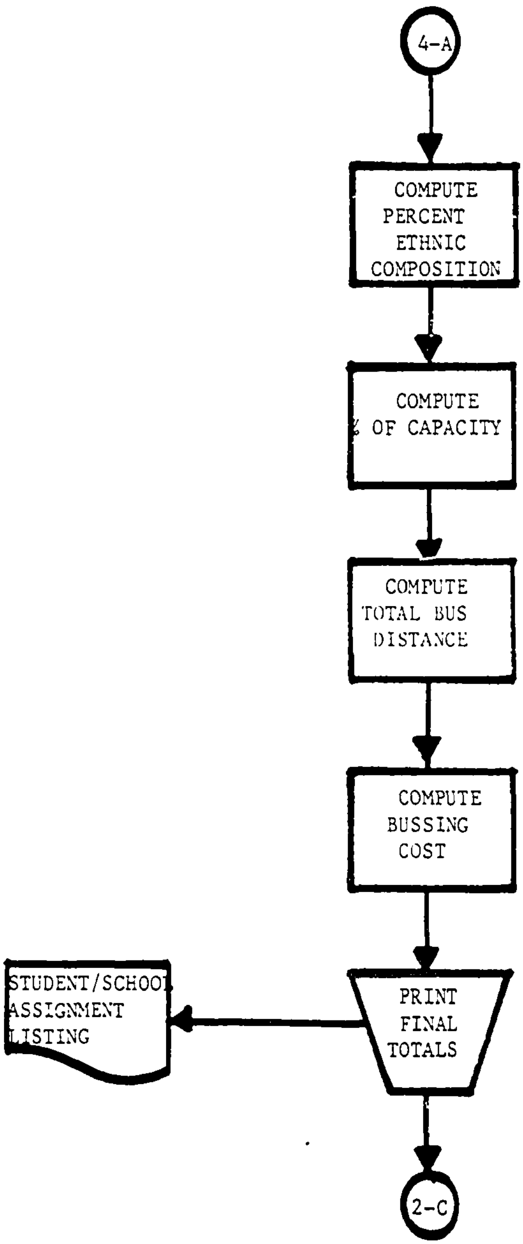
PROGRAM FLOWCHART: PROBLEM SOLUTION PRINT PROGRAM




READ SELECTED MASTER FILE
SELECTED MASTER FILE
UNEQUAL
COMPARE TRACT/BLOCK NUMBERS
WRITE ERROR MESSAGE
STOP
EQUAL
FIND ASSIGNED SCHOOL ON MATRIX
COMPUTE DISTANCE FROM SCHOOL TO BLOCK AND ADD TO OUTPUT RECORD
2-A


2-A
ADD IN ASSIGNED TRACT/BLOCK STUDENTS BY RACE TO OUTPUT RECORD
ADD TRACT/ BLOCK AND SCHOOL CODE TO OUTPUT
WRITE PRE-SORT PRINT FILE
PRE-SORT PRINT FILE
END OF DATA
NO
1-B
YES
SORT BY SCHOOL CODE AND TRACT/ BLOCK
SORTED PRINT FILE
READ FILE
2-B
JUST READ
NO
3-B
YES
SAVE SCHOOL CODE
2-C
3-A


3-A
SKIP TO NEW PAGE ON PRINTER
FIND SCHOOL NAME ON MATRIX AND PRINT HEADING
STUDENT/ SCHOOL ASSIGNMENT
UNEQUAL
4-A
COMPARE SCHOOL CODES (SAVED CODE TO NEW RECORD)
3-B
EQUAL
ADD WHITE AND BLACK STUDENTS TO COUNTER
NO
IS DISTANCE GREATER THAN MAXIMUM WALKING
YES
ADD DISTANCE TO BUSSING COUNTER
PRINT TRACT BLOCK NUMBER
2-B


4-A
COMPUTE
PERCENT
ETHNIC
COMPOSITION
COMPUTE
% OF CAPACITY
COMPUTE
TOTAL BUS
DISTANCE
COMPUTE
BUSSING
COST
PRINT
FINAL
TOTALS
STUDENT/SCHOOL
ASSIGNMENT
LISTING
2-C